# OR Environmental Report

# 2015

Reykjavík Energy

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# Summary

Environmental issues are a key element in the social debate and the performance of Reykjavik Energy (OR) and its subsidiaries is therefore important. This is a brief summary of the main progress made in the main environmental projects in 2015.

## Noteworthy results in 2015

- A milestone was reached in June when a new water protection plan came into effect in the capital area along with a new and more stringent consensus regarding activity in water protection areas.
- A hydrogen sulphide abatement unit at the Hellisheidi Geothermal Power Plant removes 25% of the hydrogen sulphide and a steam hood ejector was installed in an endeavour to further reduce the concentration of hydrogen sulphide in populated areas.
- The Hverahlíd pipeline came into use to support the operation of the Hellisheidi Geothermal Power Plant to make it possible to rest parts of the production field of the plant.
- Efforts were launched to reduce the surface discharge of disposal water from the Nesjavellir Geothermal Power Plant to reduce its impact on springs and bays by Lake Thingvallavatn.
- Initial results of research on flow paths for reinjected disposal water indicate that a distributed and moderate reinjection at Hellisheidi reduces the pressure drop in the geothermal system.
- New and effective procedures continued to be applied to reclaim vegetation and restore disturbed areas in Hellisheidi.
- It was demonstrated that it is possible to rapidly and permanently sequester hydrogen sulphide in the basaltic bedrock at the Hellisheidi Geothermal Power Plant.
- Results of marine research on the sea floor and mussels in the bay of Faxaflói showed that the wastewater from sewage treatment plants in the capital area has virtually no impact on the environment.
- Construction of sewerage systems restarted in Akranes, Borgarnes and Kjalarnes.
- Work started on increasing the production capacity of the Rangá Utility in South Iceland and preparing research into providing hot water there.
- ON Power received Iceland's SA-Business Environmental Award in 2015 for establishing a network of fast-charging stations for electrical cars.
- The OR Group was nominated for the Nordic Council Nature and Environment Prize 2015 and the theme of the award was reducing greenhouse gas emissions. District heating in the capital area has spared the earth's atmosphere about 100 million tons of carbon dioxide since the beginning of operations, compared to heating with oil.
- Over 10% of the annual carbon dioxide emissions from the Hellisheidi Geothermal Power Plant were mineralised in the bedrock by the plant.

## Challenges

- Ensure responsible resource management of geothermal production fields in the Hengill area.
- Improve management of reinjection of disposal water at the Hellisheidi Geothermal Power Plant.
- Double the capacity of the hydrogen sulphide abatement unit at the Hellisheidi Geothermal Power Plant and continue research on the sequestration of hydrogen sulphide.
- Verify that the operation of the steam hood ejector at the Hellisheidi Geothermal Power Plant reduces the concentration of hydrogen sulphide in populated areas.
- Further reduce the surface discharge of disposal water from the Nesjavellir Geothermal Power Plant.
- Promote a diversified use of thermal energy, electricity and geothermal gases from the Hellisheidi Geothermal Power Plant.
- Ensure responsible management of production from water resources and strongly emphasise water conservation and the quality of potable water.
- Continue to increase the production capacity of the Rangá Utility in South Iceland and research into providing hot water for the hot water utilities in Akranes and Borgarnes.
- Ensure that the flow of the sewerage system of the Skerjafjördur utility functions at peak times.
- Complete construction of sewerage systems at Akranes, Borgarnes and Kjalarnes.
- Use the infrastructure, products, know-how and capacity of OR and its subsidiaries to facilitate changes in the utilisation of energy in transport and reduce greenhouse gas emissions.

**Figure 1.** Summer employees mix cultured milk (súrmjólk) with moss to promote soil conservation at Hellisheidi. Photograph: Sæunn Kolbrún Thórólfsdóttir.

**Figure 2.** Working on a water supply pipeline in Reykjavik. Photograph: Hildur Ingvarsdóttir.

# Introduction

The operations of Reykjavik Energy (OR) and its subsidiaries are certified in accordance with the ISO 14001 environmental management system. In 2015, OR, ON Power and Veitur Utilities became members of Festa, the Icelandic Centre for Corporate Social Responsibility. The values of OR and its subsidiaries: foresight, efficiency and integrity serve as the guiding principles for the implementation of the environmental and resources policy of the group.

**Climate issues**

The concentration of carbon dioxide ($CO_2$) in the atmosphere is higher than it has been over the past 800 thousand years and a record was broken in this matter in May 2015. The OR Group can reduce greenhouse gas emissions in a great deal of ways. One should first mention the sustained operation and maintenance of the district heating provided by Veitur Utilities, since if oil were used to heat spaces instead, carbon dioxide emissions would almost double in Iceland. Over 6,400 tons of carbon dioxide have been sequestered in basaltic bedrock by ON Power since the launch of the CarbFix and SulFix projects at the Hellisheidi Geothermal Power Plant up to the end of December 2015. Moreover, the OR Group has recently set itself the target to avail of the possibilities of the company and its infrastructure, products, know-how and capacity to facilitate changes in the utilisation of energy in transport and reduce greenhouse gas emissions. With the City of Reykjavik and the Festa Centre for Corporate Social Responsibility, OR and ON Power signed a climate change declaration in November 2015. The performance of OR and its subsidiaries is important in this regard and in 2015 the OR Group was nominated for the Nordic Council Nature and Environment Prize for the company's contribution to the CarbFix project and the development of district heating.

**Collaboration with stakeholders**

Dialogue and collaboration with licensing authorities, stakeholders and customers are important to the personnel of OR and its subsidiaries because they focus our attention and priorities on what matters most to people. Regular meetings are held with licensing authorities and interested parties to scrutinize environmental issues. The main projects and causes for concern that have been raised are discussed, such as the state of natural resources, water conservation, water utilisation, quality of potable water and development of sewerage systems. The emission of hydrogen sulphide and discharge of disposal water has also been discussed, as well as the management of production in geothermal production fields and the restoration of disturbed areas, but also the sorting of waste. An informed discussion on challenges and how they are being tackled is vital.

**Complaints**

In 2015, 22 notifications were received from customers concerning environmental issues and six from staff members. Most of them concerned conduct, graffiti, the mowing of grass and three regarded hydrogen sulphide. In all cases they were investigated and one complaint is currently being processed. There is a discussion on how they were addressed in the sections on Developing Areas by Power Plants and Other Premises, Hydrogen Sulphide Emissions and Structures and Maintenance. Two environmental incidents occurred in water protection areas where cleaning actions were required, see section on the Conservation of Potable Water. Five notifications were sent to monitoring and emergency response units regarding the likelihood of seismic activity due to reinjection and two notifications to the licensing authorities to inform them of the likelihood of hydrogen sulphide concentrations exceeding established limits in populated areas. No earthquakes were observed in the populated areas and the concentration of hydrogen sulphide was below the threshold, see section on Seismic Activity Induced by the Reinjection of Disposal Water and Hydrogen Sulphide Emissions. Nine notifications were sent out to licensing authorities regarding discharged disposal water through overflows at the Hellisheidi Geothermal Power Plant and sixteen notifications of discharges through overflows in sewerage systems, see sections on the Discharge of Disposal Water and the section on the Discharge of Drainage through Overflows.

**Environmental Report**

As has been the case over the past two years, the 2015 Environmental Report focuses on the progress of the most significant environmental elements that have been defined under the five principles laid down in the environmental and resources policy of OR and its subsidiaries and revolve around responsible resource management, the value of utility operations, emissions into the environment caused by activities, the impact of the Group's operations and management. The values of OR and its subsidiaries: foresight, efficiency and integrity serve as the guiding principles for the implementation of the policy.

Environmental impact is a key issue in the social debate and the performance of OR and its subsidiaries is therefore important. Operations are certified in accordance with the ISO 14001 environmental management system. It entails the continuous monitoring of all stations and the evaluation and analysis of the effects operations have on the environment and community and the remedies required to reduce negative impacts. In 2015, OR, ON Power and Veitur Utilities became members of Festa, the Icelandic Centre for Corporate Social Responsibility. The objective of the centre is to find the best way of implementing Corporate Social Responsibility (CSR) in companies. The preparation of the 2015 Environmental Report, was founded on the sustainability reporting guidelines of the Global Reporting Initiative (GRI), which is a leading institution in the field of CSR reporting, see section 13 of the 2015 Annual Report of OR.

# Environmental and resource policy and significant environmental aspects

Environmental and resource policy and significant environmental aspects
The Environmental and Resources policy reflects Reykjavik Energy (OR) and its subsidiaries' commitment to continually improve in the field of environmental affairs. It serves as a guide to the company and forms the basis for good collaboration with stakeholders. The Environmental and Resources policy is founded on the values of the comprehensive policy of the OR Group.

OR and its subsidiaries comply with all the statutory and regulatory provisions that apply to its activities. The Environmental and Resources policy is established on the basis of the following principles and implemented in detail through targeted management and improvements in significant environmental elements:

**Responsible resource management**
OR is entrusted with responsibility for the resources that it utilises. The responsibility entails working according to the ideology of sustainable development and therefore ensuring sustainable utilisation. This is so that future generations can enjoy the same opportunities as current generations to utilise the resources, and that it is possible to confirm OR's commitment to that goal. OR undertakes to seek effective solutions in which the utilisation of resources for the public benefit is weighed and assessed in the context of other interests. OR shall protect the resources from threats and intrusions in line with the responsibility the company has been entrusted with.

**Importance of utility operations**
Access to OR's utilities promotes healthy living and opportunities for eco-friendly operations in the community. This positive environmental impact is a determining factor in decision-making regarding the development of power plants and utilities. Decisions are based on OR setting the bar high for quality, delivery security and efficiency, and it publishes detailed information on its activities and future plans.

**Impact of emissions and discharge**
OR's operations inevitably result in substances and energy being released into the environment. OR takes the utmost precautions in its operations. Emissions are therefore only allowed to occur in a manner that has a negligible impact on health and an acceptable effect on the environment. OR strives to reduce the emission of pollutants as much as possible and prioritises research and development to seek the best possible solutions for that purpose.

**Impact on society**
Nationally OR is a big company and its workforce possesses extensive knowledge and experience in the use of geothermal energy and other aspects of the company's operations. The company passes on its know-how and influences the value chain, which encourages a responsible treatment of the environment and has a positive impact on the community.

**Operations**
OR's operations are founded on the organised and disciplined working procedures of many employees in widespread work sites. Day-to-day tasks include, among other things, the responsible utilisation of supplies, maintenance on constructions, tending to plots of land, handling waste responsibly and promoting ecofriendly transport. OR aims to run exemplary operations and to develop its personnel's qualifications in this regard.

**Significant environmental aspects**
OR has defined the following environmental aspects as significant with regard to the principles stated in the Environmental and Resource policy. OR sets goals regarding these environmental aspects and defines responsibilities:

## Responsible resource management

Managing production in high-temperature geothermal fields
Managing production in low-temperature geothermal fields
Developing areas by power plants and other premises
Conservation of potable water resources

## Value of utility operations:

Access to a more diversified utilisation of high-temperature geothermal resources
Access to electricity utility
Access to hot water utility
Access to cold water utility
Access to sewerage system utility
Access to fibre network utility

## Impact of emissions and discharge:

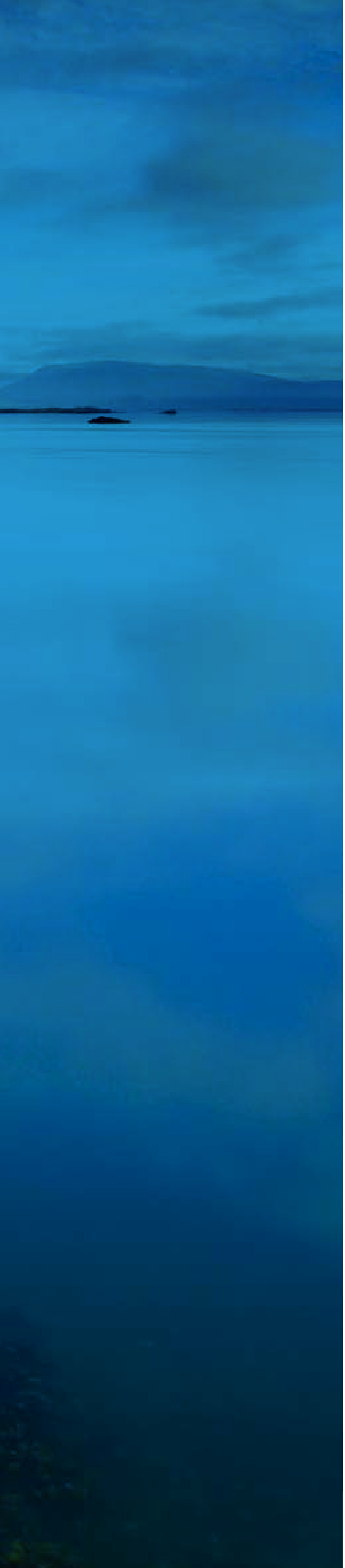
Discharge of disposal water and monitoring of groundwater
Hydrogen sulphide emissions
Carbon dioxide, hydrogen and methane emissions
Seismic activity induced by reinjection of disposal water
Discharge of waste water from sewage treatment plants.
Discharge of drainage through overflows

## Impact on society:

Dissemination of knowledge on geothermal energy utilisation and other aspects of operations
Procurement

## Operations:

Waste
Transport
Structures and maintenance
Use of hazardous substances



# Responsible resource management

Reykjavik Energy (OR) and its subsidiaries are entrusted with responsibility for the resources that it utilises. The responsibility entails working according to the ideology of sustainable development and therefore ensuring sustainable utilisation so that future generations can enjoy the same opportunities as current generations to utilise the resources, and that it is possible to confirm OR's commitment to that goal. OR and its subsidiaries undertake to seek effective solutions in which the utilisation of resources for the public benefit is weighed and assessed in the context of other interests. The group shall protect the resources from threats and intrusions, in line with the responsibility the company has been entrusted with.

# Managing production in high-temperature geothermal fields

Power production in Nesjavellir and Hellisheidi is in accordance with the operating licence for the power plants. In order to ensure the full capacity of the Hellisheidi Geothermal Power Plant over the coming years some of the production fields will be partly put on hold and instead the high-temperature geothermal resources of Hverahlíd have been connected to the Hellisheidi Geothermal Power Plant through a steam pipeline. A new production well has been drilled at the Hellisheidi Geothermal Power Plant and another at the Nesjavellir Geothermal Power Plant in 2015.

OBJECTIVES:
To ensure ON Power's geothermal power plants receive the geothermal energy required to meet its energy sale obligations within the utilisation framework stipulated in the operating licence of the Hellisheidi Geothermal Power Plant. Comparable criteria are assumed to apply to Nesjavellir. Goals on the utilisation of geothermal energy are expressed in terms of criteria regarding how fast pressure and temperatures may drop in the geothermal reservoir.

**Figure 3.** High-temperature geothermal wells in Sleggjubeinsdalur valley. Photograph: Gretar Ívarsson.

## Did you know?

The first results of the research on the flow paths of reinjected disposal water show that a distributed and moderate reinjection at Hellisheidi counteracts pressure drop in the geothermal reservoir.

**Hengill**
The responses of Hengill's production fields to utilisation are monitored. The pressure and temperatures in wells are regularly measured, and changes are closely monitored. This makes it possible to predict how the fields will respond in the future. The conceptual model for Hengill is being revised to gauge how the production capacity of the plants can be maintained in the future to guarantee a responsible utilisation of geothermal resources. The revision is expected to be completed in 2016. Production reports are compiled annually and submitted to the National Energy Authority.

**Nesjavellir Geothermal Power Plant**
Production at Nesjavellir has been going well. Over the past 25 years, the utilisation drawdown (the pressure drop in the geothermal reservoir) has risen in line with increased production, particularly after a fourth turbine came into operation in the plant in 2005 (Annex 2a). Drawdown in the field is in line with simulated pressure, but since the drilling of new wells (so called make-up wells) has been delayed, energy production has decreased slightly. In the spring of 2015 make-up well drilling began. There were difficulties drilling down to the planned depth and a decision was made to stop drilling at 1,300 metres in an attempt to utilise the well, despite its shallowness. The capacity of the well is below expectations. The possibility of deepening the well is being studied for 2016. Due to drawdown, it has been estimated that a make-up well needs to be drilled every three to five years at the Nesjavellir Geothermal Power Plant to maintain energy production. Energy production at Nesjavellir is in accordance with the power plant's operating licence and the objectives of ON Power.

**Hellisheidi Geothermal Power Plant**
As has been stated in the 2012-2014 Environmental Reports, the current production field will not be sufficient for full production in the future at the Hellisheidi Geothermal Power Plant. It was therefore deemed best to expand the production field and acquire additional steam from wells that have already been drilled at Hverahlíd, rather than drill new wells in the existing production field. Work on a pipeline connecting the geothermal field in Hverahlíd with the Hellisheidi Geothermal Power Plant started in the autumn of 2014 and came into operation in January 2016.

Measurements made in 2015 showed that the decrease in steam due to drawdown in the production field was higher than the 2014 measurements had indicated. It was therefore clearly necessary to drill a new make-up well at the plant in addition to the Hverahlíd pipeline. The well came into operation at the end of 2015 and, in addition to the utilisation of wells in Hverahlíd, endeavours will finally be made to rest the wells with ample water in the field. This is fitting because the load on reinjection at the plant is dropping. Due to drawdown, one to two make-up wells a year will be needed to maintain energy production. However, drawdown in this field is well within the thresholds of the operating licence (Annex 2b). In the autumn of 2015, the revision of the geothermal energy utilisation licence for Hellisheidi was completed. The licence is a prerequisite to start harnessing the energy to be found in the wells in Hverahlíd.

Measurements of the status of geothermal reservoirs in Hengill will be intensified and simulation models shall be reviewed more frequently than every five years. This will yield timely information on the impact that production is having on the geothermal system, thus making it possible to respond to the behaviour of the system.

**Flow paths for reinjected disposal water**
Flow paths for reinjected disposal water Tracer testing conducted in 2013 and 2014 on the reinjection fields in the Hellisheidi Geothermal Power Plant at Húsmúli and Gráuhnúkar reveal that a substantial portion of the disposal water reinjected into the geothermal system reaches the production fields on the western side of Mt.Skardsmýrarfjall and at Mt. Reykjafell. In these parts of the geothermal system, reinjection supports the pressure, but may also cause cooling, particularly on the western side of Mt. Skardsmýrarfjall. The first results of the tracer testing, which started in November 2014, show that distributed and moderate reinjection counteracts the pressure drop in the geothermal system and can increase the production capacity of the field. Production wells in the vicinity of the reinjection are carefully monitored to evaluate their cooling effect and ensure there is no excessive reinjection close to the production wells.

Tracer testing in Nesjavellir started in August 2015 with the aim of verifying whether the disposal water that is reinjected into the wells in the lower groundwater system is able to penetrate the springs of Lake Thingvallavatn. The results are expected in 2016.

# Managing production in low-temperature geothermal fields

Production from the low-temperature fields in the capital area and in South and West Iceland is in line with the objectives of Veitur Utilities. Work started on increasing the production capacity of the Rangá Utility in South Iceland and research into providing hot water for the hot water utilities in Akranes and Borgarnes will continue in 2016.

OBJECTIVES:
To ensure water extraction in low-temperature fields does not curtail the possibility of corresponding water extraction in the future.

**Heating utilities**
Veitur Utilities operates fourteen heating utilities: in the capital area, in West Iceland and South Iceland (Table 2 in the section on Access to Heating Utilities and the map of OR and subsidiaries' main area of operations in Annex 1).

Veitur Utilities possesses decades of experience in geothermal production utilising numerous low-temperature fields. The measurements of water levels and temperatures in wells are used to monitor how the production fields respond to utilisation. It is possible to respond to changes by: reducing production, reinjecting in fields and re-casing wells. The results of the chemical analyses of hot water can be seen in Annexes 3 and 4. Production reports for the heating utilities are published annually.

**Capital area**
Low-temperature fields are utilised in a stable and balanced manner in the capital area and everything indicates that this usage can be maintained for the foreseeable future, barring the unexpected. The groundwater level is generally good (Annex 5).

**South and West Iceland**
Production monitoring over the past years shows that the condition of most of the low-temperature fields, which Veitur Utilities runs in South and West Iceland, is good and in accordance with operating licences. However, over the past years water levels have dropped in Laugaland in Holt. Production decreased significantly in 2015 and more water was obtained from Kaldárholt. The water from there is considerably colder than in Laugaland, however. In 2015 preparations therefore started on the drilling of two to three temperature gradient wells in the vicinity of Laugaland, which will be drilled in 2016. The objective is to locate a new production well which is expected to be drilled in 2016 or 2017. Research into increasing hot water supplies in the utilities of Akraness and Borgarness (HAB) will continue in 2016.

**Did you know?**

In Veitur Utilities' low-temperature fields there are little or no greenhouse gas emissions.

**Figure 4.** Low-temperature geothermal wells in the Ellidaárdalur valley in Reykjavik. Photograph: Gretar Ívarsson.

# Developing areas by power plants and other premises

Emphasis will continue on the restoration and reclamation of disturbed areas in Hellisheidi in cooperation with licensing authorities. The maintenance of walking paths in the Hengill area, for example, needs to be improved to fulfil the OR's objectives.

OBJECTIVES:
To minimise disturbance to the land caused by constructions and to restore the disturbed areas in harmony with the surrounding landscape, see guidelines on visual impacts and restoration. The roads, tracks and paths that are required for the constructions shall also be utilised, where appropriate, to improve access to nearby nature areas. Travellers shall be given an opportunity to learn on-site about the utilisation of natural resources and the nature in nearby areas.

The operations of OR and its subsidiaries are broad ranging and vast areas of land have been allocated to their activities. The companies administer about 19,000 ha of land, some 16,000 ha of which are within protected areas, see Annex 6. Annex 7 contains a list of the species of birds and plants on the Red List who have habitats within the areas which are administered by OR and its subsidiaries.

**Hellisheidi restoration procedure**
In 2015, emphasis continued to be placed on good restoration and reclamation of disturbed areas at the Hellisheidi Geothermal Power Plant. The construction of a steam pipeline connecting the geothermal field in Hverahlíd to the Hellisheidi Geothermal Power Plant continued in 2015. Strips of turf, moss and other materials that were removed along the pipeline path were used in the restoration of the construction area and also the restoration of older constructions at the Hellisheidi Geothermal Power Plant. Lava slag from the pipeline path will, for example, be used for the restoration of an old mine on the eastern side of Gígahnúkur and on old drilling sites. Moss was collected from the pipeline path, stored in a freezing container in 2014, and will be used for the restoration in the spring of 2016. In 2015, six ha of land were reclaimed with local vegetation in parallel with new constructions (Figure 5) and 14 ha of land in older disturbed areas. The total restoration due to the laying of the Hverahlíd pipeline will be completed i n 2016. By utilising the native vegetation, biodiversity can be maintained, while enhancing the visual impact and effective land reclamation. A matt finish will be applied to the Hverahlíd pipeline to reduce its visibility.

Experience in Hellisheidi shows that it is important for construction designs to take into account the procedures that are used in restoration. It is also very important to instruct earthworks and servicing contractors at the beginning of a project and when new workers start working. Potential disturbances to the nature that may be caused by earth-works need to be carefully reviewed, along with the goals for the removal and restoration of vegetation and soil, and good working procedures need to be presented. It is up to the organisation and supervisors to have a prepared area for receiving materials that may be used in the construction area. This

**Figure 5a.** During construction, strips of turf were removed from the ditch by Hverahlíd and placed on the edge of the ditch. Photograph: Magnea Magnúsdóttir.

## Did you know?

The OR Group owns and tends to 110 km of marked hiking and educational paths in the Hengill area.

was largely successful in 2015 and great progress has been made in restoration and these procedures will be systematically followed in other constructions.

Construction companies have shown an interest in the procedure of simultaneously using vegetation in the restoration of construction areas, the so-called Hellisheidi restoration procedure. When the Icelandic Road and Coastal Administration (IRCA) started to widen a road, ON Power contacted the company and collected moss from the side of the road. The moss was mixed with cultured milk (súrmjólk) and water and spread over the ground to stimulate the growth of moss and speed up land reclamation. This is an example of a fruitful collaboration between companies in the use of materials for the restoration of construction sites.

**Work procedures, guidelines for restoration and various projects**
In 2015, a description of the environmental training required for contractors and subcontractors was added to the tender specification of projects. Guidelines were also issued regarding the visual impact and restoration of construction sites on vegetated land and informative booklets were issued to contractors in Icelandic, English and Polish. In 2016 guidelines will also be issued on how it is possible to reclaim native vegetation in urban areas. The aim is to publish them on the websites of ON Power and OR in 2016.

**Travellers, energy utilisation and outdoor recreation**
Endeavours are being made in the Hengill area to guide the traffic of travellers along the paths, but also to give people opportunities to experience the magnificent landscapes and diversified geothermal energy and the different uses it is put to in the area. In recent years, the Reykjavik Scout Rescue Unit has taken care of the maintenance of all walking paths in the Hengill area.

The number of visitors to the Hengill area is still rising and the walking paths there clearly show signs of this. Hikers, runners, cyclists and horse riders, as well as people in jeeps and snowmobiles, enjoy the area for outdoor recreation. When laying the Hverahlíd pipeline, solutions were sought to ensure the surrounding area could continue to be enjoyed for outdoor activities. It will be possible to cross over the pipeline in seven places. Signposts with information on this and marked walking paths in the area will be put up in the parking lots by the Hellisheidi Geothermal Power Plant, the intersection of Sudurlandsvegur and Gígahnúksvegur and at the rest stop near Gígahnúkur. The putting up of new information signs at the start of walking paths will be completed in 2016.
In the summer 2015, the emphasis was on changing bollards in Hengill and signposts were also renewed in many places. Work will continue on maintenance and signposting over the coming years and care needs to be taken to ensure the rise in travellers does not cause any damage to the landscape. It is clear that more money has to go into the maintenance and care of walking paths in the Hengill area in order to meet OR's objectives.

**Figure 5b.** The turf was placed over the ditch to utilise the native vegetation. Thus biodiversity can be maintained, while enhancing the visual impact and effective land reclamation. Photograph: Magnea Magnúsdóttir.

# Conservation of potable water resources

In 2015 a new regional plan for the capital area came into effect and a new water conservation plan forms part of it. At the same time a new and more rigorous water conservation agreement came into effect with regulations that apply to activities in water conservation areas.

OBJECTIVES:
To ensure that water supplies, which users of Veitur Utilities rely on, are not contaminated. To ensure water production does not diminish the possibility of corresponding water extraction in the future.

Veitur Utilities has a duty to meet the water requirements of people and companies in the utility area. Potable water shall fulfil the provisions of the Regulations on Food Inspection and Hygiene, cf. Regulation no. 536/2001 on Potable Water.

**Water utilities**

Reykjavik Energy (OR) and subsidiaries have 15 water sources, and the water is piped to areas in West Iceland, South Iceland and the capital area (Table 2 in the section on Access to Water Utilities and map of OR and subsidiaries' main area of operations in Annex 1). Preventive measures are systematically worked on and the quality of the water is monitored. Risk factors in water protection areas and distribution systems are analysed, and health authorities in each utility area regularly take samples to monitor the quality of the water and respond to notifications of required repairs and improvements.

**Water conservation in the capital area**

Heidmörk is Veitur Utilities' main water extraction field for the capital area and that water production is based solely on pure and untreated groundwater. The water conservation zone of the capital area comprises about 230 km$^2$. The water spring areas are in Gvendarbrunnar, Jadar, Myllulaekur and Vatnsendakrikar and amount to 7 km$^2$. The main structures that are used in water extraction are to be found in the water spring protection areas, such as wells, well head shelters, pumps and storage tanks. The traffic of motorised vehicles on roads in water protection areas is substantial; populated areas have drawn closer and numerous activities take place there. Ideas at various stages of development for or in the vicinity of the area are a source of concern for OR and its subsidiaries and they have clearly stated so.

Veitur Utilities keeps the water protected area under surveillance, including the transport of oil and gasoline, along with other hazardous substances (Table 1). Some 25 trips were made in 2015, accompanying vehicles transporting hazardous substances.

In 2015, two environmental incidents occurred in water protection areas, involving oil leakages that had to be cleaned up.

In 2015 various projects were continued to promote the conservation of potable water, such as replacing oil transformers in water protection areas with dry type transformers. Transformers that use more eco-friendly oil were set up on the Bláfjöll mountains which are on outer protection zones for potable water. There is a plan to move a back-up generator in Jadar in Heidmörk, which is powered by diesel oil, along with oil tanks, out of the water conservation area in 2018.

In mid 2015 the National Energy Authority granted a utilisation licence for the operation of three wells, thus increasing water production in Vatnsendakrikar. This is being done to increase the operational security of the water utility, and in response to the projected demographic growth over the next 15 years. The municipality of Hafnarfjördur has appealed against the issuance of the utilisation licence.

The summer house which OR acquired in 2014 and stood in the water protection area by the lake of Ellidavatn will be removed at the beginning of 2016 to ensure better water conservation in the area.

**Water conservation in South and West Iceland**

The greatest water source in Iceland is currently the Grámelur spring by Nesjavellir and the water from there is used both for the hot water utilities of the capital area and as potable water in the area of the plant. A summer house owned by OR in Ridvík once

**Figure 7.** The upper Reykjavik settlements lie close to water conservation areas. Photograph: Gretar Ívarsson.

**QUANTITY OF FUEL AND SLUDGE TRANSPORTED UNDER SUPERVISION**

| AREA | CATEGORY | UNIT | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| Bláfjöll, ski area | Oil | Liters | 42,136 | 48,100 | 45,744 | 43,189 | 54,219 |
| Elliðavatn | Oil | Liters | 3,342 | 918 | 1,486 | 1,649 | 2,688 |
| Þríhnjúkar | Oil | Liters | | | 3,000 | | |
| Jaðar | Oil | Liters | | 2,488 | | | |
| **Total oil** | | **Liters** | **45,478** | **48,100** | **50,230** | **44,838** | **56,907** |
| Bláfjöll, ski area | Gasoline | Liters | 3,006 | 2,063 | 3,663 | 2,950 | 2,951 |
| **Total gasoline** | | **Liters** | **3,006** | **2,064** | **3,664** | **2,950** | **2,951** |
| Gvendarbrunnar | Sludge | Liters | | 2,000 | | | 2,000 |
| Jaðar | Sludge | Liters | 6,500 | | | | |
| Vatnsendakrikar | Sludge | Liters | | | 2,500 | | |
| Vatnstankur T-4 | Sludge | Liters | | 2,500 | | | 2,000 |
| **Total sludge** | | **Liters** | **6,500** | **4,500** | **2,500** | **0** | **4,000** |

**Table 1.** Volume of fuel and sludge transported under supervision in the water protection area of the capital area between 2011-2015. The use of oil and gasoline in the Bláfjöll area is determined by how much it snows in the area, but also by projects. This explains the variations between years.

stood by the water source and was removed in the summer of 2015 to ensure a better protection of the water in the area. In the spring of 2015, the town of Stykkishólmur expressed concerns that construction projects at the Svelgsá in Helgafellssveit placed the town's water sources at risk. OR considered there to be little risk of contamination of the water source because of the type of bedrock, catchment area and laying of the construction area if all the requirements of the supervisory authority were carefully observed. The area above the water source in Akranes has been used for outdoor recreation. In 2015 signs were put up to draw attention to the fact that it is a water conservation area.

**Monitoring of water quality**

Every year the health authorities take samples from all of the water utilities of the OR Group for microbial analysis, and the number of samples is determined by Potable Water Regulation no. 536/2001. Samples are also taken for overall chemical analysis (Annexes 8-9).

In 2015, a hundred water samples were taken in Reykjavik and they all met the quality requirements. Results for the last 16 years are shown in Figure 6. Since the year 2000, 97-100% of the samples have met the quality requirements. In 2015, some 24 samples were taken in Akranes, Álftanes, Borgarfjördur, Grundarfjördur, Hellisheidi, Hlídarveita, Hvanneyri, Nesjavellir, Reykholt and Stykkishólmur. All samples met the quality requirements.

**New water conservation plan and agreement for the capital area**

In 2015, a new regional plan for the capital area came into effect and a new water conservation plan forms part of it. The demarcation of water protection areas is based on much more detailed research than before. But this knowledge-base needs to be complemented with drilling and measurements which are required for evaluations and making informed decisions regarding projects and activities in and around water conservation areas in order not to jeopardize potable water safety. At the same time as the changes in the demarcation of water conservation areas were made, a new and more rigorous water conservation agreement came into effect with regulations that apply to activities in water conservation areas. Many have stakes in the capital's water conservation area, and many perspectives have to be reconciled. It is important to strongly emphasise water conservation to ensure future generations can enjoy the natural quality of wholesome and untreated water.

The water utilities of the capital area share many common interests, and ideas have been proposed to improve their cooperation on water resources. Veitur Utilities will follow up on those ideas.

In mid 2015, a consultative group was formed to focus on water conservation and water utilisation in the capital area and the water utilities in the capital area have representatives in the group, including representatives from the OR Group. The formal statement of duties states, among other things, that municipalities shall implement the demarcations of water conservation areas and the regulations deriving from the water conservation agreement in its development plans and shall aim to ensure that water conservation is not jeopardised by land usage or activities within the water conservation areas.

**QUALITY OF POTABLE WATER IN REYKJAVIK**

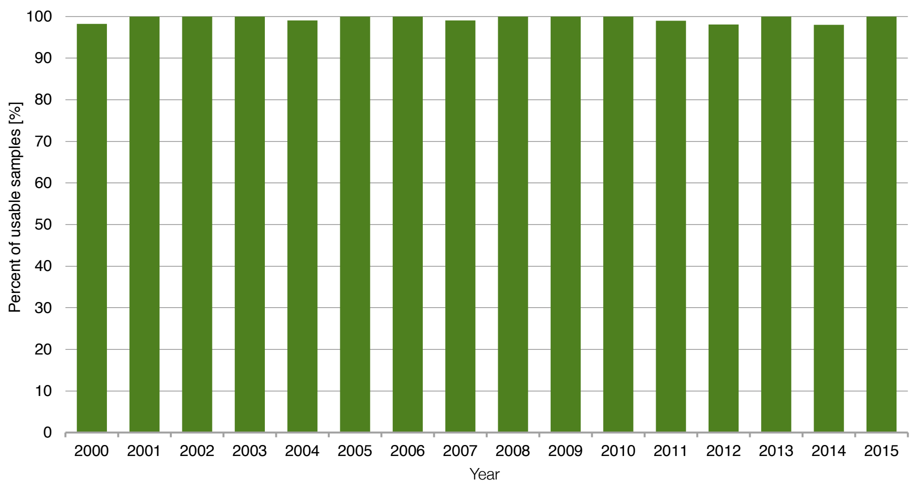
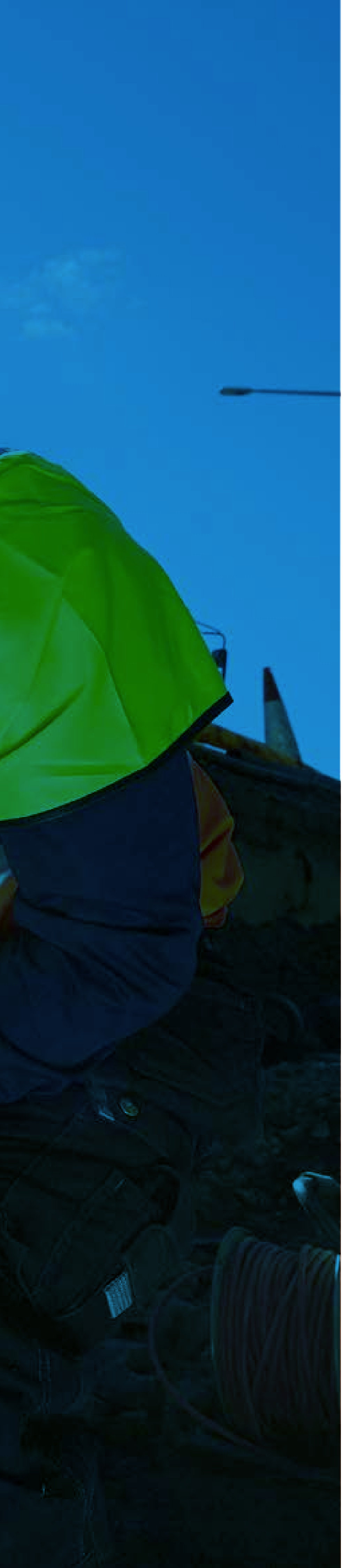



**Figure 6.** Percentage of water samples which met quality requirements between 2000-2015. The faulty and unusable samples from the year 2000 are not from a water source in Reykjavik, but from Kjalarnes.

## Did you know?

Water usage can vary between populated areas. About 50% of potable water in Reykjavik is used in business operations, for example, and 76% in Grundarfjördur.


VEITUR
VEITUR



# Importance of utility operations

Access to Reykjavik Energy (OR) and subsidiaries' utilities promotes healthy living and opportunities for eco-friendly operations in the community. This positive environmental impact is a determining factor in decision-making regarding the development of power plants and utilities. These decisions are based on OR and subsidiaries setting the bar high for quality, delivery security and efficiency, and it publishes detailed information on its activities and future plans.

# Access to a more diversified utilisation of high-temperature geothermal resources

Ways are being sought to encourage a diversified usage of the thermal energy, electricity and geothermal gases from the Hellisheidi Geothermal Power Plant in the resources park west of the plant. Increased emphasis will be placed on this project in 2016.

OBJECTIVES:
To make multiple uses of the products of high-temperature geothermal power plants, particularly thermal energy and electricity, in addition to streams of substances that would otherwise have to be discharged or disposed of, depending on environmental and efficiency requirements. The product offering shall be based on the efficient operation of systems in the core operations of ON Power.

Multiple use of geothermal energy can increase efficiency and strengthen environmentally sound operations and innovation in the business community. For this purpose the Municipality of Ölfus has made its contribution to multiple utilisations of this kind in the Hengill area by producing a local plan for a resources park at the Hellisheidi Geothermal Power Plant with the aim of utilising all the natural resources emanating from the plant.

In 2015, the GeoSilica company decided to enlarge its production unit following successful experiments in using residual water from the power plant to produce dietary supplements. Prokatín ehf., which started its experimental production of protein flour to mix into fish fodder and organic sulphur for use as a fertiliser, terminated the experiments at the Hellisheidi Geothermal Power Plant in 2015 because the project yielded less than expected. In partnership with the scientific community, grant applications for further multiple uses of geothermal gases have been submitted. In 2015 a grant was awarded by RANNÍS in the Ecogas Project. This contains a summary of the most suitable processes for the removal of carbon dioxide, and explores whether it is sensible to use carbon dioxide from the plant for the production of fuel. Work will continue on mapping and promoting multiple uses of high-temperature geothermal resources to find new customers who can better utilise the production from high-temperature plants.

In the autumn of 2015, an experimental station started to operate at the Hellisheidi Geothermal Power Plant to develop a method for removing carbon dioxide from the water reinjected in the SulFix project, see section on Hydrogen Sulphide emissions. The project will strengthen the premises underlying the design and feasibility study for an industrial scale station which can also entail the potential utilisation of carbon dioxide. Another possibility being explored is whether the water that is reinjected in the SulFix project can be used to reduce the likelihood of scale formations in the district heating utility and the injection utility of the power plant.

When decisions on innovative projects are made in connection with the development of high-temperature geothermal power stations, the requirement for positive environmental impact is a determining factor. Moreover, these decisions are always founded on quality, security and efficiency requirements.

**Did you know?**

The customers of ON Power are offered electricity, steam, hot and cold water, as well as geothermal gas in the resources park at the Hellisheidi Geothermal Power Plant

**Figure 8.** Hellisheidi Geothermal Power Plant. Photograph: Gunnar Svanberg.

# Access to electricity utility

Veitur Utilities ensures the supply of electricity to the residents and business community in the distribution area, in accordance with established quality standards and statutory and regulatory provisions. The laying of the underground Kjalarnes Power Line continued and the laying of the underground Ellidavatn Power Line was completed.

OBJECTIVES:
To ensure residents and business operations in Veitur Utilities' distribution areas have the option of connecting with an electricity utility. Ensure power outages in electricity utilities are negligible, thanks to, among other things, the reliability of the construction of the distribution grid. Ensure the quality of the electricity complies with quality standards and regulations.

## Did you know?

The Icelandic Radiation Safety Authority (www.gr.is) provides information on the effects of electromagnetic fields on the human body.

Veitur Utilities distributes electricity in Akranes, Mosfellsbaer, Reykjavik, Seltjarnarnes, Kópavogur, Gardabaer north of Hraunholtslaekur and Hellisheidi in the Municipality of Ölfus (Map of OR and subsidiaries' main area of operations in Annex 1). Over 99,000 households and companies were connected to Veitur Utilities' electricity grid in 2015 and more than 750 of them were new users. The grid's production capacity needs to be reinforced in the capital area to be able to meet the population growth, the densification of urban areas and industrial development projections for the coming years.

The load on the electricity grid is continually monitored and the quality of the voltage is evaluated on an annual basis. In 2015, the electricity supply in the capital area fulfilled quality standards and statutory and regulatory provisions. As has been the case for the past four years, only the most necessary tasks were undertaken to reinforce and maintain the grid. Oil transformers were switched for dry type transformers in the overhead substation on the southern side of Ellidavatn and temporary oil transformers were put up for the dry type transformers in the outer protection zones by Sudurlandsvegur. In the summer of 2015 the transformer plant in Sudurgil in Bláfjöll mountains were renovated and transformers that use eco-friendly oil were installed. The transformer plant is in an outer water protection zone. In addition, it is worth mentioning that the laying of the underground Ellidavatn Power Line was completed in 2015, and work was done on the second and third phases of the laying of the Kjalarnes underground Power Line. The Kjalarnes Power Line project is scheduled to be completed in 2016 or 2017. A new supply station is being built in Akranes and its purpose is to increase delivery security and to meet the growing demand for electricity.

There were more operational disturbances in the grid than there were in 2014. Factors such as the weather and construction have a considerable impact on the number of disturbances. There were 20,0 minutes of power outages due to unforeseeable operational disturbances in 2015.

**Figure 9.** Maintenance. Photograph: Hildur Ingvarsdóttir.

# Access to geothermal district heating utility

In 2015 renovation work was conducted in the Reykjaaedar area from Ellidaá under Breidholtsbraut to Bústadavegur. Various projects were undertaken in West and South Iceland to guarantee the operating safety of the district heating utilities.

OBJECTIVES:
To ensure that residents within Veitur Utilities' distribution areas have the option to connect to the distribution system in accordance with the company's connection terms. Upon fulfilment of residents' needs, companies shall have the option of utilising hot water for industrial operations. The expansion of the distribution system and customers' particular connections shall be determined by, for example, technical prerequisites and cost-effectiveness.

## Did you know?

The district heating system serves about two out of every three residents in the country and is the most universally embraced utility of the company.

Veitur Utilities operates fourteen district heating utilities, seven in South Iceland, six in West Iceland and one in the capital area, which is the largest and produced about 74 million $m^3$ of water in 2015. The hot water used in the capital area comes from Nesjavellir, Hellisheidi, Ellidaárdalur and Laugarnes within Reykjavik's city limits, as well as Reykir and Reykjahlíd in Mosfellsbaer (Table 2 and the map of OR and subsidiaries' main area of operations in Annex 1). Annex 10 shows where the various sections of the capital area get their hot water from. The productive capacity of the system, with the envisaged build-up in the capital area, is sufficient to meet the needs of a growing population and industrial development over the coming years.

In 2015 renovation work was conducted on Reykjaaedar area from Ellidaár under Breidholtsbraut to Bústadavegur. Reykjaaedar is 20 km long and stretches between the geothermal production fields in Reykir and Reykjahlíd in Mosfellsbaer to the water storage tanks in Öskjuhlíd. New storage tank for hot water in Akranes came into use in December 2014 and the restoration has been completed. The storage tank increases the operational security of the hot water utility in the town. A new pumping station for the Rangá Utility, which was installed on the land of Sörlatunga, slightly north of Lake Gíslholtsvatn was activated at the beginning of 2015 and measures have been taken to increases the transport capacity of the pipeline from Kaldárholt to Sörlatunga. This measure increases the volume of water from Kaldárholt to Laugaland, since water supplies there have been low. In the spring of 2015, a well head was renewed in Efri-Reykir, increasing the operational security of the Hlídarveita utility (Figure 11).

Approximately 56 thousand users were connected to Veitur Utilities' District Heating distribution system in 2015, some 250 of whom were new users. The district heating distribution system caters for 190 thousand residents.

**HOT WATER ACQUISITION BY MONTH**

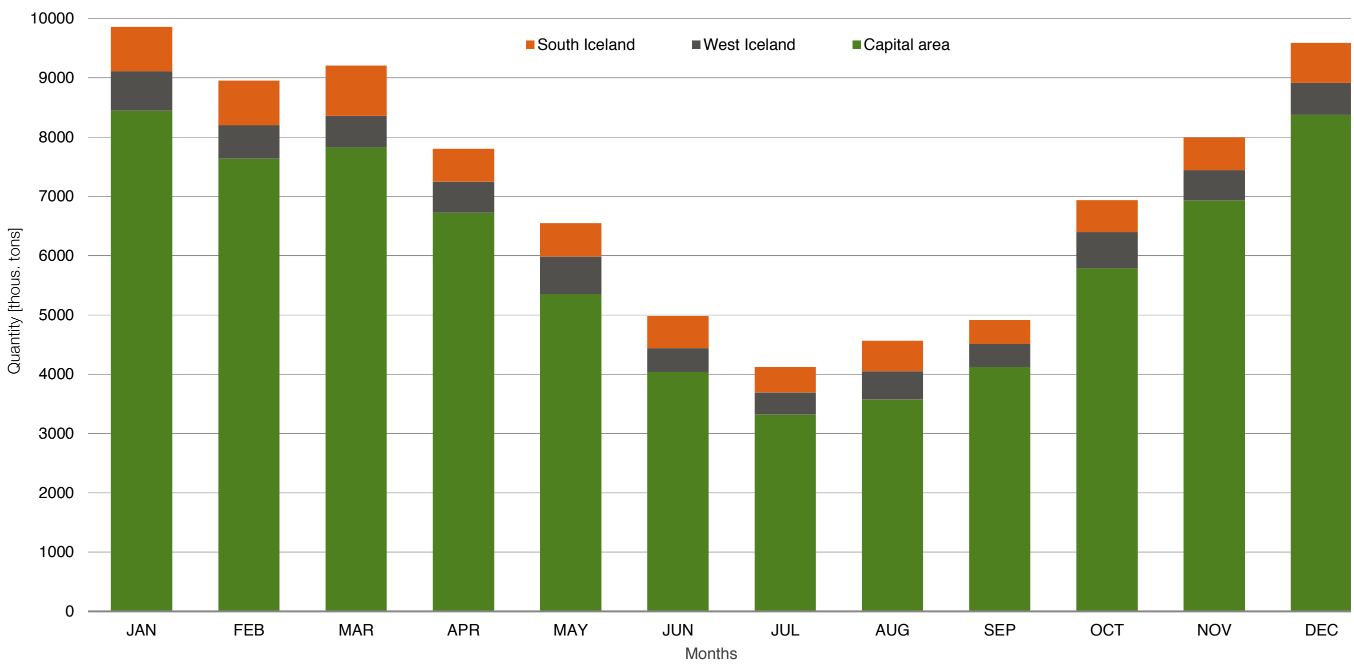



**Figure 10.** Hot water supplied by Veitur Utilities per month in its distribution area in 2015.

**Figure 11.** Changing well head in Efri-Reykir. Photograph: Gudmundur Óli Gudmundsson

**DISTRICT HEATING UTILITIES**

| UTILITY | PRODUCTION FIELD | NO. OF WELLS | ANNUAL PRODUCTION | | QUANTITY | COMMENTS | IMPROVEMENTS |
|---|---|---|---|---|---|---|---|
| | | | thous. tons | l/s | | | |
| Capital area | Laugarnes | 10 | 5,123 | 162 | Sufficient | | |
| | Elliðaár | 7 | 2,035 | 65 | Sufficient | | |
| | Reykir | 22 | 12,804 | 406 | Sufficient | Wholesale to Mosfellsbaer | |
| | Reykjahlíð | 12 | 15,627 | 496 | Sufficient | Wholesale to Mosfellsbaer | |
| | Nesjavellir | 18 | 26,797 | 850 | Sufficient | | |
| | Hellisheiði | 31 | 11,406 | 362 | Sufficient | | |
| **WEST ICELAND:** | | | | | | | |
| HAB | Deildartunguhver | 1 | 4,413 | 140 | Limited | | Further research to provide hot water in 2016 |
| | Wells in Baeir | 2 | 538 | 17 | Limited | | |
| Skorradalur | Well in Stóra Drageyri | 1 | 308 | 10 | Sufficient | | |
| Munadarnes | Well in Munadarnes | 1 | 209 | 7 | Sufficient | | |
| Nordurárdalur | Well in Svartagil | 3 | 405 | 13 | Sufficient | | |
| Bifröst | Well at Bifröst | 1 | 154 | 5 | Sufficient | | |
| Stykkishólmur | Wells at Stykkishólmur | 2 | 758 | 24 | Sufficient | One injection well and back-up power | |
| **SOUTH ICELAND:** | | | | | | | |
| Hveragerdi | Borholur í Hveragerði | 3 | Mælingar vantar | | Sufficient | Steam utility and closed circuit systems | |
| Ölfus | Bakki II | 1 | 41 | 1 | Sufficient | | |
| Thorlákshöfn | Bakki I | 2 | 1,182 | 37 | Sufficient | | |
| Austurveita Utility | Borholur við Gljúfurárholt | 3 | 480 | 15 | Sufficient | Part of the water used in Hveragerdi | |
| Grímsnesveita Utility | Borholur í Öndverdarnesi | 3 | 1,796 | 57 | More than ample | Two wells in use | |
| Hlídarveita Utility | Borhola að Efri-Reykjum | 1 | 722 | 23 | Sufficient | | |
| Rangárveita Utility | Borholur við Kaldárholt | 2 | 2,002 | 63 | Sufficient | | Work on production capacity and prepare research to provide hot water |
| | Borholur við Laugaland | 2 | 362 | 11 | Limited | | |

**Table 2.** District heating utilities with data on annual water production, remarks and improvements.

# Access to cold water utility

Veitur Utilities ensures the supply of potable water to the residents and business community in the distribution area, in accordance with established quality standards and statutory and regulatory provisions.

OBJECTIVES:
To ensure residents in the distribution area of Veitur Utilities have guaranteed access to water in accordance with quality standards and regulations. After fulfilment of the needs of residents, companies have the option to utilise potable water for production or export. The expansion of the distribution system outside urban areas and customers' particular connections shall be determined by, among other things, technical prerequisites and cost-effectiveness.

**Did you know?**

It takes cold water about seven hours to flow from the Gvendarbrunnar source in Heidmörk to Seltjarnarnes but three hours to flow to Lower Breidholt.

The production of potable water for the capital area is in Heidmörk, but Veitur Utilities also operates water utilities in Stykkishólmur, Grundarfjördur, Akranes, Borgarnes and the upcountry of Borgarbyggd, Úthlíd and Álftanes. ON Power operates water utilities at the Nesjavellir and Hellisheidi Geothermal Power Plants (Table 3 and map of OR and subsidiaries' main area of operations in Annex 1). Cold water is also sold wholesale to Seltjarnarnes and Mosfellsbaer.

The cold water distributed by Veitur Utilities and ON Power meets quality standards in accordance with statutory and regulatory provisions. However, over the past years consumers have complained about silt in the water from the source in Grábrók. In the autumn of 2015, filtering equipment was installed to address the issue and is currently being tested.

In the spring of 2015, the residents of Kjalarnes received water from the water source of Vallá in Kjalarnes because of damage done to the cold water pipeline in the sea between Gunnunes up to Kjalarnes. Repairs were completed in the summer of 2015. In 2015, the operating licence of the water utility in Grundarfjördur was renewed.

The volcanic eruption in Holuhraun started in the autumn of 2014 and lasted until the end of February 2015. The eruption resulted in substantial gas pollution in the country. Measurements conducted by the OR Group in the wake of the Holuhraun eruption indicated that the snow that fell in the south-western part of the country in December, January and February showed little or no sign of pollution from the eruption. The results of comparable measurements of potable water from Veitur Utilities' water sources revealed no sign of pollution. Fortunately, the impact of the eruption on the quality of potable water was non-existent, but the company gained valuable experience on how to out for the potential contamination of potable water from volcanic eruptions.

Approximately 24 thousand users were connected to Veitur Utilities' District distribution system in 2015, 100 of whom were new users. It should be noted that user data are missing in some cases, since a large portion of intake was initially installed by house owners at the time. The district heating distribution system caters for 130 thousand residents.

**COLD WATER ACQUISITION BY MONTH**

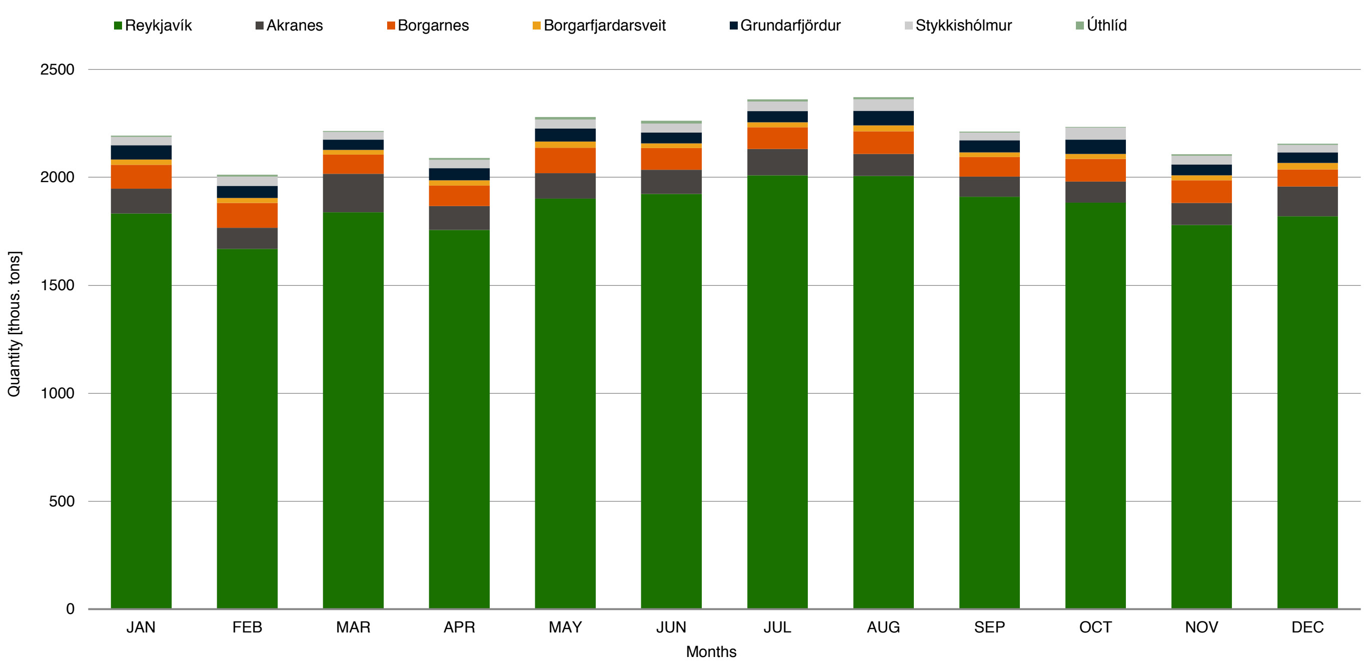



**Figure 12.** Cold water extraction per month in the distribution area of Veitur Utilities in 2015.


**Figure 13.** Work on water pipeline on Kringlumýrarbraut in Reykjavik. Photograph: Hildur Ingvarsdóttir.

**COLD WATER UTILITIES**

| AREA | UTILITY | WATER SUPPLY | MONITORING METHOD | ANNUAL PRODUCTION | | COMMENTS | IMPORVEMENTS |
|---|---|---|---|---|---|---|---|
| | | | | thous. tons | l/s | | |
| Capital area | Reykjavík | Gvendarbrunnar, Jadar, Myllulaekur and Vatnsendakrikar | Well sampling | 22,331 | 708 | | |
| | Seltjarnarnes | | | | | | |
| | Mosfellsbaer | | | | | | |
| | Álftanes | Vatnsendakrikar | Well sampling | 419 | 13 | Water purchased from Gardabaer | |
| | Hellisheidi | Engidalur | Well sampling | 24,232 | 768 | | |
| | Nesjavellir | Grámelur | Tank sampling | 54,716 | 1,735 | Thermal pollution | Substantially thermal release before year end 2016 |
| West Iceland | Akranes | Berjadalur, Slöguveita Utility and Ósveita Utility | Overflow | 1,386 | 44 | UV water purification | |
| | Borgarnes, Bifröst and Munadarnes | Grábrók, Seleyri as back-up for Borgarnes | Well sampling | 1,308 | 41 | Wells at Seleyri used as a backup water supply for Borgarnes in water shortages and when silt is detected from Grábrók | Filter unit installed in autumn 2015 and is under testing |
| | Grundarfjördur | Grund | Well sampling | 671 | 21 | | |
| | Hvanneyri | Fossamelar | Overflow | 74 | 2 | | |
| | Reykholt, Kleppjárnsreykir | Steindórsstadir | Well sampling | 122 | 4 | | |
| | Stykkishólmur | Svelgsárhraun | Overflow | 508 | 16 | | |
| South Iceland | Hlídarveita Utility | Bjarnarfell | Overflow | 96 | 3 | Water obtained from Bláskógabyggd if there is water shortage | |

**Table 3.** The cold water utilities of Veitur Utilities and ON Power and information on the supervisory procedures applied to the water level in each area, annual water production, remarks and improvements.

# Access to sewerage system utility

In the spring of 2015, Veitur Utilities restarted construction on sewerage systems in West Iceland.

## Did you know?

Wet wipes, cotton wool, cotton buds, sanitary napkins and dental floss etc. should not be thrown into a toilet. These alien objects can block the piping system and cause wear and damage to pumps and treatment equipment.

OBJECTIVES:
To ensure residents and the business community in the collection areas of Veitur Utilities have the option of connecting to sewerage systems or treatment works fulfilling statutory and regulatory requirements.

Veitur Utilities manages the development and operation of sewerage systems in Reykjavik, Akranes, Borgarnes, Bifröst, Hvanneyri, Varmaland and Reykholt. Sewage from Kópavogur and Mosfellsbaer, in addition to parts of Seltjarnarnes and Gardabaer, is also handled in sewage treatment plants at Ánanaust and Klettagardar (Map of OR and subsidiaries' main area of operations in Annex 1). In Reykjavik over 99% of residents and companies are connected to sewerage systems or treatment plants.

In the spring of 2015, Veitur Utilities restarted construction work on sewerage systems in West Iceland, which had been postponed until 2015 and 2016. Work had started when it became clear in 2010 and 2011 that Veitur Utilities' finances were insufficient to complete the project. Four biological treatment plants had been built in population clusters in the upcountry of Borgarfjördur, and among other things new pipelines were laid in many places. The most extensive construction in 2015 was the laying of the sea pipeline from Akranes and Kjalarnes, but the laying of a sea pipeline in Borgarnes is being envisaged for 2016 in addition to the work on the pumping and treatment equipment, steel works and the electricity and management systems. Following the launch of the treatment plants, work will start on connecting areas that do not have access to sewerage systems.

**Figure 14.** Changing emergency outlet valve of the pumping station in Ingólfsstraeti in Reykjavik. Photograph: Hildur Ingvarsdóttir.

# Access to fibre network utility

The Reykjavik Fibre Network (Gagnaveita Reykjavíkur) operates a telecommunications network, fibre optics and quality connections that cover some 70 thousand households and companies. Access to an open high-speed telecommunications distribution network is a prerequisite for improving the efficient processing of issues and promoting the Internet of Things (IOT) in the community and reducing greenhouse gas emissions.

## Did you know?

Through the Reykjavik Fibre Network light travels at a speed of 200 thousand kilometres per second, which is equivalent to 150 rounds of Iceland per second.

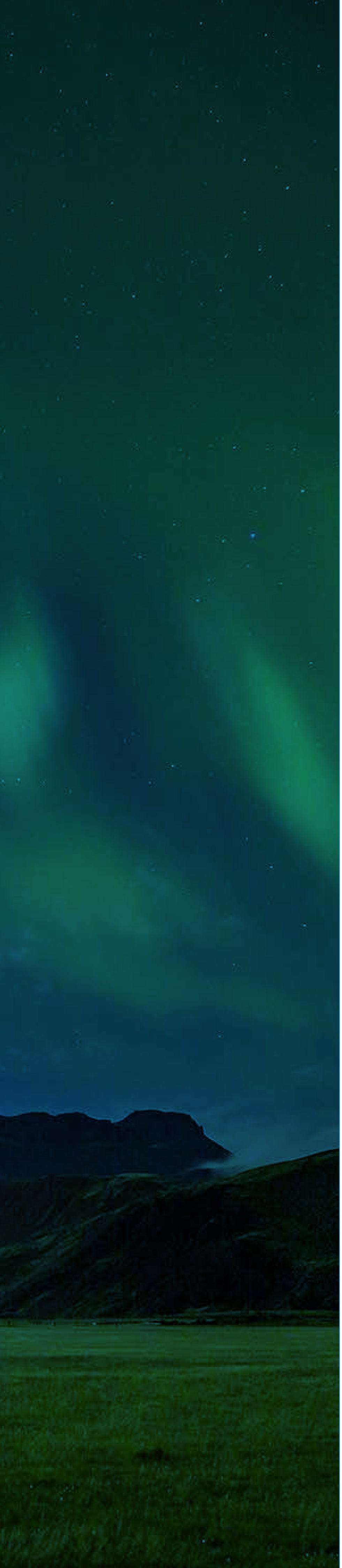
OBJECTIVES:
To ensure residents and businesses in the servicing area of the Reykjavik Fibre Network (RFN) have the option of connecting to the high-speed telecommunications distribution network of RFN. The distribution system is based on principles of reliability and foresight regarding further developments in the future. The Reykjavik Fibre Network is an ISO 9001 certified company, operates in accordance with these standards and establishes measurable objectives to guarantee its high level of service to customers.

The Reykjavik Fibre Network (RFN) is a telecommunications company owned by Reykjavik Energy (OR). The operations of the RFN consist in developing and managing a high-speed telecommunications distribution network and business with the system, i.e. the sale of data transmission services to households, companies and institutions in south-west Iceland. The current action plan of the RFN is to connect all households in the greater Reykjavik area over the coming years. The distribution system of the Reykjavik Fibre Network is founded on its fibre optics system and IP networks. The company possesses over 100 active PoPs. The Reykjavik Fibre Network operates under the guiding principle of working well and minimising disruptions in its tasks both outside and inside the homes of its customers.

Granting everyone access to an open high-speed telecommunications distribution network is a prerequisite for increasing efficiency, speed and cost effectiveness in, for example, resolving issues and it helps to promote home automation in the community. The network therefore offers a technical solution that reduces the use of paper, but also greenhouse gas emissions, by reducing journeys between places.

Approximately 70 thousand households and businesses were connected to the Reykjavik Fibre Network in 2015.


**Figure 15.** Laying fibre optic cables in Hafnarfjördur. Photograph: Sigurjón Ragnar.



# Impact of emissions and discharge

Reykjavik Energy (OR) and subsidiaries' operations inevitably result in substances and energy being released into the environment. OR and subsidiaries take the utmost precautions in its operations. Emissions are therefore only allowed to occur in a manner that has a negligible impact on health and an acceptable effect on the environment. OR and subsidiaries reduce the emission of pollutants as much as possible and emphasize research and development to be able to utilise the best possible solutions for that purpose.

# Discharge of disposal water and monitoring of groundwater

The reinjection fields at the Hellisheidi Geothermal Power Plant have received about 95% of the disposal water intended for them and projects designed to increase reception are prioritised. In 2015 projects were launched to reduce the surface discharge of disposal water at the Nesjavellir Geothermal Power Plant and the plant's impact on springs and bays by Lake Thingvallavatn.

OBJECTIVES:
To ensure that requirements in power plant and operating licences are fulfilled regarding chemical and heat pollution in groundwater outside the defined dilution areas in the vicinity of the power plants. To ensure no disposal water is discharged on the surface of the ground, except if breakdowns occur. To offset the pressure drop in the geothermal system.

**Hellisheidi Geothermal Power Plant**
At the Hellisheidi Geothermal Power Plant, most of the fluid that is harnessed is returned to the geothermal reservoir by reinjection into wells. The fluid is called disposal water, which means both separated water (geothermal water from wells which contains dissolved solids from the rock) and condensate water (geothermal steam that has condensed with cooling so as to form water, which may contain dissolved geothermal gases). In accordance with the power plant licence, all separated water and part of the condensate water needs to be reinjected into the geothermal reservoir. This is done to protect surface water and groundwater, in addition to better utilising the geothermal reservoir.

As was mentioned in the 2014 Environmental Report, extensive research and development projects have been undertaken to fulfil reinjection requirements at Hellisheidi. The following projects are in progress to ensure secure operations of the injection utility at the Hellisheidi Geothermal Power Plant:

- Analysis of behaviour of reinjection fields.
- Disposal water is cooled to facilitate its release.
- Disposal water is reinjected into wells that are not utilised for the production of steam and this is distributed over the production field of the Hellisheidi Geothermal Power Plant.
- Reinjection wells are stimulated with the pumping of cold water.
- Condensate water is mixed in an endeavour to prevent scale formations in the reinjection wells.
- Drilling additional injection wells is being considered, as well as channelling disposal water to the ocean.

In 2015 these projects managed to prevent a further decrease in reception in the reinjection fields. The projects continue in 2016, since there is still room for improvements.

**DISPOSAL WATER**

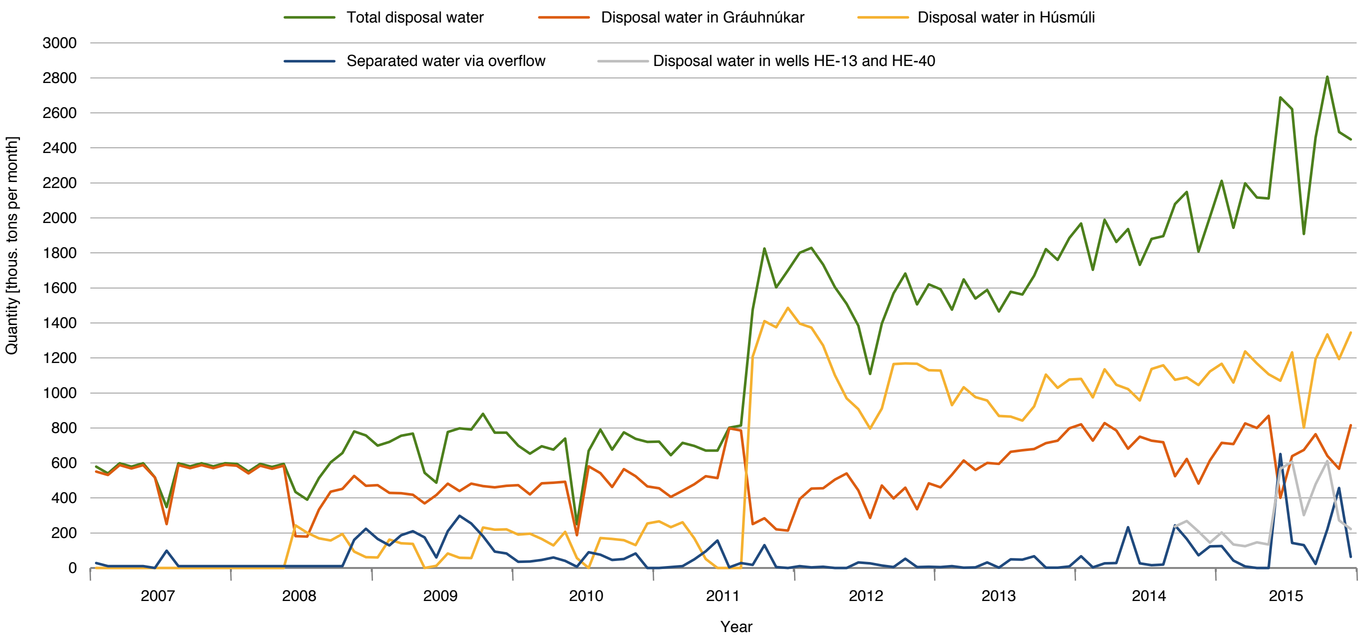



**Figure 16.** Volume of disposal water (tons/month) from the Hellisheidi Geothermal Power Plant between 2007 – 2015 by release route. Until September 2011 the largest part of disposal water was reinjected through a well in Gráuhnúkar. Disposal water from the plant increased when the Sleggjan plant was launched in autumn 2011, but the reinjection field at Húsmúli was then taken into full operation. Since then the disposal water from the plant has increased. There was a significant decrease in the release of disposal water on the surface via overflow in the latter part of 2011 with improvements in the power station's operations, but it increased again around mid-2014 with the diminishing reception of reinjection fields.

**DISPOSAL WATER AT HELLISHEIDI**

| YEAR | SEPERATED WATER VIA OVERFLOW [tons/yr] | SEPARATED WATER IN GRÁUHNÚKAR [tons/yr] | DISPOSAL WATER IN HÚSMÚLI [tons/yr] | DISPOSAL WATER IN WELLS HE-13 AND HE-40 [tons/yr] | TOTAL DISPOSAL WATER [tons/yr] |
|---|---|---|---|---|---|
| 2007 | 215,290 | 6,502,485 | 0 | | 6,717,776 |
| 2008 | 482,961 | 5,439,180 | 1,123,300 | | 7,045,441 |
| 2009 | 2,050,421 | 5,334,842 | 1,381,544 | | 8,766,807 |
| 2010 | 571,887 | 5,684,478 | 1,825,974 | | 8,082,339 |
| 2011 | 505,895 | 5,373,601 | 6,461,122 | | 12,340,619 |
| 2012 | 163,496 | 5,223,595 | 13,358,110 | | 18,745,201 |
| 2013 | 232,714 | 7,620,175 | 11,732,828 | | 19,585,717 |
| 2014 | 1,024,406 | 8,281,272 | 12,841,626 | 859,838 | 23,007,142 |
| 2015 | 1,869,993 | 8,422,037 | 13,909,532 | 3,802,757 | 28,004,320 |
| **TOTAL** | **7,117,065** | **57,881,666** | **62,634,036** | **4,662,594** | **132,295,361** |

**Table 4.** Disposal water (tons/year) from the Hellisheidi Geothermal Power Plant 2007-2015 by release route.

To ensure the production capacity of the Hellisheidi Geothermal Power Plant, all available production wells have been used for the production of steam over the past two years, despite the fact that some of them are not very productive. These wells contain a lot of water and disposal water from the power plant has therefore increased. This increases the load on the injection utility of the power plant beyond the benefit gained with the projects described above. The injection utility is therefore sensitive to any kind of changes in operations and over 6.5% of the disposal water went into overflows, one fifth of which was due to major malfunctions. The licensing authorities have been kept informed of the situation and the possible measures that can be taken each time as well as the projects that are being worked on to increase the reception of the plant's injection utility.

Figure 16 shows the volume of disposal water from the Hellisheidi Geothermal Power Plant and its release routes. In 2015 more than 28 million tons of disposal water were reinjected down into the geothermal system at Gráuhnúkur, Húsmúli and in production wells not used for steam production. Part of the disposal water, about 1.8 million tons, were released on the surface via overflow (Table 4). Up to now more than 132 million tons of disposal water have been reinjected into the geothermal system and over 7 million tons of disposal water were released via overflow since the power plant started operating. Annex 11 shows a summary of events in 2015, which caused disposal water to be released via overflow at the Hellisheidi Geothermal Power Plant.

The geothermal system is under close surveillance, e.g., with the help of chemical tracers and borehole measurements so that the impact of reinjection can be analysed. Results indicate that the reinjection supports pressure in part of the geothermal system, but that there is also a risk of reinjection cooling the production fields, see section on Managing Production in High-Temperature Geothermal Fields. There is therefore a need to strike a balance between reinjection and production in the field and controlling the volume of water in the injection wells to hinder the cooling of the fields.

In connection with the aforementioned measures to increase the reception of reinjection fields, a procedure has been adopted to reduce the likelihood of increased seismic activity induced by reinjection, see section on Seismic Activity Induced by Reinjection of Disposal Water.

Hopefully within a few years, experience and increased knowledge of the complex process of reinjection in Hellisheidi will become sufficient to ensure efficient and secure operation of the power plant's injection system.

**Monitoring groundwater at the Hellisheidi Geothermal Power Plant**

The impact of the Hellisheidi Geothermal Power Plant on groundwater in surveillance wells at and around the plant is monitored. Samples are taken for analysis of overall chemical and heavy-metal content, in addition to measuring their temperature, conductivity and acidity (Annexes 12 and 13). The concentration of dissolved solids in wells is far below the limits set for potable water and has not increased since the plant started operating. A new surveillance well was drilled and an old surveillance well was cleaned in December 2015 to be able to monitor the plant's impact on groundwater even better. Annex 14 shows the typical concentration of several trace elements in separated water from the Hellisheidi Geothermal Power Plant and their maximum recommended concentration in potable water.

**Nesjavellir Geothermal Power Plant**

Disposal water at the Nesjavellir Geothermal Power Plant consists of separated water and condensate water, but also heated groundwater from Grámelur at Lake Thingvallavatn, which is used to cool machinery but is not utilised in the hot water utility when there is less demand. Projects were launched in Nesjavellir in 2015 to release geothermal water from the plant into the upper groundwater layer through reinjection. The tasks yielded good results and many of them will be completed in 2016. About half of the separated water and more than half of the condensate water are now reinjected into the lower groundwater layer via injection wells, while the rest is released on the surface, i.e. into shallow wells or the Nesjavellir Brook (table 5) This marks a significant improvement. In the summertime, when there is less demand for hot water to heat spaces than in the winter, the largest portion of the disposal water, which is released on the surface at the Nesjavellir Geothermal Power Plant, is heated up groundwater (hot water for space heating) (Table 5). The aim is to substantially reduce this discharge in the future. The following projects were conducted in Nesjavellir in 2015:

- Drilling of three injection wells to dispose of separated and condensate water, which was previously released onto the surface.
- Experimental injection of heated groundwater in a well in Mosfellsheidi and in further two which reach the geothermal reservoir in Kýrdalur by Nesjavellir.
- Plans were examined for the connection of more residential areas in the capital area to the hot water utility at the Nesjavellir Geothermal Power Plant to optimise the utilisation of the excess production of hot water from the plant.

The objective of these projects is to stop the discharge of separated water and condensate water on the surface by the end of 2016. Another objective is to find a good solution for the utilisation or release of heated groundwater from Nesjavellir as soon as possible. It is to be expected that some

**DISPOSAL WATER AT NESJAVELLIR**

| | SEPARATED WATER | | CONDENSATE WATER | | HEATED GROUNDWATER | DISPOSAL WATER |
|---|---|---|---|---|---|---|
| YEAR | INJECTION WELLS [thous. m³/yr] | STREAM [thous. m³/yr] | INJECTION WELLS [thous. m³/yr] | SURFACE [thous. m³/yr] | SURFACE [thous. m³/yr] | TOTAL [thous. m³/yr] |
| 2013 | 3,461 | 4,567 | 4,269 | 3,257 | 26,687 | 42,241 |
| 2014 | 2,788 | 5,288 | 4,529 | 3,078 | 29,333 | 45,016 |
| 2015 | 3,131 | 5,288 | 4,257 | 3,043 | 26,371 | 42,090 |

**Table 5.** Disposal water (thousand cubic metres/year) from the Nesjavellir Geothermal Power Plant 2013 - 2015 by release route.

separated and condensate water has to be released on the surface when the control equipment of the power plant needs to respond to disturbances or fluctuations and the equipment has to be protected against shocks.

It is the responsibility of ON Power to minimise the impact of the power plant on the quality of the ground water and this needs to be particularly monitored in Lake Thingvallavatn (Figure 17). As has been mentioned in the environmental reports of recent years, there is thermal pollution caused by the impact of the power plant on the springs and bays by Lake Thingvallavatn. The aforementioned projects are all aimed at mitigating this impact.

**Monitoring groundwater at the Nesjavellir Geothermal Power Plant**

The impact of the Nesjavellir Geothermal Power Plant on groundwater in surveillance wells in Nesjahraun is monitored near the power plant. In addition to temperature measurements in the wells, the chemical composition and temperature in brooks near the power station and springs by Lake Thingvallavatn are also monitored. In 2015, tracer testing was conducted in order to determine whether the disposal water which is released into the lower groundwater layer through the injection wells enters springs by Lake Thingvallavatn. Annex 14 shows the typical concentration of various trace elements in the separated water by the Nesjavellir Geothermal Power Plant along with their permitted concentration in potable water.

**Numerical groundwater model of the Hengill area and casing of injection wells**

The numerical groundwater model of the Hengill area is revised annually, but a part of the groundwater model also covers the water supply of the capital area. This information is important for the water supply of the power stations' heating utility and for gauging the impact of disposal water on groundwater. Injection wells are cased down past the upper groundwater layers in the production fields to prevent disposal water from mixing with the upper groundwater layers.

**WATER TEMPERATURE IN VARMAGJÁ IN LAKE THINGVALLAVATN**

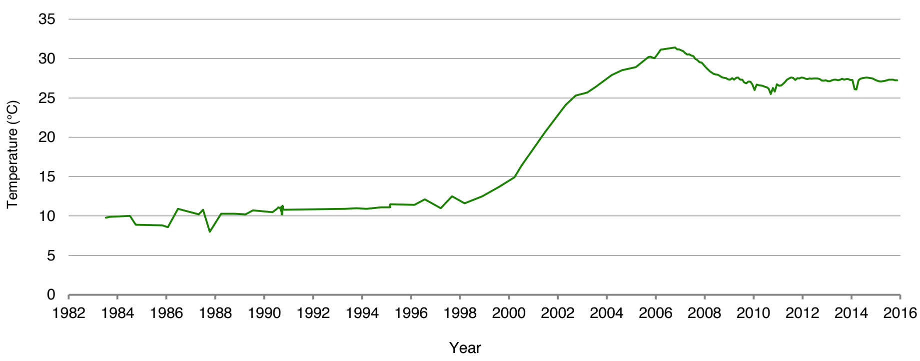



**Figure 17.** Water temperature (°C) in Varmagjá 1983-2015. When electricity production started at the Nesjavellir Geothermal Power Plant in 1998, thermal pollution increased significantly, but decreased somewhat after injection wells came into use in the period 2004-2008 and the cooling tower came into operation in 2005.

## Did you know?

After hot water production started at Nesjavellir in 1990 it was possible to reduce production in the low-temperature fields in the capital area. They evened out after some years and production is now stable and balanced. Barring the unexpected, everything indicates that it will be possible to maintain this in the future.

**Figure 18.** Varmagjá in Lake Thingvallavatn. Photograph: Gretar Ívarsson.

# Hydrogen sulphide emissions

The concentration of ambient hydrogen sulphide in urban areas was below regulation limits in 2015. The hydrogen sulphide abatement unit at the Hellisheidi Geothermal Power Plant is operating effectively and removes over 25% of the power plant's hydrogen sulphide emissions. The capacity of the unit will be doubled in 2016. In 2015, an experimental steam hood ejector was built near Hellisskard in an endeavour to increase the dispersal of hydrogen sulphide and further reduce its concentration in populated areas under particular weather circumstances.

OBJECTIVE:
To ensure compliance with regulations regarding the concentration of hydrogen sulphide in the atmosphere.

Hydrogen sulphide ($H_2S$) causes air pollution in the vicinity of the power plant in the Hengill area and has been the biggest environmental issue that ON Power grapples with in its operations. Hydrogen sulphide emissions from the Nesjavellir and Hellisheidi geothermal power plants amounted to approximately 15 thousand tons in 2015. Figure 19 shows hydrogen sulphide emissions per energy unit from Hellisheidi and Nesjavellir.

**Monitoring concentration of hydrogen sulphide in the atmosphere.**
In accordance with the provisions of operating licences, the concentration of hydrogen sulphide in the atmosphere is monitored in the vicinity of the power stations and in populated areas, in collaboration with the South Iceland Health authorities, i.e., in Hveragerdi, Nordlingaholt, as well as the industrial areas at Hellisheidi and Nesjavellir.

In February 2015, a mobile air quality monitoring station was set up in Laekjarbotnar. The plan is to operate the station for one to two years and use it in other places if necessary. The real-time data can be accessed on the website of the South Iceland Public Health Board, www.heilbrigdiseftirlitid.is, and the website of the Environment Agency of Iceland, www.loftgaedi.is.

Following volcanic activity north of the Vatnajökull glacier, upon request from the Environment Agency and the South Iceland Public Health Board, a decision was made to change the measurements of the air quality monitoring station so that they could both measure the concentration of hydrogen sulphide and the concentration of sulphur dioxide due to the volcanic activity. This change resulted in greater inaccuracies in the measurement of hydrogen sulphide, particularly while the concentration of sulphur dioxide was high. The monitoring station then reverted back to its previous form in October 2015.

In 2015, the concentration of hydrogen sulphide was below the annual average in Hveragerdi (3.6 µg/m³) and in Nordlingaholt (2.8 µg/m³). The concentration was below the environmental limits for the maximum daily running 24-hour average (50 µg/m³) in Nordlingaholt and Hveragerdi, Figures 20 and 21. The concentration of hydrogen sulphide was below the notification limits (150 µg/m³). Annex 18 shows the 24-hour averages and monthly averages for the concentration of hydrogen sulphide in Hveragerdi and Nordlingaholt for 2015. Annex 19 specifies the 30 highest hourly averages for the concentration of hydrogen sulphide in

**EMISSION OF HYDROGEN SULPHIDE PER ENERGY UNIT**

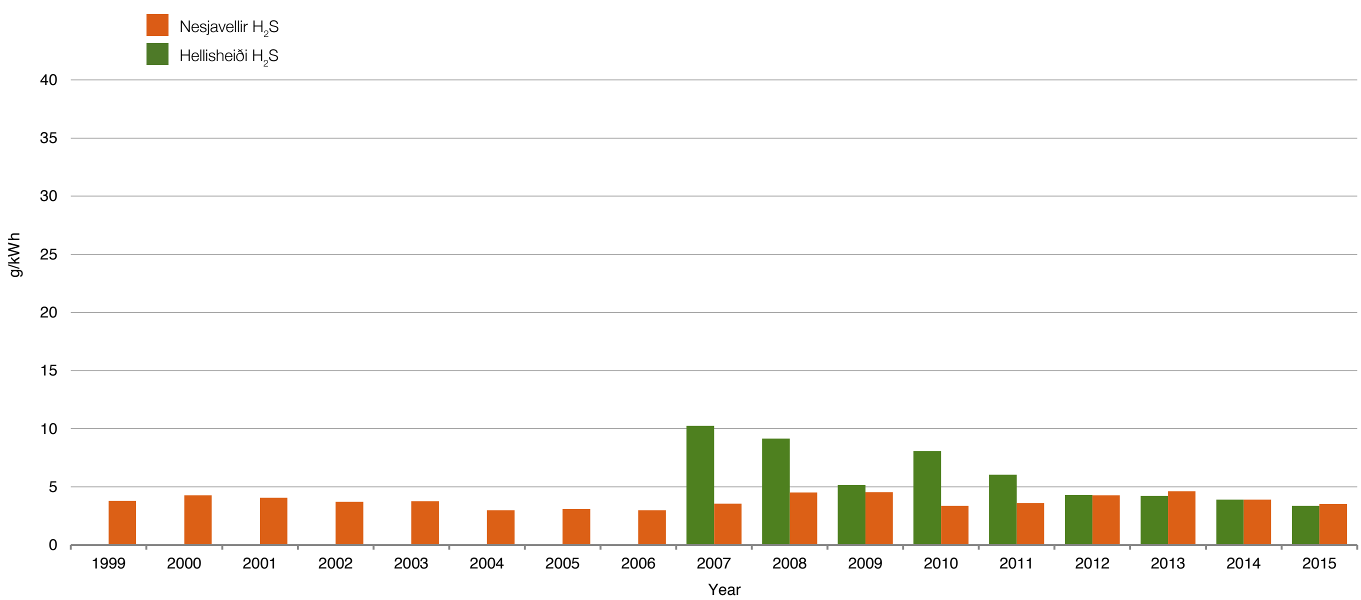



**Figure 19.** Hydrogen sulphide emissions ($H_2S$) per energy unit from the Hellisheidi Geothermal Power Plant 2007 – 2015 and from the Nesjavellir Geothermal Power Plant 1999 – 2015. There are some differences in emissions between years which can be attributed to, among other things, the volume of water and steam that is extracted from the fields and variable concentrations of the gas between fields.

**Figure 22.** Steam hood ejector near Hellisheidi Geothermal Power Plant. Photograph: Gretar Ívarsson.

Hveragerdi and Nordlingaholt. This data can be found on the ON Power website www.on.is. In Hellisheidi the minimum average hourly concentration was 0 µg/m³, and the maximum concentration was 728 µg/m³, which is below the pollution limits for a work environment. In Nesjavellir the minimum concentration was 0 µg/m³ and the maximum value was 2,449 µg/m³, which is below the pollution limits for a work environment. In ON Power's mobile air quality monitoring station in Laekjarbotnar the concentration was below regulation limits. Two notifications were sent to the licensing authorities to inform them of the likelihood of hydrogen sulphide concentrations exceeding established limits in populated areas. There was some discussion in the media following the notifications. The concentration was below the set limits for populated areas in 2015. Three notifications regarding hydrogen sulphide were received from customers in 2015.

Hydrogen sulphide in the atmosphere is also regularly measured at over 130 measuring plots in the Hengill area. The results show significant localised increases in the concentration of hydrogen sulphide west of the plant but no marked increase on its eastern side.

Annex 20 shows a comparison between regulatory environmental limits for hydrogen sulphide in µg/m³, on one hand, and ppm, on the other.

### Hydrogen sulphide abatement unit and steam hood ejector at the Hellisheidi Geothermal Power Plant

A hydrogen sulphide abatement unit came into operation in early June 2014. There hydrogen sulphide and carbon dioxide are separated from other geothermal gases in the steam, dissolving them in water from the power plant and reinjecting them into basaltic rock at a depth of 1000 m. The hydrogen sulphide abatement unit removes over 25% of the power station's hydrogen sulphide emissions. According to calculations, about 2,200 tons of hydrogen sulphide were channelled down into the bedrock in 2015. In preparations for the SulFix project, numerous studies were undertaken on the sequestration of hydrogen sulphide in geothermal systems, using among other things chemical tracers. The results show that about 75-80% of the hydrogen sulphide that is reinjected into the geothermal system is sequestered in the form of minerals within six months. In the spring of 2015 a decision was made to double the capacity of the hydrogen sulphide abatement unit. These projects are expected to be completed in the summer of 2016.

In parallel with the reinjection of hydrogen sulphide, in 2015 a steam hood ejector was installed at the plant on an experimental basis (Figure 22). The operation of the ejector has gone well and its effectiveness will be verified in the winter. Meteorological research there indicates that the steam hood ejector will ensure a greater dispersal of hydrogen sulphide and thereby reduce its concentration in the air of populated areas during particular weather conditions. In 2016, a mast will be raised to monitor the weather on Mt. Skardsmýrarfjall. The results of the measurements will be used, among other things, to improve forecasts on the dispersal of hydrogen sulphide from the Hellisheidi Geothermal Power Plant.

### Further experiments with geothermal gases

In the autumn of 2015, an experimental station started operating at the Hellisheidi Geothermal Power Plant to remove carbon dioxide from the water reinjected in the SulFix project. This opens up possibilities for utilising carbon dioxide, which could facilitate multiple utilisations of geothermal energy, see section on Access to more Diversified Utilisation of High-Temperature Geothermal Resources. Known procedures for isolating carbon dioxide from hydrogen sulphide entail the use of non-local chemicals. On the other hand, ON Power, in collaboration with the power companies Landsvirkjun and HS Orka, wants to find other environmentally sounder ways of separating hydrogen sulphide without using hazardous chemicals.

### Research of impact of hydrogen sulphide on vegetation

In 2012, the monitoring of vegetation began in the vicinity of the geothermal power plants in Nesjavellir and Hellisheidi. The first results indicate that hydrogen sulphide affects the moss closest to the power station.

## Did you know?

About 75-80% of the hydrogen sulphide that is reinjected into the geothermal system in the SulFix project at the Hellisheidi Geothermal Power Plant is sequestered in the form of minerals like Pyrite within six months.

### HYDROGEN SULPHIDE ($H_2S$) IN HVERAGERDI

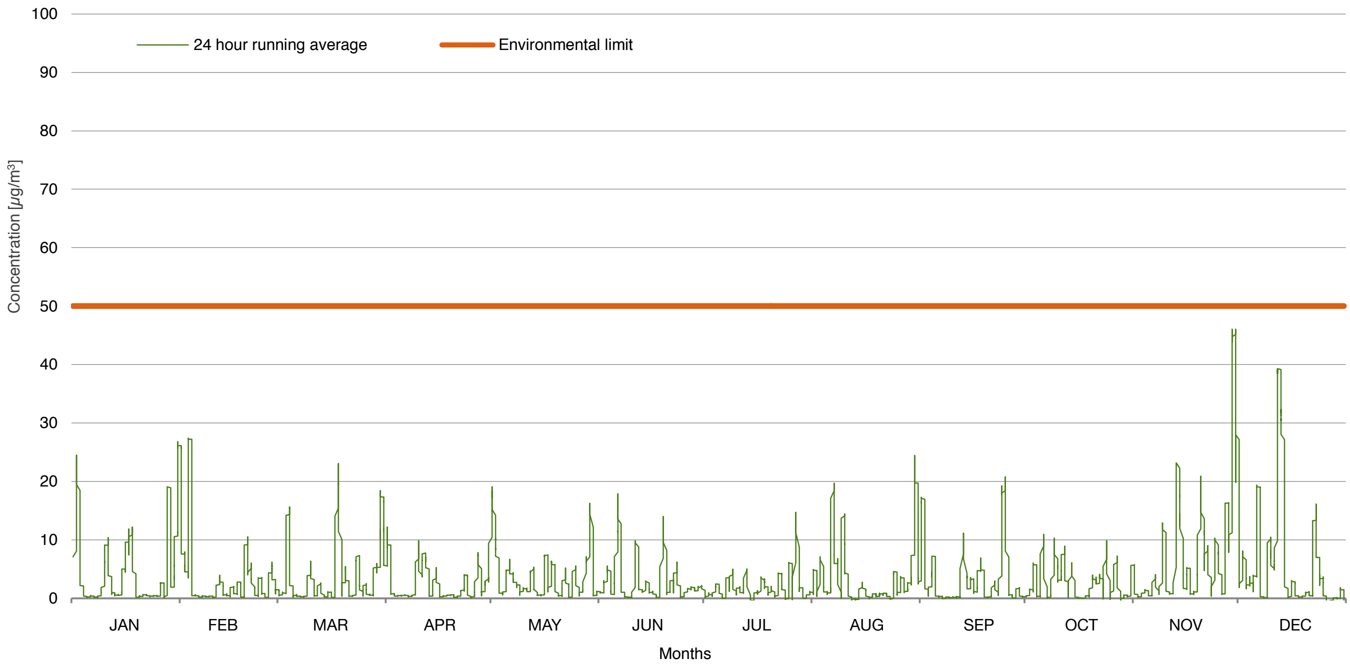



**Figure 20.** 24 hour concentration (daily running 24-hour average) of hydrogen sulphide ($H_2S$) in Hveragerdi in 2015. As a frame of reference these are the environmental limits in regulations no. 514/2010. The concentration did not exceed the established limits.

### HYDROGEN SULPHIDE ($H_2S$) IN NORDLINGAHOLT

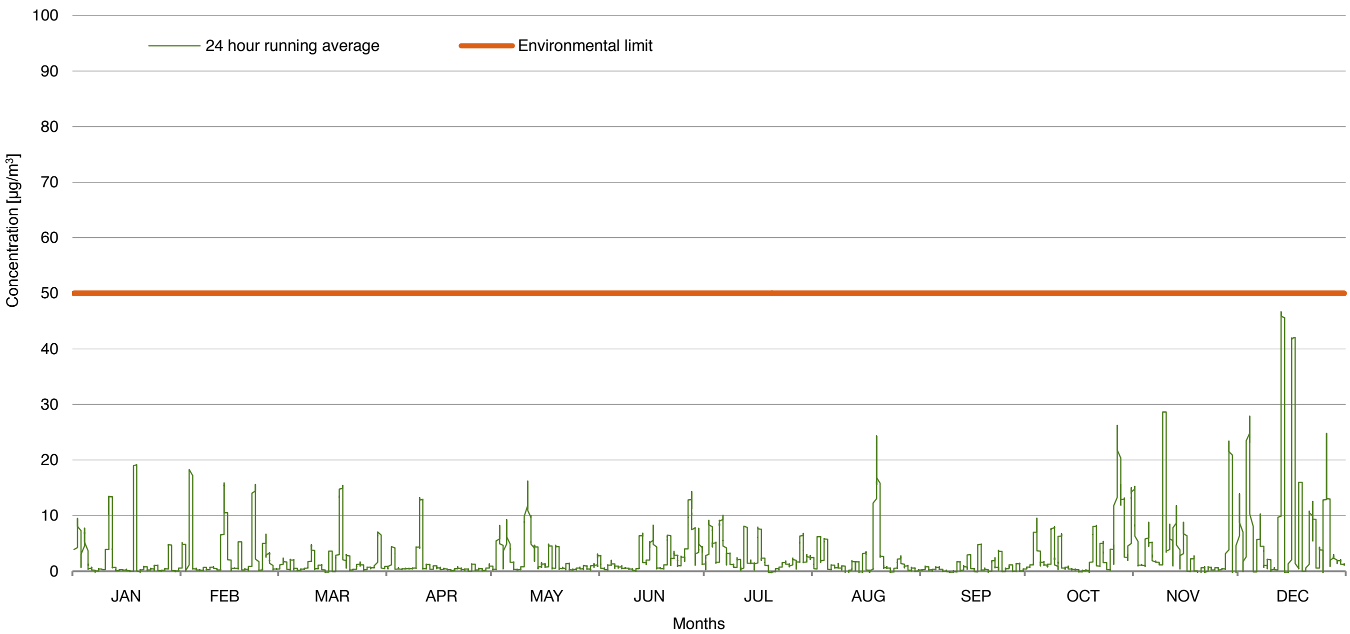



**Figure 21.** 24 hour concentration (daily running 24-hour average) of hydrogen sulphide ($H_2S$) in Nordlingaholt in 2015. As a frame of reference these are the environmental limits in regulations no. 514/2010. The concentration did not exceed the established limits.

# Carbon dioxide, hydrogen and methane emissions

There is a growing interest in utilising geothermal gases and making them marketable. Some 3,900 tons of carbon dioxide have been reinjected into the bedrock at the Hellisheidi Geothermal Power Plant in 2015 where it is permanently sequestered, i.e. 10% of the annual carbon dioxide emissions from the power plant.

## Did you know?

The OR Group was nominated for the Nordic Council Nature and Environment Prize in 2015. The central idea of the prize was to reduce greenhouse gas emissions and the CarbFix project was one of the initiatives the company had to offer.

OBJECTIVES:
To increase the multiple utilisations of ON Power's power plants by making geothermal gases marketable, depending on cost-effectiveness.

Carbon dioxide emissions from the Nesjavellir and Hellisheidi geothermal power plants amounted to a total of 48 thousand tons in 2015. Hydrogen emissions totalled 900 tons and methane 135 tons in 2014. Annexes 15 and 16 provide an overview of the emissions of carbon dioxide, hydrogen and methane from Hellisheidi and Nesjavellir.

In Nesjavellir carbon dioxide emissions per energy unit diminished between 2000 and 2006 and in Hellisheidi between 2007 and 2013 and 2015 (Figure 23). This is partly due to the fact that in the earlier part of the operational period of the power plants new wells were allowed to blow in order to measure their capacity.

**Innovation and development projects**
Over the past years there has been a growing interest among ON Power, OR, scientists and potential clients to utilise geothermal gases, see section on Access to a more Diversified Utilisations of High-Temperature Resources. The CarbFix project started at the Hellisheidi Geothermal Power Plant in 2007. Its goal is to reduce carbon dioxide emissions from the power plant by reinjecting it, dissolved in water, into the basaltic bedrock in the vicinity and sequestering it there in mineral form. Some 3,900 tons of carbon dioxide were channelled down into the bedrock in 2015, i.e. over 10% of the carbon dioxide annually emitted by the plant (Figure 23). Results indicate there is a sequestration rate of at least 90% in mineral form within a year from reinjection. The carbon dioxide is therefore being swiftly and permanently sequestered in the basaltic bedrock. The results of the CarbFix project, as well as its methodology and technical equipment have been used directly in the SulFix project where the goal is to remove the hydrogen sulphide emissions from the Hellisheidi Geothermal Power Plant, see section on Hydrogen Sulphide Emissions. The CarbFix project is an example of collaboration between an Icelandic company and universities on both sides of the Atlantic. This was a prerequisite for the development of this idea into a realistic project useful to the business community. It is clear that ON Power is much better equipped to handle the numerous demanding tasks that come with the SulFix project, thanks to its experience and networks from the CarbFix Project.

**Figure 24.** Edda Sif Aradóttir, Project manager of the CarbFix Project being interviewed by the New York Times. Photograph: Screenshot from video on New York Times website.

**EMISSON OF CARBON DIOXIDE PER ENERGY UNIT**

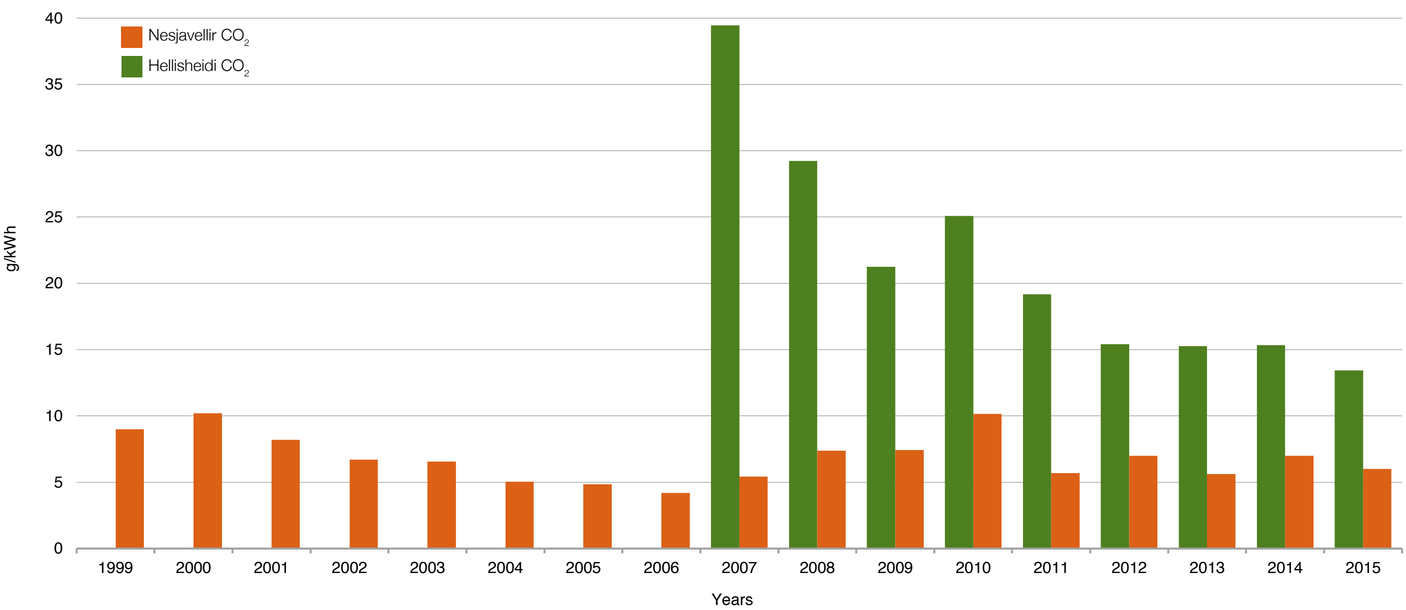



**Figure 23.** Carbon dioxide emissions per energy unit from the Hellisheidi Geothermal Power Plant from 2007-2015 and the Nesjavellir Geothermal Power Plant from 1999-2015. There are substantial differences in emissions from the power plants, which can be attributed to, among other things, variable gas quantities between fields.

# Seismic activity induced by reinjection of disposal water

There was little seismic activity in the Húsmúli area of the Hellisheidi and Nesjavellir power plants in 2015. None of the seismic events were large enough to be noticed in populated areas.

OBJECTIVE:
To ensure that seismic activity that may be associated with the reinjection of disposal water causes the least possible inconvenience and never damage.

In 2015, there was little seismic activity either in the Húsmúli area by the Hellisheidi Geothermal Power Plant or the Nesjavellir Geothermal Power Plant (Annex 20). Five notifications were sent to the Icelandic Meteorological Office and the Department of Civil Protection of the Icelandic Police due to changes in reinjection. This was in compliance with work procedures, which are designed to reduce the risk of seismic activity caused by reinjection at power plants and to inform surveillance and emergency response units of the likelihood of seismic activity due to reinjection. There was some discussion in the media following the notifications. Some seismic activity was measured in the field, as expected, but none of them were large enough to be noticed in the populated areas.

The above procedures will be revised with external experts to evaluate when notifications should be issued to the public. In 2016, the correlation between reinjection and seismic activity will be further analysed n light of the experience acquired in recent years in managing reinjections at power plants with the procedures that have been applied until now.

In 2015, the National Energy Authority worked on rules and guidelines regarding preparations and responses to seismic activity due to the injection of liquids into the earth through wells, in consultation with energy companies and other entities.

## Did you know?

Disposal water has been uninterruptedly reinjected into the geothermal reservoir in Húsmúli west of the Hellisheidi Geothermal Power Plant since 2011 and there is little seismic activity now.

**Figure 25.** Cirrocumulus tropospheric clouds and the Hellisheidi Geothermal Power Plant. Photograph: Gunnar Gunnarsson.

# Discharge of wastewater from sewage treatment plants

Results of marine research on the sea floor and mussels in the bay of Faxaflói show that the wastewater from the Veitur Utilities' treatment plants in the capital area has virtually no impact on the environment.

OBJECTIVE:
**Veitur Utilities shall ensure that the load within the sewage dilution areas is within acceptable limits, and that pollution at their perimeter and the coast does not exceed the legal and regulatory limits. Veitur Utilities shall monitor the reception of sewage in accordance with the provisions of operating licences.**

## Did you know?

The first sewer was built in Reykjavik in 1902 and stretched down Ægisgata from the National Hospital, the shortest way to the sea. The initiative for the building came from the Sisters of St. Joseph who ran the hospital and it can therefore be said that women are responsible for the building of the first sewer in Reykjavik.

**Sewage discharge reporting for Reykjavik**
The sewage discharge reports for the treatment plants in Ánanaust and Klettagardar in Reykjavik provide information on the outflow of pollutants exceeding the reference values in Annex II of Regulation (EC) no. 166/2006. Calculations are based on the results of analyses on samples collected from treated sewage four times a year regarding measurements of nitrogen and phosphorus and twice a year for trace elements. The measurement results for 2015 are to be found in Annex 21 and sewage discharge reporting results for the plants in Ánanaust and Klettagardar areas are presented in Annexes 22 and 23.

**Research on marine load within dilution areas and at the coast of the capital area**
The operating licences of sewage treatment plants in Reykjavik define dilution areas, where microbial contamination may exceed environmental limits, but outside their boundaries microbial contamination shall be below limits (Figure 27). Operating licences stipulate that exhaustive research into the impact of discharges into the sea must be carried out every four years. Research in accordance with operating licences was conducted by Innovation Centre Iceland 2008-2011. This was broad-ranging research focused on three aspects: 1) a chemical analysis was conducted on the sea 2) research on marine sediment and 3) research on mussels at outlets. Results indicated that the discharge of sewage has a negligible impact on the quality of the sea water, behaviour and sediment nor on the flora and fauna around the outlets. The procedure of cleaning solids out of the treatment plants and pumping sewage four to five kilometres out into the bay of Faxaflói, where there is a great deal of dispersal and nature takes cares of breaking down the residual elements, has therefore worked successfully. It is therefore clear that further treatment of the sewage would not have improved the environment. The results have been communicated to the licensing authorities.

Under Regulations no. 798/1999 on Sewerage Systems and Sewage and the objectives of Veitur Utilities, the number of heat-tolerant microbes outside dilution areas in the sea shall be less than 1000 in a 100 ml sample in at least 90% of cases. At the coast where there are outdoor recreational areas, or there is food manufacturing in the vicinity, the number shall be less than 100 in a 100ml sample in 90% of cases.

In 2015, samples were collected by Veitur Utilities to measure the number of heat-tolerant microbes at 11 sites at the coast near overflows, and eight samples were collected on the periphery of the dilution area (Figure 27). The samples were collected four times, in March, June, September and December. The measurements came in addition to sampling by Reykjavik's health authority, which collects samples from nine sites within the area of influence of Veitur Utilities' sewerage system, where there is relatively easy access to the shore. The health authorities' sampling is conducted once a month during the period from April to October, with a total of 63 samples. Results show that samples are under the criteria limits in 90% of instances (Table 6).

**Figure 26.** Installation of a new emergency outlet valve at a pumping station on Ingólfsstraeti in Reykjavik. Photograph: Hildur Ingvarsdóttir.

**Washing equipment for waste and sand**
At the beginning of 2015, washing equipment for waste and sand came into use in Klettagardar and Ánanaust. Subsequently the volume of waste coming from sewage treatment plants has been reduced by 51% or over 600 tons, see section on Waste. With this method 500-600 tons of fluid that was previously disposed of is pressed out of the waste. The fluid steadily mixes with the over 80 million tons of waste water which is produced by the sewage treatment plants per year.

**Biological sewage treatment plants in West Iceland**
In Borgarfjördur Veitur Utilities runs four biological sewage treatment plants in Bifröst, Hvanneyri, Varmaland and Reykholt. Sewage is tested at the plants four times a year, in accordance with their operating licences. Samples are collected from the drainage of the stations and/or at reception and suspended particles, fat/grease, COD, phosphorus, nitrates, enterococci and faecal coliform are analysed. The values of samples taken in 2015 were within the set limits, except in the cases of enterococci and faecal coliform. Last year, endeavours have been made to find an explanation for this in collaboration with the health authorities of West Iceland. An acceptable explanation for the presence of the microbes has yet to be found, but work will continue on trying to find a remedy.

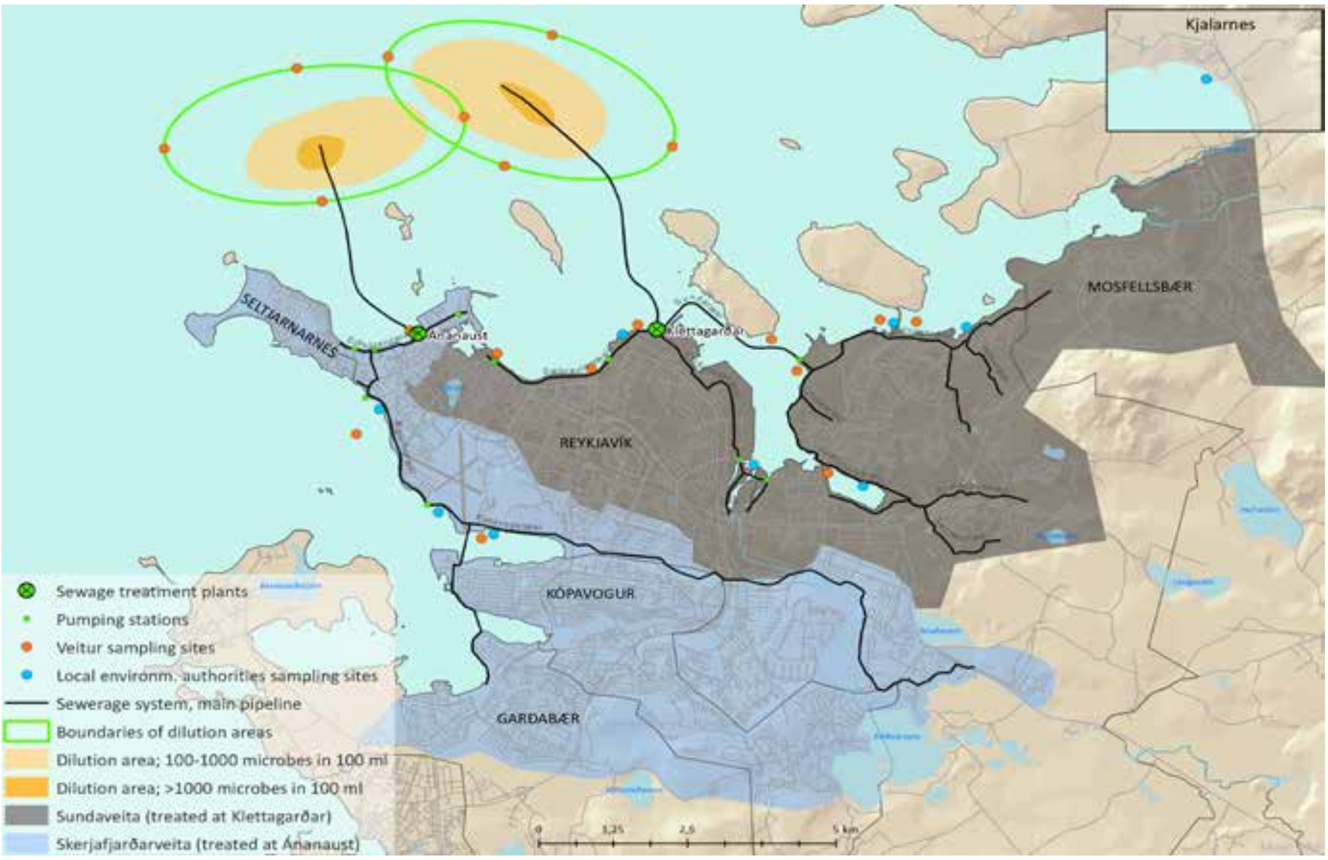



**Figure 27.** Veitur Utilities is responsible for the development and management of sewerage systems in Reykjavik. Drainage from Kópavogur, Mosfellsbaer and large parts of Gardabær and Seltjarnarnes is treated in sewage treatment plants in Klettagardar and Ánanaust. The map also shows the dilution areas for the outlets of the sewage treatment plants and locations used for sampling.

**SEA WATER QUALITY**

| **SEA WATER QUALITY AT THE COAST** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Samples** | **Heat-tolerant microbes** | | **2011** | **2012** | **2013** | **2014** | **2015** |
| RDEP and Veitur Utilities | Faecal coliforms | % | 96 | 97 | 90 | 86* | 92* |
| | Enterococci | % | 97 | 99 | 99 | 95* | 96* |
| **SEA WATER QUALITY AT THE PERIPHERY OF DILUTION AREAS** | | | | | | | |
| **Samples** | **Heat-tolerant microbes** | | **2011** | **2012** | **2013** | **2014** | **2015** |
| Veitur Utilities | Faecal coliforms | % | | | | 97 | 97 |
| | Enterococci | % | | | | 100 | 100 |

* In 2014 and 2015 Veitur Utilities collected samples in addition to those collected by Reykjavik's Department of Environment and Planning (RDEP), and the findings are shown in the table.

**Table 6.** Sea water quality. The percentage (%) of samples below limits, i.e., less than 100 in a 100 ml sample at the coast in Reykjavik and less than 1000 in a 100 ml sample at the periphery of dilution areas for the period 2011-2015.

# Discharge of drainage through overflows

Discharge of drainage via overflows was within limits in the capital area, except in Faxaskjól.

OBJECTIVES:
To ensure the use of overflows to deal with loads from rainwater is less than 5% of the year, and that emergency overflows are never active.

Under Regulation no. 798/1999 on Sewerage Systems and Sewage, overflow in the sewerage system may be active for up to 5% of the year, or when the sewage mixed with hot water from district heating utilities or rainwater is at least on a ratio of 1:5. In 2015, the discharge of drainage via overflows was within Veitur Utilities' established limits, with the exception of Faxaskjól where the overflow was active for 7.4% of the year. (Figure 28). The emergency overflow in Skeljanes was active for 2.3% of the year. The emergency overflow was opened repeatedly due to heavy precipitation in the spring and autumn of 2015 and also due to malfunctions in the emergency outlet valve.

Part of the pipeline between Skeljanes and Faxaskjól and the system between Faxaskjól and Bodagrandi do not perform drainage at peak times and this situation will worsen with, for example, the expansion of Vatnsmýri. Work is being done on examining the system as a whole to ascertain where rainwater penetrates into it and where the transport capacity needs to be increased. The situation in Skeljanes is cause for concern because of its closeness to the geothermal beach in Nauthólsvík.

## Did you know?

With the densification of urban areas, there is a need to ponder on whether existing sewage pipes could meet the new demand for services. This may call for a higher capacity sewerage system than the one that has been used so far. The development of Thórunnartún in Reykjavik, for example, called for new and considerably wider pipes than those that had been in use.

**DRAINAGE THROUGH OVERFLOWS**

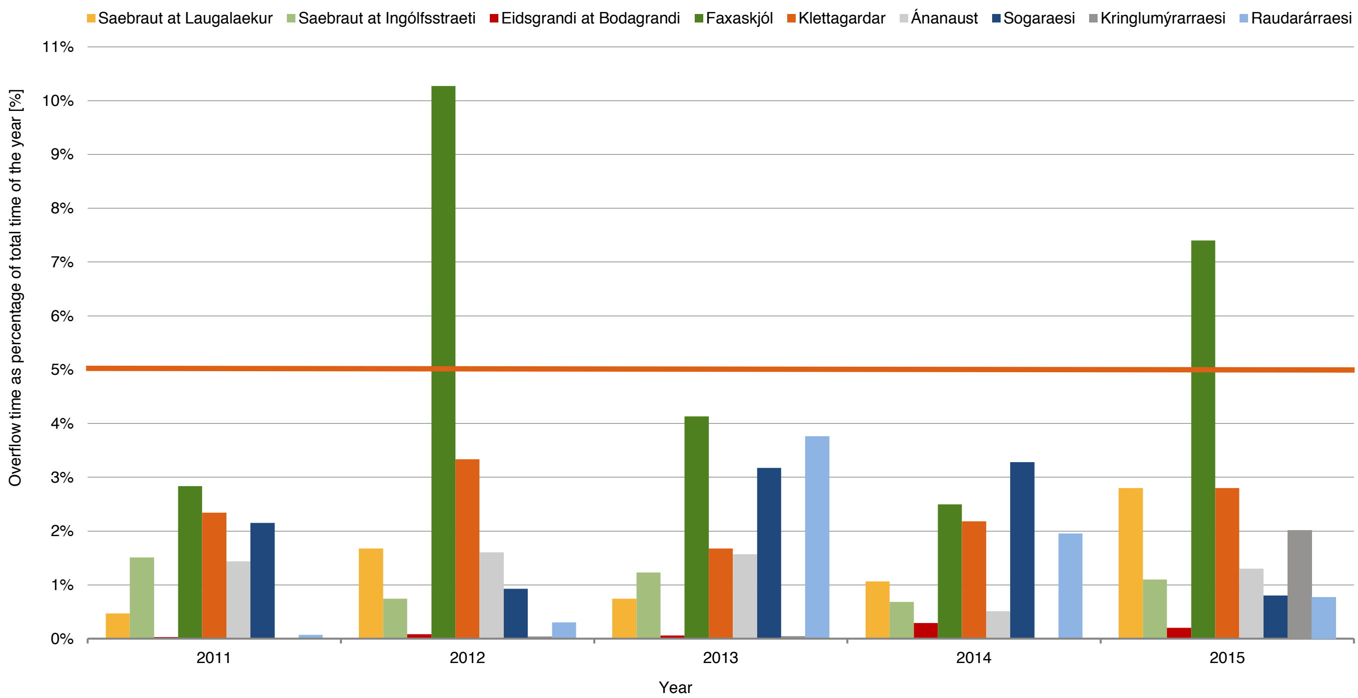



**Figure 28.** Overflow times in pumping stations and overflows of Veitur Utilities in the capital area 2011-2015. The 5% limit is indicated with the red line.

# Impact on society

The OR Group is a big company in Iceland and its workforce possesses vast knowledge and experience in the use of geothermal energy and other aspects of the company's operations. The Group disseminates its know-how and influences the value chain, which encourages a responsible treatment of the environment and has a positive impact on the community.

# Dissemination of knowledge on geothermal energy utilisation and other aspects of operations

The OR Group's Science Day was held for the second time in 2015. The CarbFix and SulFix projects continued to attract attention from the domestic and foreign media. Employees gave diverse talks on the operations of the Group at conferences and international congresses.

## Did you know?

OR Group and the Árbaejar school for children are working on a joint project which gives10th grade pupils from the school an opportunity to learn about the industrial and technical fields the company is involved in.

OBJECTIVES:
To ensure information, which may be useful to others and does not undermine the utility systems of the OR Group or its business interests, is accessible. This applies to, for example, reports, articles and presentations, insofar as possible, as well as published promotion material.

The personnel of OR and its subsidiaries possesses a vast knowledge regarding the production and distribution of power and water to residents and businesses. It is important to pass on this useful know-how which can encourage a responsible treatment of the environment and have a positive social impact.

**Dissemination of knowledge domestically**
The OR Group's Science Day was held for the second time on 20 March 2015. Its purpose was to present research conducted for and in collaboration with the companies of the Group. On this occasion, delegates were able to follow the almost 98% solar eclipse under the best conditions on the roof of the headquarters of the OR Group before the official agenda started (Figure 29). The results of 15 research and scientific projects were presented and the utilisation of geothermal energy in Iceland and its impact featured prominently in the programme. About 120 guests attended the Science Day.

Four open presentation meetings were held at the Group's headquarters in 2015 where 15 presentations were given about various aspects of its operations.

In 2015, the N4 television network broadcast its Power of the Land series, which focused on utility operations and energy utilisation. The series was made in collaboration with Samorka (Icelandic Energy and Utilities), the National Energy Authority and Iceland's Energy Agency Orkusetur. The subjects tackled in the series included water, sewerage systems, electrical power, geothermal energy and fuel. Interviewees included several experts from the OR Group. In 2015, the Icelandic state TV channel RÚV did broadcast a series called Man and Environment. An episode on the Utilisation of Geothermal Energy: "Where are we headed?" focused on the nature and importance of geothermal energy production, the speed of power plants development, discharge of disposal water, gas pollution and various related innovations. Several specialists from the OR were interviewed.

**Figure 29.** Guests at the Science Day hosted by the OR Group observing the solar eclipse on the roof of the headquarters in Baejarháls in Reykjavik. Photograph: Gretar Ívarsson.

Samorka hosted a conference on heating, water and sewerage system utilities in Borgarnes in May 2015. About 50 presentations were made, eight of which were by employees of the OR Group or they chaired discussions. They later presented the same papers at a presentation meeting for their colleagues.

In 2015 a decision was taken to OR devote its income from the sale of fishing permits in Lake Thingvallavatn from 2015 to 2017 for research on the ecosystem of the lake, a total of 14 million. Three projects are funded by the occasion.

In the autumn of 2015, ON Power took over the management of the geothermal exhibitions at Hellisheidi Geothermal Power Plant which had previously been run under the logo of Orkusýn.

**International dissemination of knowledga**
The CarbFix and SulFix innovation and development projects continued to be in the spotlight. The emphasis was placed on presenting the history and status of this international research and development project on geothermal gases, which has been conducted at the Hellisheidi Geothermal Power Plant for almost a decade. This has attracted considerable attention in Iceland and abroad, including from the New York Times. More than 70 peer-reviewed articles relating to these projects have been published and discussed at countless conferences and seminars.

Five papers by staff from OR and ON Power were on the agendas of the biggest geothermal event in the world: the World Geothermal Congress (WGC), which was hosted in Australia in the latter part of April 2015. The papers focused on the utilisation of geothermal energy in the Hengill area, reinjection issues and the OR Group's 85 years of experience in the utilisation of geothermal energy in the capital area. They also discussed the results achieved in tackling hydrogen sulphide emissions from the Hellisheidi Geothermal Power Plant. Many other Icelandic scientists delivered papers at the congress. The WGC is held every five years and the next one will be held in Iceland in 2020.

At the annual meeting of the Danish Water Forum in Copenhagen in January, a representative from Veitur Utilities delivered a presentation on the experience and challenges facing hot and cold water utilities in separate systems. At a conference called the Mayor's Geothermal Club hosted by the European Union in Hungary in October, the CEO of the OR Group delivered a paper on Icelanders' 85 years of experience in the utilisation of geothermal energy for district heating. In November, two employees from ON Power participated in the Global Cleaner Production & Sustainable Consumption conference in Spain where the themes were sustainability and accelerating the transition to equitable post fossil-carbon societies.

The United Nations Conference on Climate Change (COP21) was held in December 2015 and there the nations of the world placed an emphasis on reducing climate change. In the lead-up to the conference climate issues and renewable energy sources were in the spotlight. Icelanders' utilisation of geothermal energy formed part of this discussion and Euronews and Swiss television, for example, both covered the CarbFix and SulFix projects and their possibilities of carbon sequestration in bedrock. Swiss television also covered the utilisation of geothermal energy in Iceland, and the Franco-German TV channel Arte broadcast a documentary about Icelanders' energy utilisation and placed the operations of the OR Group in the foreground. At an informative meeting on the direct utilisation of geothermal energy, which was held at the Conference on Climate Change, the director of OR's R&D division delivered a presentation on the development of hot water utilities in Reykjavik. Iceland Geothermal organised the meeting in collaboration with GEORG, the National Energy Authority and the Ministry of Foreign Affairs.

# Procurement

OR is a founding member of the Procurement Network and its environmental requirements will continue to be tightened for procurement in 2016.

OBJECTIVES:
To take the environmental impact of procurement into consideration wherever possible by, for example, analysing life cycle costs and applying recognised environmental criteria and checklists. Procurement shall be organised and coordinated bearing side effects in mind, such as transport and the quantity of packaging.

OR and its subsidiaries' purchases of goods and services are extensive. Procurement requirements are systematically analysed in the companies and efforts are made to utilise materials that have been purchased or are in stock or to sell them off. As an indication of this, there was a good usage of older inventories in 2015, and the balances of older inventories decreased by 11%. The purchase of about 724 products was discontinued.

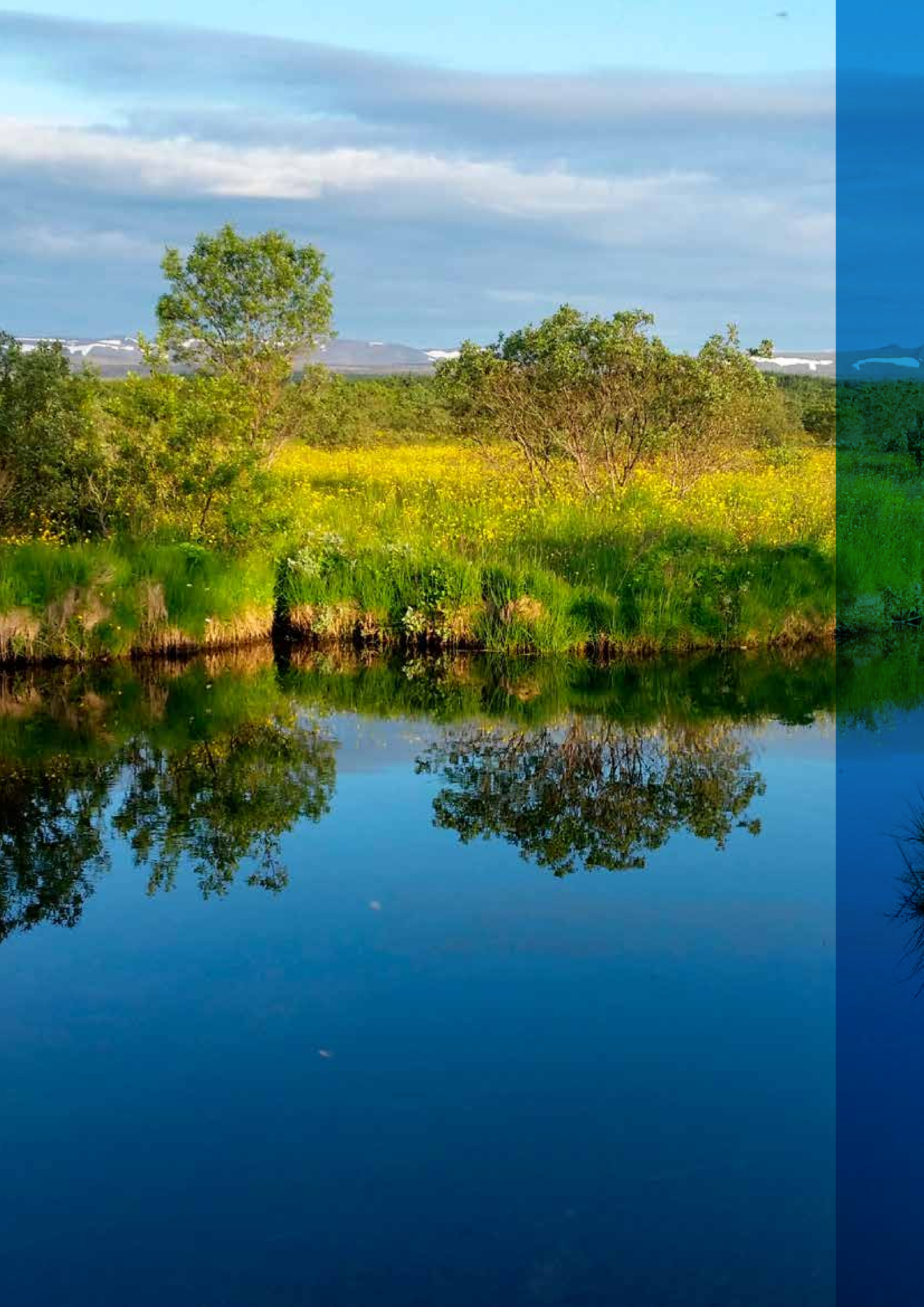
In tenders for vehicles in 2015, criteria were set for carbon dioxide emissions (80g $CO_2$/km) for cars, and in a tender for delivery vans, the possibility of requiring them to be powered by methane was explored. This proved to be unsuitable, but as a result more efficient vans were bought. Electric cable spools are returned to the manufacturers instead of disposing of them. Generally speaking, each spool is used four times. All printing paper and cleaning materials carry eco-friendly labels, except for chlorine, which is used to clean cloths. The use of print control has steadily increased and printing and photocopying have dropped by about 38% since 2012 thereof 19% in 2015.

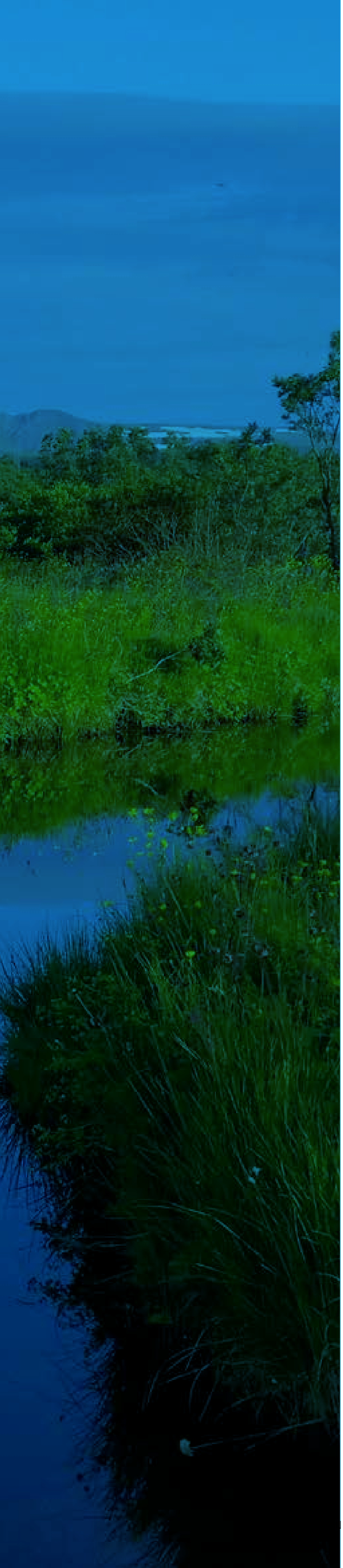
OR is a founding member of the Procurement Network, which is a group of companies that wants to reduce environmental impact with eco-friendly purchases. Eco-friendly labels are favoured in the procurement of operational goods, such as paper and detergents, for example. In 2015, efforts continued to boost OR's knowledge of eco-friendly procurement. In 2016, the aim is to distinguish eco-friendly products from other products on suppliers' invoices in the product categories defined in the Procurement Network. In 2016, the environmental requirements linked to procurement will be further tightened.

## Did you know?

The steam pipeline that was used in Hverahlíd and was part of OR's inventory was over 5 km long. They were insulated with rock wool from the Steinull company in Saudárkrókur, which was designated as Iceland's SA-Business' Environmental Company of the Year in 2015.

**Figure 30.** Warehouse in Baejarháls. Photograph: Thorsteinn Ari Thorgeirsson.





# Operations

The operations of OR and its subsidiaries are founded on the organised and disciplined working procedures of many employees in widespread work sites. Day-to-day tasks include, among other things, the responsible utilisation of supplies, maintenance on constructions, tending to plots of land, handling waste responsibly and promoting eco-friendly transport. The OR Group aims to run exemplary operations and to develop its personnel's competence in this field.

# Waste

The staff's awareness of recycling and sorting issues has generally been good. Particular care was taken in the sorting of waste in the offices of OR and its subsidiaries in the first three months of 2015 and the sorting went well.

## Did you know?

Sewage waste for landfilling has contracted by 50% following the installation of washing equipment for waste and sand at sewage treatment plants in Klettagardar and Ánanaust in 2015.

**OBJECTIVE:**
**To minimise waste and recycle as much as possible. To ensure the least possible amount of active waste is buried.**

A great deal of waste accumulates in the operations of OR and its subsidiaries and it is divided into three categories:

- Waste for landfilling (e.g. general waste and sewage)
- Waste for recycling
- Hazardous waste

The total volume of waste amounted to approximately 1.000 tons in 2015, most of which came from sewage treatment plants, which produced over 700 tons, i.e. 70% of the waste (Figure 31). Waste from sewerage systems contracted by 50% following the installation of washing equipment for waste and sand at the sewage treatment plants in Klettagardar and Ánanaust in 2015. Waste other than waste from sewage treatment plants amounted to 300 tons, some 70 tons of which was general and bulk waste and 18 tons asbestos. There were 200 tons of waste for recycling and over 9 tons of hazardous waste. Annexes 24 and 25 show how waste is divided between categories and work sites.

In the wake of a campaign to promote the recycling and sorting of waste in 2014, there were no significant changes in the volume of waste that went into landfilling or recycling. Particular care was taken in the sorting of waste in the offices of OR and its subsidiaries in the first three months of 2015 and the sorting went well. The staff's awareness of the recycling and sorting of waste has generally been good. In 2015 information was gathered for the Environmental Report regarding the gravel, soil and asphalt that is accumulated and disposed of in projects. (Annex 24). Most of the asphalt goes into recycling.

By sorting and recycling waste, we can all make a contribution and minimise our impact on the environment.


**Figure 32.** Sorting guidelines in the offices of OR and its subsidiaries. Photograph: From the operating handbook of OR.

**WASTE**

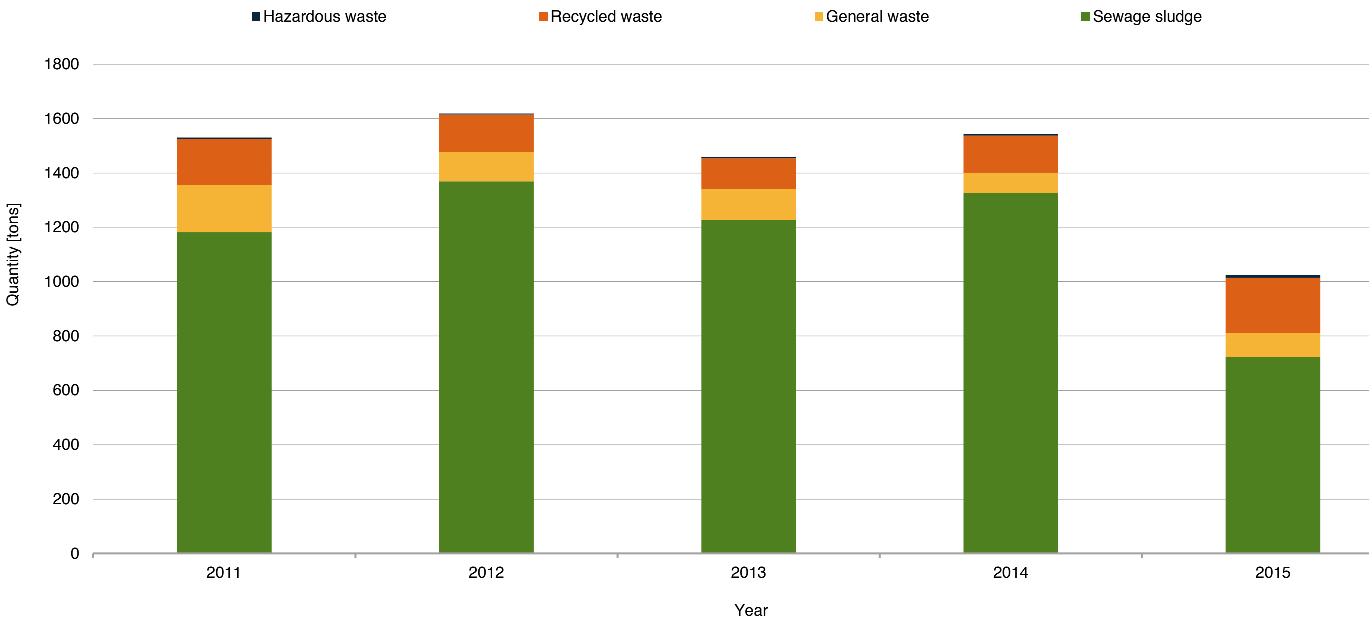



**Figure 31.** Waste from the operations of OR and its subsidiaries 2011-2015. Waste from sewerage systems contracted by 50% following the installation of washing equipment for waste sand at sewage treatment plants at the beginning of 2015.

# Transport

ON Power received Iceland's SA-Business Environmental Award in 2015 for establishing a network of fast-charging stations for electrical cars.

OBJECTIVE:
**To ensure that transport due to the operations of OR and its subsidiaries emits the least possible greenhouse gases by selecting vehicles with the lowest emissions and that are deemed cost-effective and suitable for operations. To encourage employees to choose eco-friendly means of transport to and from the workplace. OR and its subsidiaries shall play an active role in acquiring experience and disseminating knowledge about foreseeable changes in energy sources for transport.**

## Did you know?

Based on the annual use of a Toyota Yaris, which is a popular gasoline-fuelled car, and a Nissan Leaf electric car, the difference in running costs on an annualised basis is approximately ISK 133,000 in petrol costs and 1,800 kg in $CO_2$ emissions.

At the end of 2015, OR and its subsidiaries completed work on an eco-friendly transport strategy. The focus will be on eco-friendly vehicles, fuel and infrastructure to ensure access to eco-friendly energy, along with the utilisation of various modes of transport. The objective is to reduce greenhouse gas emissions in transport and use the infrastructure, products, know-how and capacity of OR and its subsidiaries to facilitate changes in the utilisation of energy in transport. By the end of 2015, there were 25 parking spaces with charging stations for electric cars at OR's headquarters and these are set to increase in 2016. Electric cars are given priority in these parking spaces although other vehicles are free to park there if the space is free. This is done to encourage and facilitate staff and others to acquire and run an electric car.

In 2011-2013 the percentage of vehicles and heavy machinery at OR and its subsidiaries, which were powered by renewable energy sources, such as methane, hydrogen and electricity, was about 15%. In 2014 the percentage rose to 28% and in 2015 to 32% (Figure 33). In 2015, some 14 alternative fuel vehicles were purchased for the OR Group, 7 of which were electric cars. Annex 26 contains a list of the company's vehicle fleet from 2011 to 2015. Fuel consumption for the company's own vehicles and leased vehicles is shown for the same period in Annex 27. Information was gathered on the number of kilometres driven by the company's own cars in 2014 and 2015. As can be seen, the company's own cars are consuming less fuel for every 100 kilometres driven in 2015 than in 2014 (Figure 34). In 2016 more detailed information will be collected on this aspect.

At the end of September 2015, ON Power won Iceland's SA-Business Environmental Award for its contribution to the year, i.e. developing a network of fast-charging stations for electric cars. The number of electric cars in Iceland has increased sixfold since the beginning of 2014. At the same time the company has opened ten fast-charging stations for electric cars and thus been at the forefront of the development of infrastructure for electric cars (Figure 35). In 2015 most of the stations owned by ON Power were upgraded to enable them to service more types of vehicles. In 2016 two fast-charging stations will be installed in Akureyri and one at the Hellisheidi Geothermal Power Plant.

Since the spring of 2015 the staff of OR and its subsidiaries have been offered transport agreements. The purpose of transport grants is twofold: on one hand to promote eco-friendly means of transport and, on the other, to encourage exercise and enhance the staff's health. About 80-90 employees out of over 450 availed of the grant in 2015, i.e. about 20%. In the autumn of 2015 a survey was conducted on the travel habits of personnel to and from work. About 74% of the employees who responded travelled to work in a private car or got a lift and 2% of the staff travelled by electric car. Some 20% of the staff cycled, walked or took a bus (Figure 36). About 59% of respondents could envisage using other modes of transport than those used when they took the survey, which is an increase from last year. Some 49% of them wanted to cycle, 20% to use an electric car, 18% take a bus, 6% walk or run, 4% travel with others, 2% travel by motor-bike and 1% use a private car and drive themselves.

**THE VEHICLE FLEET 2015**

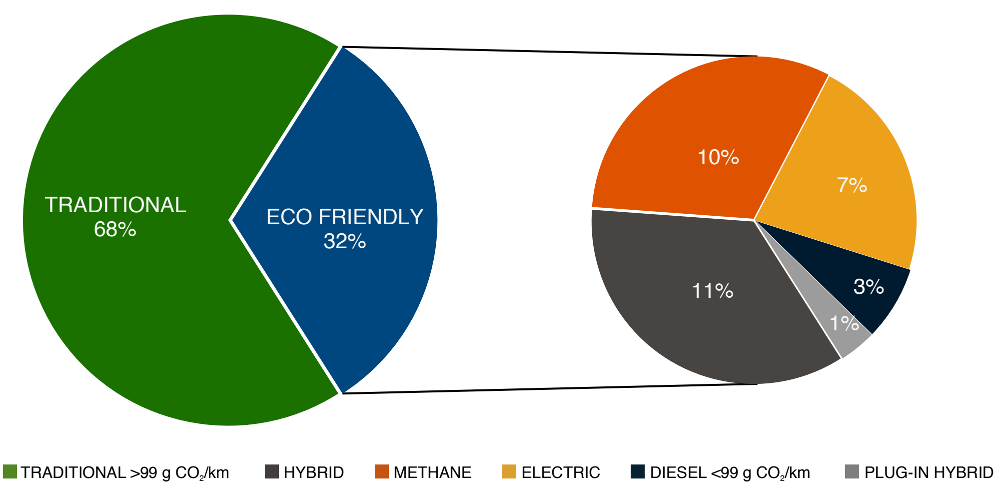



**Figure 33.** Composition of OR's car fleet in 2015. Conventional cars powered by gasoline or diesel oil accounted for 68% and alternative fuel vehicles 32%, some 11% of which were hybrid vehicles, 10% were methane-powered, 7% electric, 3% diesel and 1% plug-in hybrid.

## FUEL EFFICIENCY

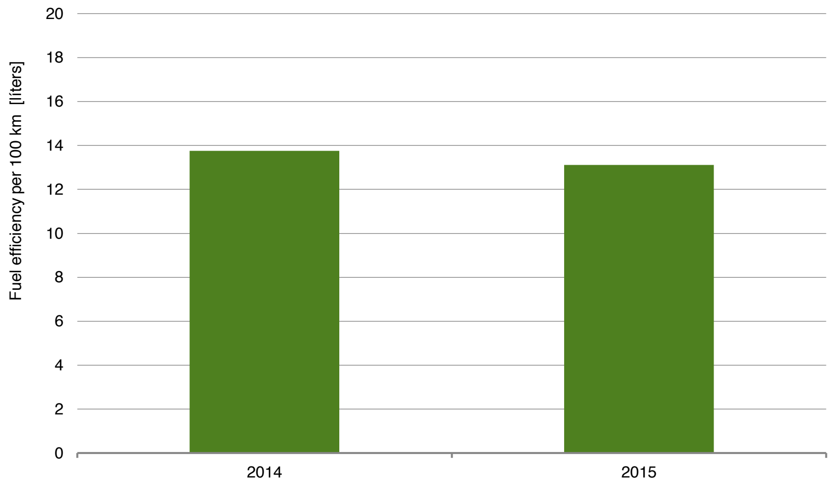



**Figure 34.** Fuel consumption per 100km driven in 2014-2015. The data do not include exclusively electric cars and methane cars.

## NUMBER OF ELECTRIC CARS AND ON POWER'S FAST-CHARGING STATIONS

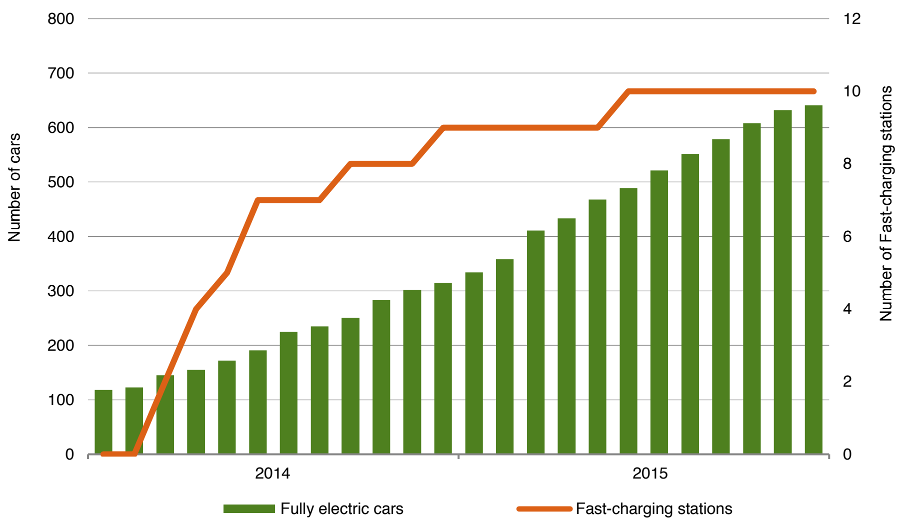



**Figure 35.** The number of electric cars has almost increased sixfold since the beginning of 2014. At the same time ON Power has installed fast-charging stations to encourage this trend. Data from Icelandic Transport Authority.

## COMMUTING CUSTOMS TO AND FROM WORK

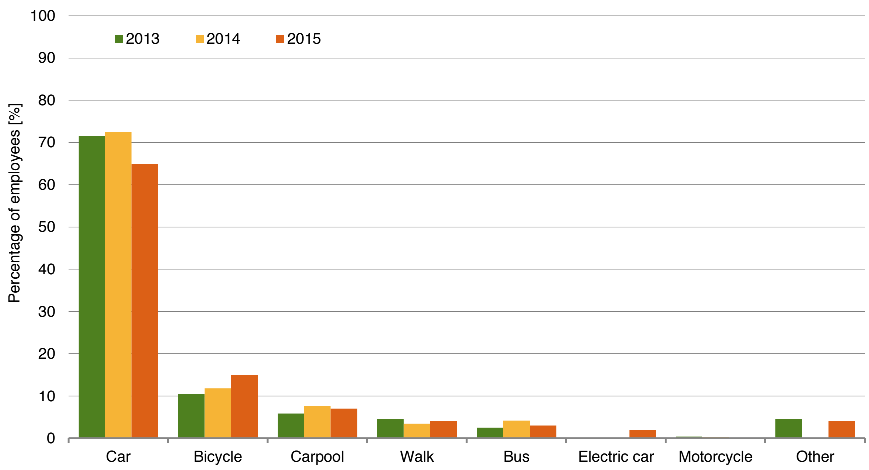



**Figure 36.** Results of survey on the travel habits of employees to and from work from 2013, 2014 and 2015. The response rate was 58% in 2013, 67% in 2014 and 65% in 2015.

# Structures and maintenance

In 2015, lots and structures were successfully kept tidy, despite limited financial resources. Guidelines were issued on the visual impact and restoration of vegetated land following projects. In 2016 guidelines will also be issued on how it is possible to reclaim local vegetation in urban areas.

OBJECTIVES:
To ensure all of the structures and lots of the OR Group are tidy and blend in harmoniously with their environment.
To ensure that the design of structures and restoration of lots are in accordance with visual impact and restoration guidelines.

The caring and maintenance of plots went well in the summer of 2015. The company's structures were successfully kept tidy. It is clear, however, that more funds need to be devoted to their maintenance and care, if the company's goals are to be reached. Generally the condition of structures and lots is assessed annually. The comments that are received by the company principally concern graffiti, weeds, lawn mowing and maintenance. Work was done on clearing up and finishing lots at the ON Power plants in order to utilise native vegetation and minimise maintenance. OR and its subsidiaries operate under the guiding principle of working well and minimising disruptions in its tasks both outside and inside the homes of its customers.

In 2015, environmental training was added as a requirement to the tender specification of projects. Visual impact and restoration guidelines were issued for the restoration of vegetated areas and design of plots of land and this was completed with the development of an app that features a condition assessment checklist. In 2016 visual impact and restoration guidelines were issued on how it is possible to reclaim native vegetation in urban areas. Many construction companies have shown an interest in the procedure of using local vegetation in the restoration of project sites and the plan is to publish guidelines on the websites of ON Power and OR in 2016. The cladding of cooling towers at the Hellisheidi Geothermal Power Plant suffered considerable damage in a violent storm in March 2015 and was subsequently repaired. Vegetation was utilised to restore the site where the summer house owned by OR in Ridvík at Nesjavellir was removed in the summer of 2015.

## Did you know?

The mowed grass from OR's plots is sent to the City of Reykjavik to be used as compost, in planting beds, and scattered over dry land as a fertilizer to reclaim vegetation at Hellisheidi.

**Figure 37.** Low-temperature geothermal wells in Ellidaárdalur before and after maintenance. Photograph: Benedikt Thór Jakobsson.

# Use of hazardous substances

In 2015 workshops and courses were held for the employees of OR and its subsidiaries regarding hazardous substances. At the same time procedures were reviewed on the choice of substances used in operations.

## Did you know?

Every year it is required to examine the workplaces of the OR Group for hazardous substances that are used and ascertain whether they can be replaced with harmless substances.

OBJECTIVES:
To minimise the use of hazardous substances as much as possible and dispose of them responsibly. To facilitate access to information regarding harmless substances that can substitute hazardous ones.

In the spring of 2015, workshops were held on hazardous substances to prepare courses for the staff members of the OR Group who handle these materials in their work. The workshops focused on, among other things, elements to be improved and shed light on the most hazardous substances being used by the Group. These are asbestos, the base material used in insulation foam, chlorine, acids and bases, welding gases and vapours, geothermal gases, hydrogen sulphide, oil and solvents. The transport of various hazardous substances is covered in Table 7 and also Table 1 of the section on the Conservation of Potable Water. The personnel of most of the company operating units that use hazardous substances attended the workshops as well as an external consultant.

In the wake of the workshops, most of the work areas of the OR Group were visited to go over working facilities and the use of substances in the relevant areas, and the storage of hazardous waste was examined, as well as the sorting and disposal of hazardous substances. This was followed by a review of work procedures regarding the choice of substances, procurement, usage, storage and supervision. In parallel with this, guidelines on new warning signs to be put up in workplaces were drafted (Figure 38) and responses to chemical accidents. The participants in the workshops highlighted the importance of training and three courses on hazardous substances were held in the autumn of 2015 and the aim is to schedule further courses in 2016.


**Figure 38.** Guidelines for new warning signs to be put up in the workplaces of OR and its subsidiaries. Photograph: From the operating handbook of OR.

**QUANTITY OF HAZARDOUS SUBSTANCES TRANSPORTED**

| SITE | CATEGORY | UNIT | 2015 |
|---|---|---|---|
| Nesjavallavirkjun | Oil | Liters | 2,028 |
| **Total oil** | | **Liters** | **2,028** |
| Hellisheidarvirkjun | Sludge | kg | 16,000 |
| Nesjavellir | Sludge | kg | 51,940 |
| West Iceland | Sludge | kg | 28,760 |
| **Total sludge** | | **kg** | **96,700** |
| Hellisheidarvirkjun | Chlorine | Liters | 13,420 |
| Nesjavallavirkjun | Chlorine | Liters | 9,680 |
| **Total chlorine** | | **Liters** | **23,100** |
| West Iceland | Asbestos | kg | 18,260 |
| **Total asbestos** | | **kg** | **18,260** |

**Table 7.** The quantity of asbestos that was moved for landfilling in Fíflholt in West Iceland and sludge by Veitur Utilities and the quantity of fuel, chlorine and sludge that was moved by ON Power in the Hengill area.

# Other environmental factors

Goals were achieved on minimal flow below the Andakílsá Hydropower Station and apart from a few days in February, June and October, goals were achieved on water level fluctuations in Lake Skorradalsvatn. Increased natural radioactivity was measured on scale formations at the Hellisheidi Geothermal Power Plant. These are small in quantity and ON Power will apply for the appropriate permit for the temporary storage of the scale formations for up to three years, after which it will be possible to dispose of them in the traditional manner.

**Noise**

In 2015 Veitur Utilities worked on improving the noise issue at the pumping station in Sörlatunga, the well in Hátún in Reykjavik and the supply station at Hnodraholt in Kópavogur.

**Hydroelectric power**

In 2015 the goal of keeping the flow below the Andakílsá Hydropower Station within limits to ensure it is no less than 2 $m^3/s$ was achieved to safeguard the river's ecosystem and salmon. At a meeting of stakeholders in 2015, a decision was made to reduce the goal from 2.23 $m^3/s$ to 2 $m^3/s$ because more precise measurements have indicated that this has always been the targeted volume of water.

Apart from a few days in February, June and October, water level fluctuation targets in Lake Skorradalsvatn were met and within the limits, which are 1.08 m in normal operations in the winter and 0.4 m in the summer (Annex 28). At a meeting of stakeholders in 2015, a decision was made to redefine winter time so that it would stretch from September 15th to April 15th instead of to May 15th, as it did previously. In addition to this, the spring schedule stretched from April 16th to May 14th.

**Radiation measurements**

In 2015, the Icelandic Radiation Safety Authority worked on evaluating the concentration of natural radioactivity from scale formations in geothermal power plants in Iceland in, among other places, Nesjavellir and Hellisheidi. At the Nesjavellir Geothermal Power Plant, handheld measurements indicated no increase in radioactivity and gamma spectroscopy on two samples yielded the same results. At the Hellisheidi Geothermal Power Plant handheld measurements revealed some slight radiation over the background in three places. Samples were taken and examined in gamma spectroscopic tests by the Icelandic Radiation Safety Authority. One of the samples, from a so-called mist eliminator, seemed to indicate increased radioactivity. Because the radioactivity was so low and close to the limit, the two samples were sent to Finland for analysis. The results arrived at the end of 2015 and were presented by the Icelandic Radiation Safety Authority at a meeting with representatives from ON Power and the South Iceland Administration of Occupational Safety and Health. The conclusion of the meeting was that the maximum potential radiation due to the cleaning of these scale formations is 0.019 millisivert (mSv) inhaled over two days in mist eliminators filled with dust in Hellisheidi, i.e. far below the limit which workers can be exposed to according the regulations (1 mSv per year). It should be pointed out that working conditions for the cleaning of these scale formations are never filled with dust and the risk of inhaling radioactive dust is therefore negligible. Figure 39 shows the results placed in the context of radiation in daily life.

Since there is an increase in natural radioactivity in the scale formations, ON Power shall apply for a special permit to store them for three years or until their radioactivity has been broken down and it is possible to dispose of the scale formations in the traditional manner. It is a very small quantity that needs to be stored after the mist eliminators have been cleaned.

## Did you know?

There is very low background radiation in Iceland and it is mostly determined by the type of rock and soil. Icelandic basaltic rock is alkaline and low in radioactive materials. The estimated radiation dose from natural radiation in other Nordic countries is twice to three times higher than in Iceland.

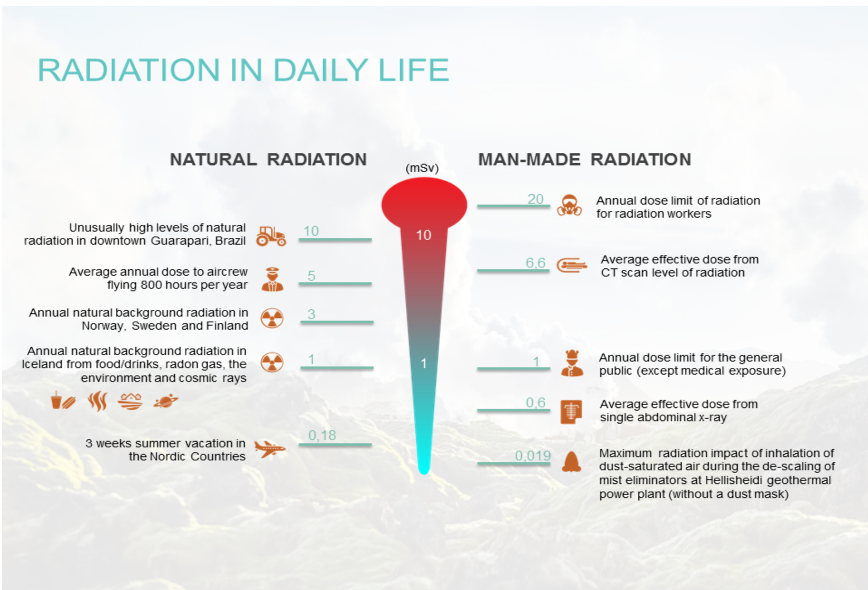



**Figure 39.** Potential impact of radiation, 0.019 millisivert (mSv) based on an employee inhaling dust in a mist eliminator in Hellisheidi for a period of two days while cleaning scale formations seen in relation to the radiation people are exposed to in their daily lives and current permitted levels of radiation exposure per year.

# Production, own use and carbon footprint

Veitur Utilities supplies pure potable water and hot water for space heating, channels drainage and rainwater out to sea and distributes electricity to customers. Moreover, ON Power produces electricity for households and industry from high-temperature geothermal fields in the vicinity of the capital area. Electricity is also produced at the Andakílsá Hydropower Station. OR and its subsidiaries use hot and cold water at their worksites. The own use of electricity is mainly due to the production of hot water, pumping of sewage, hot and cold water and the operation of its premises. Own use of electricity is solely for treatment of hot water, the pumping of sewage, hot and cold water and the operation of premises. Greenhouse gas emissions from the activities of OR and its subsidiaries account for 1.2% of total emissions in Iceland.

# Production and own use

In 2015, the OR Group's production of electricity, potable water and hot water for space heating was similar to what it was in 2014. The own use of hot water and electricity increased, while the use of cold water decreased.

**Total production**
In 2015, the OR Group's production of hot water was approximately 87 million m$^3$ and nearly 27 million m$^3$ of cold water (Table 8). Of the almost 87 million m$^3$ of hot water produced, nearly 38 million m$^3$ was cold water which was heated in ON Power's geothermal plants in the Hengill area, but the rest was geothermal water from the low-temperature areas. ON Power's electricity production with geothermal steam was over 3.4 million MWh. On the other hand, more than 1 million MWh were produced in Nesjavellir and about 2.4 million MWh in Hellisheidi. About 27 thousand MWh of the electricity was produced in the Andakílsá Hydropower Station.

**Own use**
The OR Group's own use of hot water and electricity increased, while the use of cold water decreased (Table 9). Own use of electricity is solely for treatment of hot water, the pumping of sewage, hot and cold water and the operation of premises. All of the thermal energy used to heat buildings in Hellisheidi is in a closed system. The same water is re-circulated, and the use of thermal energy is not measured. Own use of cold water is almost exclusively for ON Power's geothermal power plants in the Hengill area. There, nearly 79 million m$^3$ of cold water were pumped up in 2015. Of these, almost 41 million m$^3$ were utilised for heat production in, among other things, space heating in the capital area, and about 38 million m$^3$ were utilised for the power plants' operations and cooling of equipment.

## Did you know?

About half of the hot water in the capital area is groundwater which is heated up with geothermal energy at the power plants in the Hengill area. The other half is geothermal water from low-temperature fields in Reykjavik and Mosfellsbaer.

**TOTAL PRODUCTION**

| | | | | ON POWER | VEITUR UTILITIES | ON POWER | VEITUR UTILITIES |
|---|---|---|---|---|---|---|---|
| | UNIT | 2012 | 2013 | 2014 | | 2015 | |
| Hot water | m$^3$ | 80,949,330 | 81,300,498 | 34,920,000 | 43,791,000 | 38,042,194 | 48,956,870 |
| Cold water | m$^3$ | 26,930,000 | 27,106,000 | | 26,976,788 | | 26,914,174 |
| Electricity from Hellisheidi Geothermal Power Plant | MWst | 2,438,841 | 2,390,439 | 2,388,344 | | 2,227,374 | |
| Electricity from Nesjavellir Geothermal Power Plant | MWst | 1,011,932 | 1,004,570 | 1,028,335 | | 983,997 | |
| Electricity from Andakílsá Hydro Power Plant | MWst | 28,271 | 26,753 | 26,752 | | 37,883 | |

**Table 8.** Total production of the OR Group 2012-2015.

**OWN USE**

| | | | | ON POWER | OR | ON POWER | VEITUR UTILITIES | GR | OR |
|---|---|---|---|---|---|---|---|---|---|
| | UNIT | 2012 | 2013 | 2014 | | 2015 | | | |
| Electricity | MWh | 287,539 | 295,451 | 231,824 | 52,456 | 232,760 * | 74,228 | 815 | 2,940 |
| Hot water | m$^3$ | 609,729 | 552,023 | 339,646 | 306,238 | 395,219 | 52,600 | | 289,245 |
| Cold water | m$^3$ | 66,844,128 | 75,399,668 | 80,852,000 | 78,873 | 78,849,438 | 27,526 | 4,909 | 83,922 |

* Data were not received from Andakílsá hydroelectic power plant in May and June. The missing power is estimated 30-40 MWh.

**Table 9.** Own use of the OR Group 2012-2015. GR refers to Reykjavik Fibre Network (Gagnaveita Reykjavikur) and OR to the mother company.

been discovered that reclamation results in an average sequestration of 2.8 tons of carbon dioxide per hectare per year. The forested areas under the auspices of the OR Group amounted to 824 ha and reclaimed land totalled 437 ha in 2015. The results of carbon sequestration in the basaltic bedrock in the SulFix and CarbFix projects showed 70-95% mineralisation within two years from reinjection. Annex 30 shows the total carbon sequestration of the OR Group, which is about 9 thousand tons a year.

The carbon footprint of OR and its subsidiaries shows annual greenhouse gas emissions, calculated in $CO_2$-equivalents, from the operations of the company minus the carbon sequestration due to land reclamation, forestation and reinjection into the basaltic bedrock. Table 10 shows the carbon footprint of the Group for 2015 in comparison with 2011 to 2014. Emissions from Nesjavellir and Hellisheidi are based on the operations of the power plants as well as testing and maintenance wells in the areas. Oil consumption from back-up power generators and cars is converted into emissions of greenhouse gases by using emissions constants, which are published and approved by the United Nations Intergovernmental Panel on Climate Change (IPCC). Back-up power generators are, for example, small electricity generators powered by coloured diesel fuel to run pumps during drilling, or if there is a breakdown in electricity connections where pumps are operated. Coloured diesel fuel is bought every second year. Emissions from cars are calculated on the basis of the recorded quantity of fuel. A heating station in Bæjarháls was closed and its operating licence returned at the end of 2011. Emissions from waste contracted by 600 tons $CO_2$ equivalents, as the volume of waste from sewerage systems that is disposed of was reduced, following the cleaning of waste and sand at sewage treatment plants in Klettagardar and Ánanaust in Reykjavik.

On the basis of all the operations of OR and its subsidiaries in 2015 the total emission of greenhouse gases amounted to 56,372 tons $CO_2$ equivalents. Taking into consideration the carbon sequestration achieved by the company through land reclamation, silviculture and reinjection into the basaltic bedrock, amounting to 4,828 tons $CO_2$ equivalents, net greenhouse gas emissions from operations in 2015 amounted to 47,633 tons $CO_2$ equivalents, representing a 15% contraction between years. Greenhouse gas emissions from the operations of OR and subsidiaries accounts for 1.2% of total emissions in Iceland on the basis of the total emissions recorded in 2013 (Environment Agency of Iceland, 2015).

**CARBON FOOTPRINT**

| | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|
| | $CO_2$-equivalence [tons] | $CO_2$-equivalence [tons] | $CO_2$-equivalence [tons] | $CO_2$-equivalence [tons] | $CO_2$-equivalence [tons] |
| **Emission from power production** | | | | | |
| Nesjavellir Geothermal Power Plant | 15,779 | 19,200 | 15,764 | 17,702 | 15,850 |
| Hellisheidi Geothermal Power Plant | 40,676 | 44,229 | 46,446 | 42,939 | 38,659 |
| Steam from Hverahlíð | 0 | 0 | 0 | 0 | 0 |
| Sulfur hexafluoride ($SF_6$) at Nesjavellir | 0 | 0 | 13 | 0 | 0 |
| Sulfur hexafluoride ($SF_6$) at Hellisheidi | 0 | 13 | 0 | 13 | 0 |
| **Emission from district heating** | | | | | |
| Low-temperature geothermal fields* | 0 | 0 | 0 | 0 | 0 |
| **Emissions from fuel consumption** | | | | | |
| Backup power (fixed and mobile stations) | 29 | 75 | 5 | 25 | 5 |
| Vehicles (own and leased) | 778 | 553 | 513 | 484 | 585 |
| Heating central (because of testing) | 1 | 0 | 0 | 0 | 0 |
| Flights, international and domestic | 33 | 39 | 72 | 88 | 100 |
| **Emissions from waste for landfilling** | | | | | |
| Waste | 1,744 | 1,846 | 1,664 | 1,759 | 1,173 |
| **Emissions from supply and distribution systems** | | | | | |
| Sulfur hexafluoride ($SF_6$) | 0 | 0 | 0 | 0 | 0 |
| **Total greenhouse gas emission** | **59,040** | **65,954** | **64,477** | **63,009** | **56,372** |
| **Carbon sequestration** | | | | | |
| Land reclamation and forestation | -4,938 | -4,712 | -4,736 | -4,774 | -4,828 |
| Sequestration in CarbFix og SulFix | | -110 | -3 | -2,381 | -3,911 |
| **OR Group's carbon footprint** | **54,102** | **61,133** | **59,738** | **55,854** | **47,633** |

OR Group's net greenhouse gas emissions rate as a precentage of total emissions from Iceland, see table 2.1 in http://ust.is/library/Skrar/Atvinnulif/Loftslagsbreytingar/ICELAND%20NIR%202014.pdf

Estimated net greenhouse gas emissions from Iceland 2013: 4,539 Gg in $CO_2$-equivalence

*Greenhouse gas emission is negligible in low-temperature geothermal fields.

Global warming potential (GWP): https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

**Table 10.** Carbon footprint of OR and its subsidiaries 2011-2015.

## CARBON EMISSIONS AND CARBON SEQUESTRATION 2011-2015

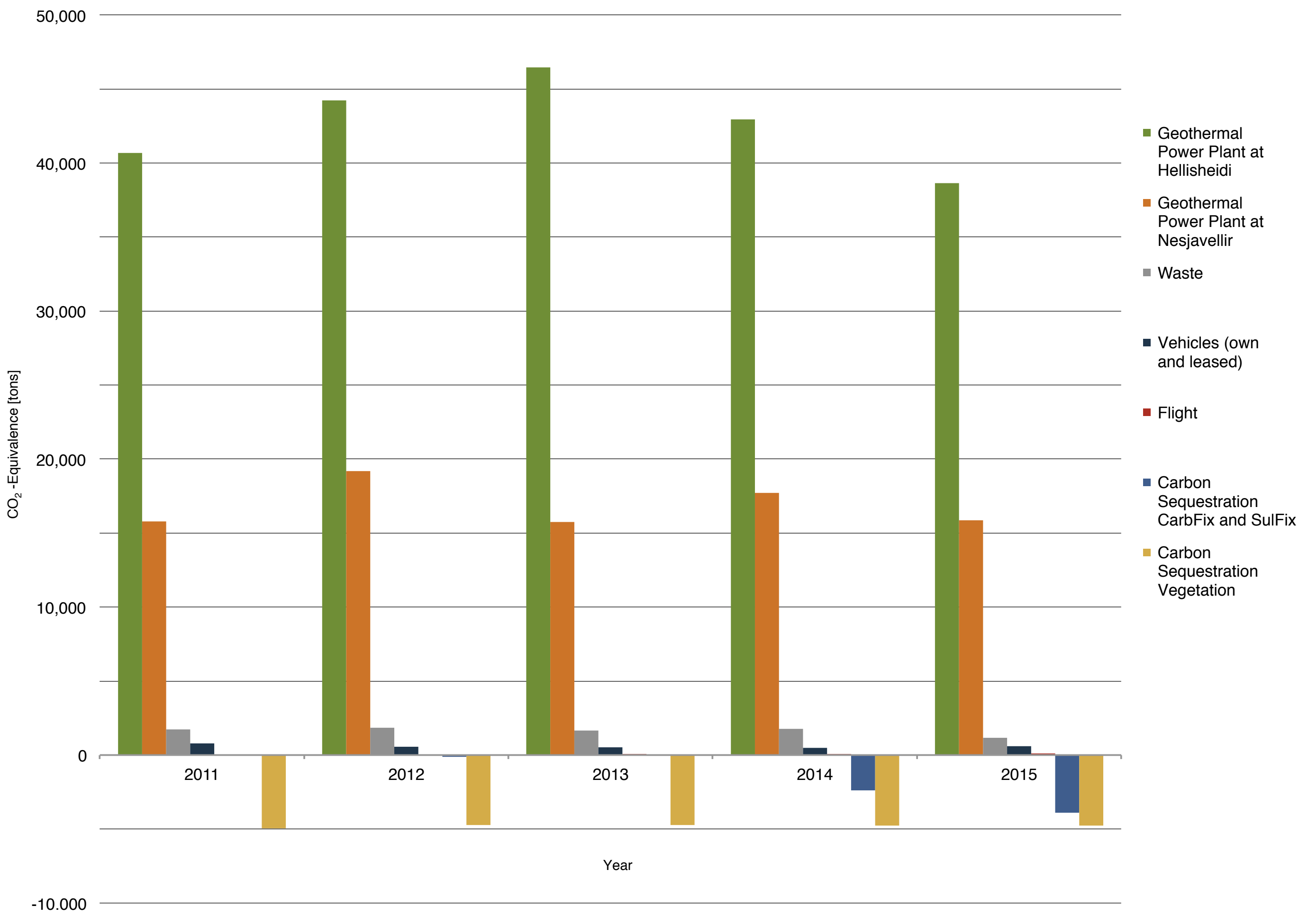



**Figure 40.** Carbon emissions and carbon sequestration of OR and its subsidiaries 2011-2015.

# Statement by OR's Board of Directors

To the best knowledge of the Board of Directors of Orkuveita Reykjavíkur (OR), the 2015 Environmental Report complies with the provisions of Regulation no. 851/2002 on Green Accounting. The Environmental Report discusses the aspects of OR and subsidiaries' operations that have an impact on the environment, and how environmental issues are addressed in operations.

It is the opinion of the Board of Directors that the figures and information specified in the Environmental Report compiled by OR, and which come from its accounts, give a good picture of the trends and results achieved in its environmental affairs.

The Board of Directors of Orkuveita Reykjavíkur hereby endorses the Environmental Report 2015.

Reykjavík, 22 February 2016
Board of Directors:

Haraldur Flosi Tryggvason
chairman

Brynhildur Davíðsdóttir
vice-chairman

Áslaug Friðriksdóttir

Gylfi Magnússon

Kjartan Magnússon

Valdís Eyjólfsdóttir

# Indipendent Auditor's Report

I have reviewed the calculations and information presented in the 2015 Environmental Report of Reykjavik Energy (OR) and its subsidiaries. The Environmental Report is presented by the management of OR and subsidiaries and under their responsibility. My responsibility is to express an opinion on the information presented in the Environmental Report based on the audit.

The audit is in accordance with the stipulations of Regulations no. 851/2002 on Green Accounting. It entails analytical procedures, spot checks and the examination of data to verify information in the Environmental Report. The audit also entails checking calculations applied in assessing the scale and importance of particular factors listed in the Environmental Report.

I believe that the audit is a sufficiently reliable basis on which to base my opinion.

In my opinion, the Environmental Report gives a true and fair view of the environmental impact of operations in 2015, in accordance with sound and recognized practices in this sector.

Reykjavík, 10 February 2016
VSO Consulting

Guðjón Jónsson
Chemical Engineer

# Carbon footprint of OR and its subsidiaries

The net greenhouse gas emissions from the operations of OR and its subsidiaries in 2015 amounted to approximately 48,000 tons of $CO_2$ equivalents, i.e. 1.2% of total emissions in Iceland.

**2015 warmest year to date**
The average global temperature has increased by 0.85°C over the past 100 years. Thirteen of the fourteen warmest years were recorded in the 21st century and 2015 was the hottest year to date. The concentration of carbon dioxide ($CO_2$) in the atmosphere is now higher than it has ever been over the past 800 thousand years and a record was broken in this regard in May 2015. High temperatures, extreme weather, rising sea levels and ocean acidification are some of the factors that are considered to be consequences of global warming and can have a vast impact on the world. Examples worth mentioning include water shortages, changed conditions of food production, a higher frequency of problems caused by flooding, high winds, tsunamis and droughts. It is clear that systematic actions need to be taken to reach the target of keeping global warming under 2°C, which was approved by the UN Conference on Climate Change in Paris in December 2015.

**How OR and its subsidiaries can reduce emissions**
Since 2007, OR and ON Power have been striving to reduce carbon dioxide emissions from the Hellisheidi Geothermal Power Plant with partners in the international CarbFix project which was launched in 2007, as well as the SulFix project. In 2015, some 3,900 tons of carbon dioxide were injected into the bedrock in these projects where the carbon dioxide has permanently mineralised in solid form, see section on the Carbon Dioxide, Hydrogen and Methane Emissions. Moreover, the OR Group has set itself the target to avail of the possibilities of the company, infrastructure, products, know-how and capacity to facilitate changes in the utilisation of renewable energy sources in transport, see section on Transport. Over the coming year the company will furthermore commence on the reclamation of the wetlands it owns, in collaboration with the Agricultural University of Iceland.

**Greenhouse gas emissions**
Some greenhouse gas emissions stem from the activities of the OR Group, see details in section on Carbon Dioxide, Hydrogen and Methane Emissions. Emissions from operations are classified according to their source:

- Energy production from geothermal power plants in the Hengill area.
- Fuel consumption in back-up power generators, car fleet and flights.
- Waste for landfilling.
- Supply and distribution systems.

Data on greenhouse gas emissions due to OR Group's operations in 2011-2015 is to be found in Annex 29. Carbon dioxide emissions contracted in Hellisheidi and Nesjavellir in 2015 in relation to 2014, whereas methane emissions decreased in Hellisheidi and increased slightly in Nesjavellir. At the Hellisheidi power plant less steam was harnessed in 2015 than in the previous year and the concentration of gases varied between wells. Carbon dioxide was also reinjected into basaltic bedrock at Hellisheidi. Greenhouse gas emissions from the car fleet were higher in 2015 than in previous years. Sulphur hexafluoride ($SF_6$) is used as an insulating gas in the power stations' high-voltage equipment in the supply and distribution stations of the OR Group. There were no sulphur hexafluoride emissions in 2015. The total quantity of $SF_6$ in electrical equipment is about 3.9 tons and in stock about 1 ton.

**Carbon footprint**
The carbon footprint is a measure showing greenhouse gas emissions caused by human activity in warming the atmosphere. The impact of greenhouse gases on the Earth's temperature varies. The unit of measure for the carbon footprint is kg or tons of $CO_2$-equivalents, i.e., the global warming effect of different greenhouse gases is converted into equivalents of $CO_2$.

Land reclamation and forestry sequester carbon and offset emissions, but this also occurs by reinjecting carbon dioxide into the basaltic bedrock. The sorting and recycling of waste instead of landfilling reduces greenhouse gas emissions. This offsets emissions. Net emissions are therefore total emissions minus sequestration. The calculation of carbon sequestration is founded on the findings of studies indicating that the average sequestration in an Icelandic forest is about 4.4 tons of carbon dioxide per hectare of land a year. A density of 2,000 plants per hectare is assumed. It has also

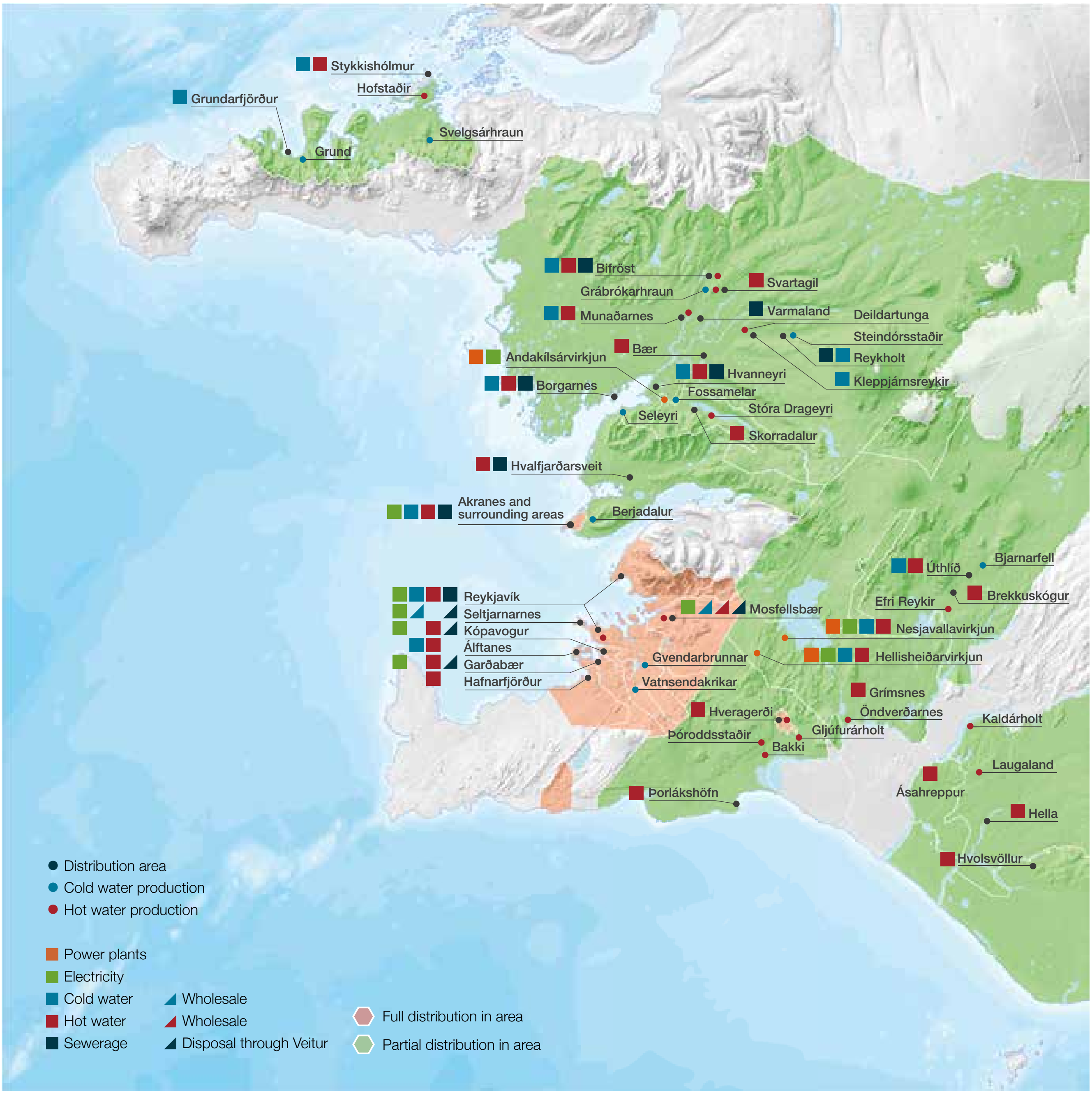
## Did you know?

The OR Group was nominated for the Nordic Council Nature and Environment Prize in 2015. The company's contribution were the CarbFix and SulFix projects, but also the savings in carbon emissions obtained by the Group's district heating systems. Carbon dioxide emissions would almost double in Iceland if oil were used for space heating.

# Annexes

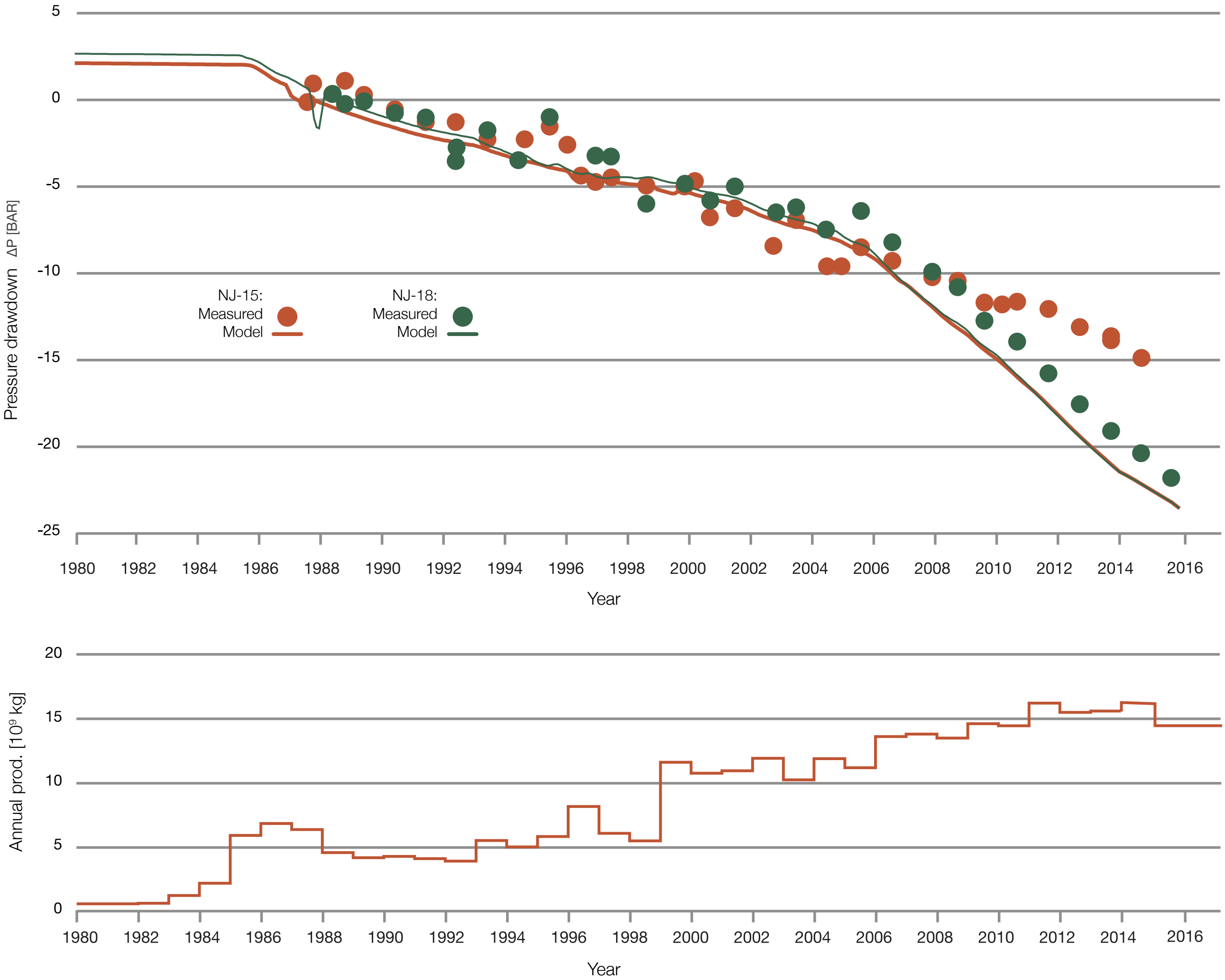
## Annex 1. **OR and subsidiaries' main area of operation**

Our service area is primarily in the capital but also in many parts of the South and West Iceland. Our system is extensive; pipes and cables are a total of 9,000 km in length, corresponding to the distance from Reykjavik to Shanghai. In the capital area there are distribution stations, wells, well shelters, tanks, pumping stations, sewage treatment plants etc. in our care.

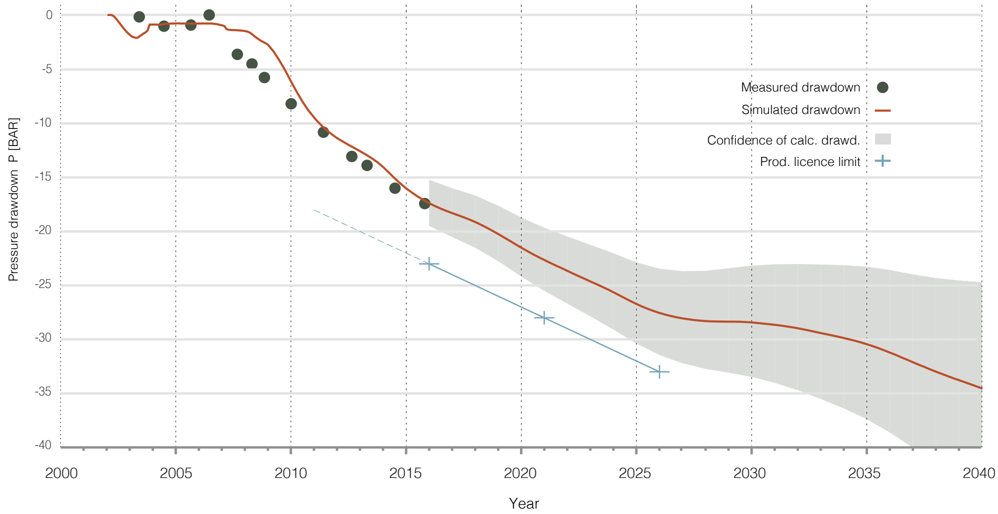


## Annex 2. **Drawdown 1980-2015**

2a). Drawdown (bar) and average annual production (kg/s) in Nesjavellir 1980-2015. A comparison between the measured and calculated drawdown appears in the upper part of the figure and the annual average production in the lower part. Solid curves show simulated results, while dots show measured values in wells at a depth of 800-1000 m. The red curve shows the drawdown in well NJ-18 and the blue curve in well NJ-15. The NJ-15 well came into operation in 2015 and was therefore not measured.



2b). Drawdown in Hellisheidi. Comparison of the measured and estimated pressure drop, the so-called drawdown (bar), in well HE-4 in Hellisheidi 2000-2040. The crosses are limits according to the power plant licence. A line is drawn between the crosses, but the points are drawn according to 2011 when the licence entered into force. The confidence of the simulated pressure drawdown are shown in grey.




## Annex 3. **Chemical analyses of hot water in the capital area 2015**

**CHEMICAL ANALYSES OF HOT WATER IN THE CAPITAL AREA**

| | UNIT | LAUGARNES RV-5 | ELLIÐAÁR RV-23 | REYKIR MG-25 | REYKJAHLÍD MG-39 | NESJAVELLIR HEATED WATER | HELLISHEIDI HEATED WATER |
|---|---|---|---|---|---|---|---|
| **DATE** | | **1/27/2015** | **1/14/2015** | **1/29/2015** | **2/3/2015** | **8/7/2015** | **8/7/2015** |
| **SAMPLE NO.** | | **15-5052** | **15-5019** | **15-5066** | **15-5089** | **15-5385** | **15-5392** |
| Water temp. | °C | 128.9 | 88.3 | 92.8 | 92.2 | 80 | 80 |
| pH | | 8.78 | 9.52 | 9.60 | 9.71 | 8.22 | 7.80 |
| pH-temp. | °C | 23.4 | 23.2 | 23.5 | 23.3 | 25.2 | 21.8 |
| Conductivity | µS/cm | 299 | 214 | 195.8 | 202 | 185.6 | 86.4 |
| Conduct. temp. | °C | 22.8 | 22.6 | 22.8 | 22.7 | 23.1 | 23.1 |
| $CO_2$ | mg/kg | 19.1 | 27.5 | 25.1 | 25.4 | 46.3 | 27.1 |
| $H_2S$ | mg/kg | 0.52 | 0.00 | 0.69 | 1.27 | 0.58 | 0.20 |
| $SiO_2$ | mg/kg | 151.1 | 84.2 | 95.6 | 95.8 | 44.8 | 24.3 |
| Na | mg/kg | 67.3 | 47.4 | 46.9 | 46.6 | 18.9 | 7.1 |
| K | mg/kg | 2.71 | 1.17 | 0.93 | 1.09 | 2.52 | 1.17 |
| Ca | mg/kg | 3.40 | 2.94 | 2.46 | 1.95 | 9.06 | 5.12 |
| Mg | mg/kg | <0.005 | <0.005 | <0.005 | <0.005 | 4.435 | 2.958 |
| Fe | mg/kg | 0.009 | 0.006 | 0.006 | 0.007 | 0.028 | 0.009 |
| Al | mg/kg | 0.203 | 0.129 | 0.161 | 0.184 | 0.172 | 0.008 |
| Li | mg/kg | - | - | - | - | - | - |
| Cl | mg/kg | 46.4 | 25.1 | 16.8 | 13.2 | 14.6 | 7.4 |
| $SO_4$ | mg/kg | 23.9 | 13.2 | 14.8 | 15.3 | 12.9 | 2.9 |
| F | mg/kg | 1,470 | 0.310 | 0.580 | 0.700 | 0.030 | 0.070 |
| B | mg/kg | 0.064 | 0.018 | 0.043 | 0.042 | 0.102 | <0.01 |
| Dissolved $O_2$ | µg/kg | 0 | 400 | 0 | 0 | 0 | 0 |

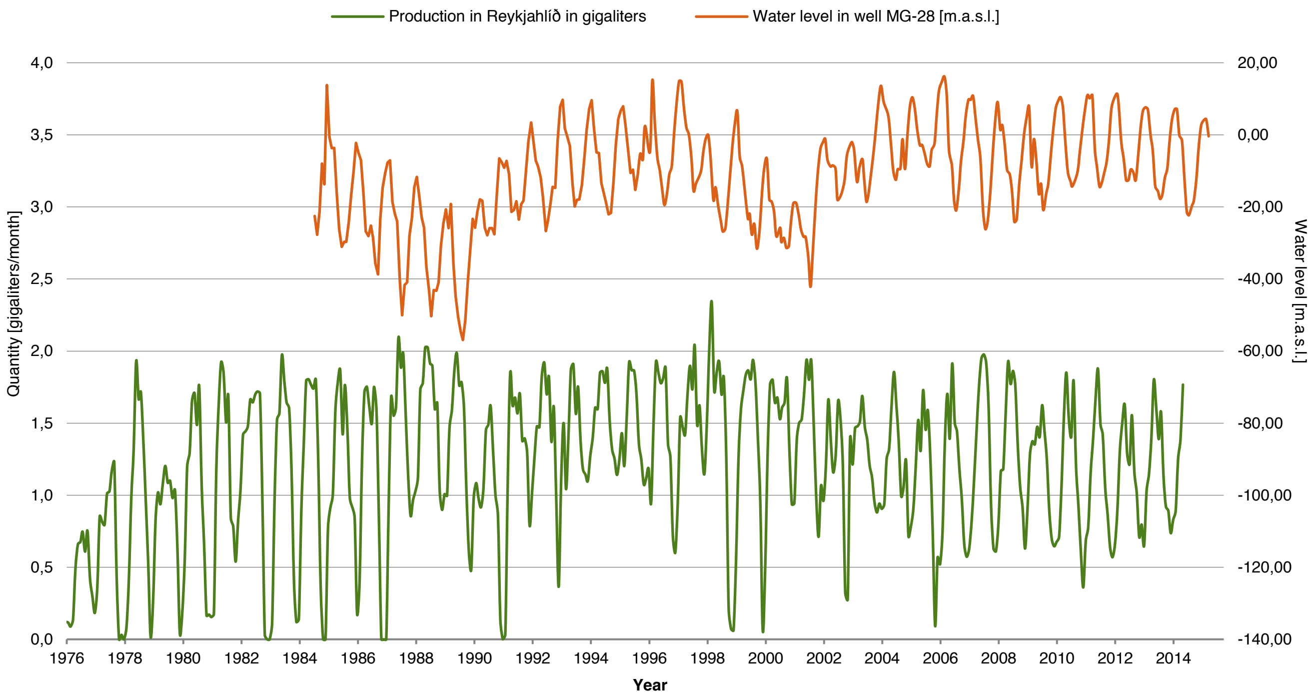
## Annex 4. **Chemical analyses of hot water in South and West Iceland 2015**

**CHEMICAL ANALYSES OF HOT WATER IN SOUTH AND WEST ICELAND**

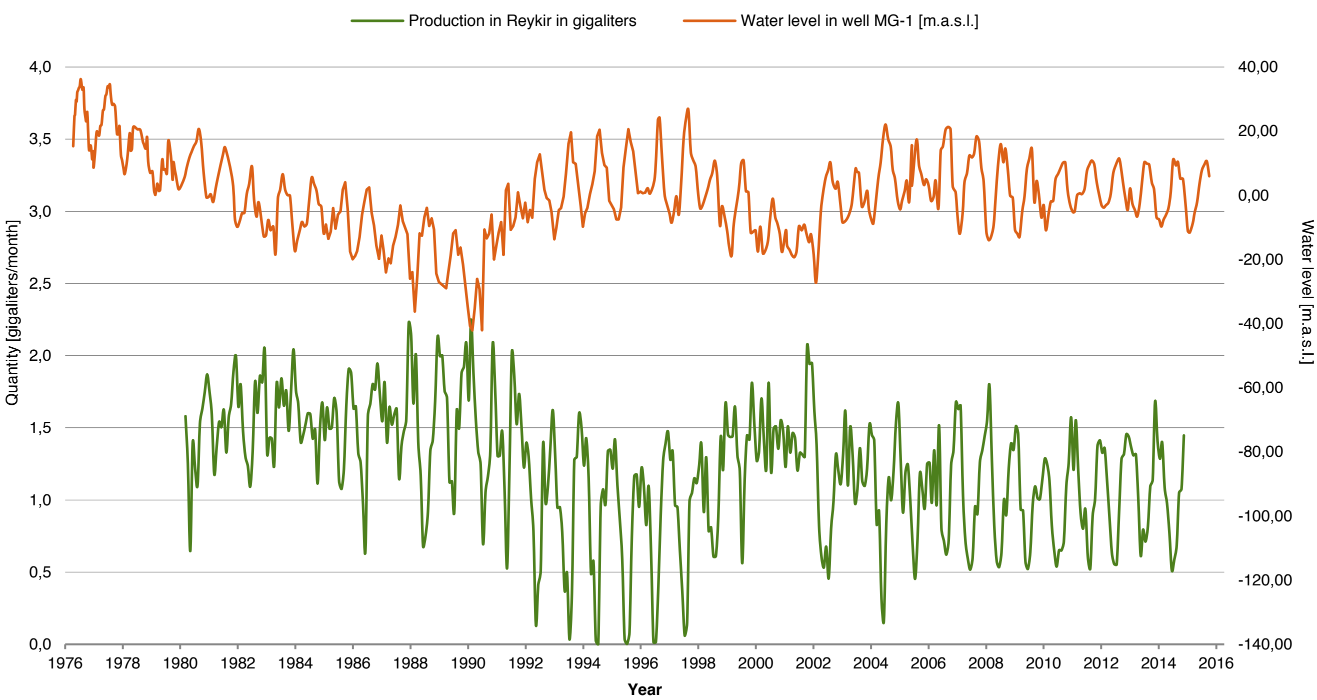
| | UNIT | HITAVEITA AKRANESS OG BORGARFJARÐAR | | RANGÁ UTILITY | | ÞORLÁKSHÖFN UTILITY | ÖLFUS UTILITY | AUSTURVEITA | GRÍMSNES UTILITY | HLÍÐ UTILITY | MUNAÐARNES | NORÐURÁRDALUR UTILITY | | STYKKISHÓLMUR UTILITY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SAMPLE SITE** | | **Deildartunguhver** | **LH-1** | **KH-37** | **LW-4** | **BA-01** | **EB-01** | **GH-4** | **HÖ-29** | **ER-23** | **MN-8** | **SG-3** | **BI-3** | **HO-1** |
| **DATE** | | **2/9/2015** | **2/9/2015** | **2/18/2015** | **2/18/2015** | **2/17/2015** | **2/17/2015** | **2/18/2015** | **2/17/2015** | **2/17/2015** | **2/9/2015** | **2/9/2015** | **2/9/2015** | **2/4/2015** |
| **SAMPLE NO.** | | **15-5115** | **15-5116** | **15-5151** | **15-5146** | **15-5145** | **15-5143** | **15-5154** | **15-5141** | **15-5140** | **15-5112** | **15-5114** | **15-5113** | **15-5101** |
| Water temp. | °C | 96.3 | 89.6 | 65.9 | 97.3 | 109.2 | 119.5 | 116.3 | 79.7 | - | 87.6 | 67.7 | 66.7 | 85.5 |
| pH | | 9.46 | 9.22 | 10.34 | 9.81 | 8.91 | 8.87 | 8.91 | 9.44 | 9.51 | 9.40 | 8.92 | 9.11 | 8.07 |
| pH-temp. | °C | 23.5 | 23.2 | 23.2 | 23.4 | 23.2 | 23.0 | 23.2 | 23.2 | 23.3 | 23.1 | 23.2 | 23.3 | 23.2 |
| Conductivity | μS/cm | 330 | 546 | 329 | 408 | 2460 | 1723 | 640 | 539 | 438 | 487 | 364 | 351 | 8,530 |
| Conduct. temp. | °C | 23.0 | 23.0 | 22.7 | 22.7 | 22.8 | 22.9 | 22.7 | 22.9 | 22.9 | 22.7 | 22.8 | 22.7 | 22.7 |
| $CO_2$ | mg/kg | 26.8 | 17.0 | 13.0 | 19.7 | 5.7 | 9.8 | 43.7 | 15.7 | 26.6 | 15.8 | 80.0 | 62.2 | 8.1 |
| $H_2S$ | mg/kg | 1.18 | 0.73 | 0.14 | 0.07 | 0.48 | 0.65 | 0.17 | 0.11 | 2.98 | 0.33 | 0.01 | 0.04 | 0.03 |
| $SiO_2$ | mg/kg | 134.6 | 115.0 | 89.4 | 97.2 | 131.0 | 117.4 | 139.4 | 83.2 | 231.7 | 115.2 | 103.9 | 92.3 | 71.6 |
| Na | mg/kg | 78.7 | 114.8 | 65.8 | 96.1 | 398.3 | 299.9 | 121.7 | 116.1 | 105.4 | 88.7 | 77.1 | 70.3 | 726.9 |
| K | mg/kg | 2.17 | 2.61 | 0.70 | 1.90 | 16.84 | 12.15 | 3.65 | 2.94 | 5.56 | 2.74 | 1.31 | 1.30 | 14.41 |
| Ca | mg/kg | 2.97 | 14.14 | 2.68 | 3.20 | 69.37 | 46.36 | 4.39 | 7.90 | 1.96 | 7.03 | 3.40 | 2.88 | 1,093,30 |
| Mg | mg/kg | <0.005 | 0.043 | <0.005 | <0.005 | 0.009 | 0.006 | <0.005 | <0.005 | <0.005 | 0.008 | 0.011 | <0.005 | 0.533 |
| Fe | mg/kg | 0.020 | 0.083 | <0.005 | 0.013 | 0.012 | 0.012 | <0.005 | 0.020 | 0.04 | 0.014 | <0.005 | <0.005 | 0.094 |
| Al | mg/kg | 0.119 | 0.104 | 0.123 | 0.198 | 0.078 | 0.096 | 0.144 | 0.060 | 0.480 | 0.058 | 0.018 | 0.021 | 0.007 |
| Li | mg/kg | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Cl | mg/kg | 34.9 | 115.6 | 24.6 | 50.5 | 639.1 | 436.7 | 112.0 | 130.4 | 57.3 | 74.9 | 26.5 | 29.0 | 2,875,8 |
| $SO_4$ | mg/kg | 53.0 | 72.2 | 21.5 | 74.1 | 117.4 | 126.6 | 52.9 | 48.1 | 57.5 | 55.3 | 29.5 | 31.6 | 337.2 |
| F | mg/kg | 2.4 | 1.91 | 2.22 | 0.93 | 0.43 | 0.46 | 0.89 | 0.54 | 2.57 | 1.74 | 0.53 | 0.6 | 1.1 |
| B | mg/kg | 0.265 | 0.272 | 0.128 | 0.26 | 0.29 | 0.295 | 0.307 | 0.115 | 0.185 | 0.227 | 0.207 | 0.232 | 0.127 |
| Dissolved $O_2$ | μg/kg | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Annex 5. **Water production and water level in wells in the low-temperature geothermal fields in Reykjahlíd and Reykir in Mosfellsbaer and Ellidaárdalur and Laugarnes in Reykjavik**

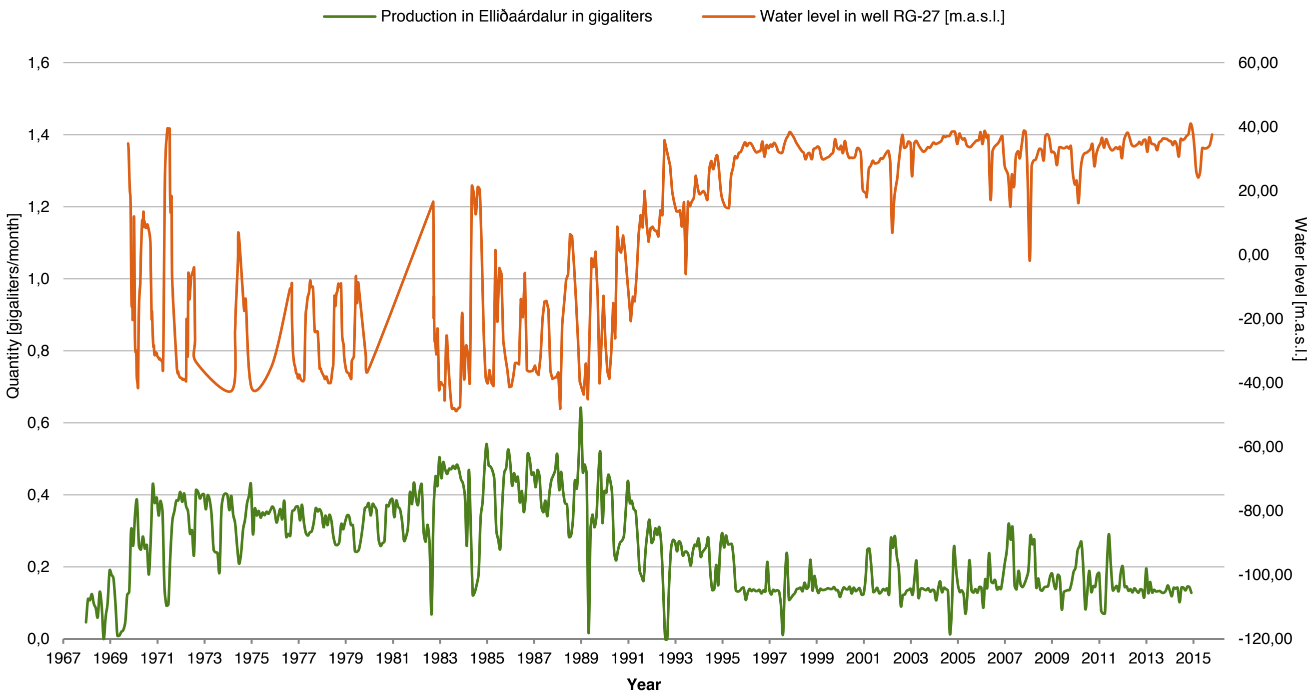
5a) Low-temperature geothermal fields in Reykjahlíd in Mosfellsbaer. Water production and water level in well MG-28 between 1976-2015.



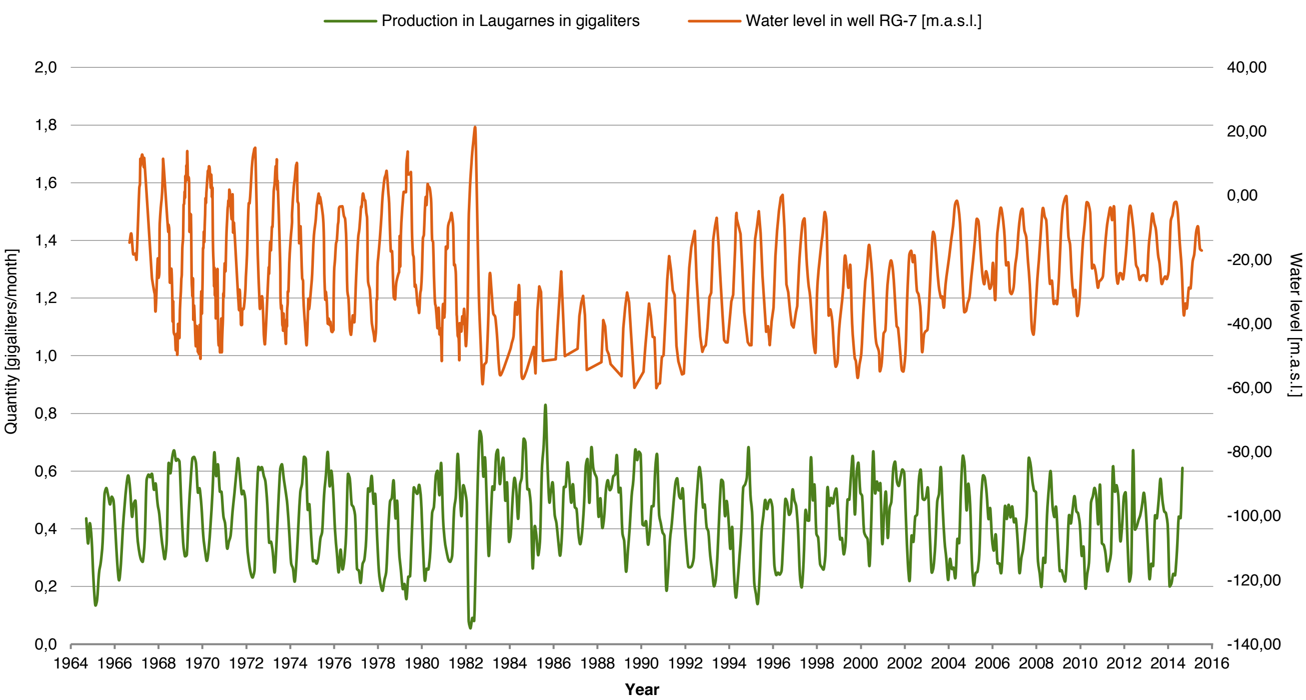

5b) Low-temperature geothermal fields in Reykir in Mosfellsbaer. Water production and water level in well MG-1 between 1976-2015.



5c) Low-temperature geothermal fields in the Ellidaárdalur valley in Reykjavik. Water production and water level in well RG-27 between 1968-2015.




5d) Low-temperature geothermal fields in Laugarnes in Reykjavik. Water production and water level in well RG-7 between 1965-2015.



## Annex 6. **Location and name of land owned, rented or administered by OR and its subsidiaries in protected areas**

OR and its subsidiaries administer about 19,000 ha of land, some 16,000 ha of which are within protected areas. These include water conservation areas, protected characteristics in regional, municipal and local plans, protected areas around Lake Thingvallavatn, areas covered by the natural features' data base etc.

| AREA | NAME OF PLACE | WATER CONSERVATION | PROTECTED ARCHAEOLOGICAL SITES | NATURAL FEATURES DATA BASE | PROTECTED CHARACTERISTICS IN REGIONAL, MUNICIPAL AND LOCAL PLANS |
|---|---|---|---|---|---|
| Capital area | Bláfjöll - Heidmörk etc. | Water conservation areas. | | | Sudurá: Wetland, abundant birdlife. Hólmshraun: Lavafields covered with moss. |
| | Heidmörk | Water conservation areas in Gvenndarbrunnar, Myllulaekur and Vatnsendakrikar. | Thingnes: Archaeological remains at an ancient gathering site. Raudhólar: Protected as naturepark 1974. Size 45 ha. | Myllulaekjartjörn in Heidmörk | Bugda and Raudhólar: Wetland, abundant birdlife. Raudhólar: Protected naturepark. Rootless cones in lava approx. 4500 years old. Bugda wetland, abundant vegetation and birdlife during nesting time. |
| | Ellidavatn | | | | Ellidavatn: Local environment, vegetation and birdlife. |
| West Iceland | Berjadalur, Slögu-veita and Ósveita, Grábrók, Seleyri, Grund, Fossamelar, Steindórsstadir, Svelgsárhraun | Water conservation area etc. | | | |
| South Iceland | Úthlíd | Water conservation area Bjarnarfell | | | |
| Hengill | Nesjavellir | Law on the protection of lake Thingvallavatn and its water catchment area no. 85/2005. | | The Hengill area: Magnificent landscapes and geologically diverse including geothermal areas. | |
| Nesjavellir | Dyrdalur Sporhelludalur Skeggjadalur | Water spring in Grámelur in Nesjahraun lava field for Nesjavellir geothermal power plant. Two water springs and water conservation areas in Nesjalaugagil. | | | Small valley and ridges consisting of hyaloclastite. The ancient Dyravegur path in Dyradalur valley. In Sporhelludalur valley are visible ancient paths in the ground. Dyrnar and Sporhellan classified as historic relics. |
| | Fálkaklettar-Sel-klettar (crater row) | Water conservation area. | | | Multiformed row of craters, the whole magnificent, and the greatest of the northern Hengill area. Historical artefacts related to the oldest farm site at Nesjavellir and Selklettar. |
| | Botnadalur, Illagil, Krummar | | | | A magnificent landscape in Botnadalur valley and well-preserved remains of human settlement. Continuous brushy lands in Illagil canyon and east of Krummi. |
| | Skógarhóll, Eldborg and Grámelur | Water conservation area. | | | Remarkable eruptive remnants in Nesjahraun, a moss and brush covered lava field with beautifully shaped craters. Eldborg is an elegantly shaped rootless cone. |
| | Raudstrýta and surroundings | Water conservation area. | | | Brushy and fractured lava formation with a crater and a fault. |
| | Gíghólar east of Hveralaekur | | | | Impressive crater formations that have been preserved within Nesjavellir power plant's production field. |
| | Nesjalaugargil Köldulaugargil | Nesjalaugagil: Water conservation area. | | | Colourful geothermal area with scales and deposit and a variety of hot springs and pools. Spectacular river gullies with waterfalls. |
| | Hagavíkurlaugar | | | | Due to its increasing popularity as a general outdoors recreation area, general guideline rules regarding orderliness and conduct are to be made. The building of huts will be forbidden, the traffic of automotive vehicles limited, grazing of horses prohibited along with all use of firearms. |
| Kolvidarhóll | Engidalur Hellisskard | Hellisheidi power plant's water supply in Engidalskvísl west of Húsmúli. Groundwater recharge area. | | | Faults in the B/C lava below Hellisskard. It circumvents the slope downhill of Búasteinn and in the same manner on the side of mt. Reykjafell. |
| | Stóra-Reykjafell | | | | All of mt. Stóra-Reykjafell. However the mountain contains two large explosive craters; Daudadalur valley in the north face of mt. Stóra-Reykjafell and Hveradalir valley on its southern flanks. Both craters are relatively unspoiled. Daudadalur valley is as good as untouched. |
| | Kolvidarhóll | | | | Archeological remains by Kolvidarhóll are protected according to the local plan in the area - sources like dwellings, burial sites, field wall, peat extraction sites, cairns etc. |

| AREA | NAME OF PLACE | WATER CONSERVATION | PROTECTED ARCHAEOLOGICAL SITES | NATURAL FEATURES DATA BASE | PROTECTED CHARACTERISTICS IN REGIONAL, MUNICIPAL AND LOCAL PLANS |
|---|---|---|---|---|---|
| Hjallatorfan (Hellisheidi and Ölfus) | Eldborg by Meitlar etc. | Water conservation area. | Old national routes | Eldborg by Meitlar. A big cinder cone. | Preservation of the Hengill area as a nature and recreation reserve. |
| | Hellukofi, Varmá and Ölfusforir | | A rock hut stacked between 1830-1840. Archeologically preserved. | Varmá and Ölfusforir - Ölfusforir include expansive, wet pastures and inhabited by a great a diverse birdlife. Varmá holds a high scientific value. | The southern craters in the B/C lava, which is about 5.800 years old. These are low-rising unspoiled cinder- and scoria cones. |
| | Cairns by Hellukofinn, Thurá, D-lava | Thurá: Water conservation area. | Cairns by the path to the east of Hellukofinn. | A old shoreline west of Thurárhnúkur. Shore ridges above Thurá by the main road. The most prominent evidence in the region of sea-level changes at the end of the last ice age. | The northern craters in the D-lava, which is aged at around 2.000 years. These are low-rising unspoiled cinder- and scoria cones. |
| | Thorlákshafnarsel Eldborgir by mt. Lambafell Eystri-Thurá | Eldborgir by mt. Lambafell: Water conservation area. | The ruins of Thorláks-hafnarsel in Hellisheidi. Document signed by ÞM 20.01.1976. Officially registered 16.06.1977 | Eldborgir by mt. Lambafell. Beutifully shaped volcanic craters formed in historical times. The volcanic craters, their lava channels and the surrounding lava field. | Archeological remains by East-Thurá. Sources of dwellings, staples, barns and peat excavation sites (528;1-9) |
| | Meitlar Eldborgarhraun Skálafell | Water conservation area. | | | Outdoors recreation area located between Sudurlandsvegur (main road), Threngsli and Hjallatorfan. |
| | Breidabólsstadur | | | | Archeolandical remains that are protected according to the local plan in the area - Breidabólsstadur 544:1-44. Sources of dwellings, a church, staples, field walls, irrigation, cairns etc. |
| Bakki | | | | Varmá and Ölfusforir - Ölfusforir are expansive, wet pastures and inhabited by a great a diverse birdlife. Varmá holds a high scientific value. | |
| Ölfusvatn | Kýrgil Ölkelduháls Tjarnahnjúkur Ölfusvatnsbaerinn | Law on the protection of lake Thingvallavatn and its water catchment area no. 85/2005. | Artefacts near the old Ölfusvatn farm. | | Pristine geothermal field, wetlands and river gullies. Power utilization needs to be developed with great care. Ölfusvatn's old farm along with its surroundings. Diverse archeolandical remnants. |
| | Laki, Álftatjörn and Efri-Kattartjörn | Water supply by Ölfusvatnsá river - water not safe for consumption. | Ancient wall fence, named Grímkelsgerdi and a large hummock within called the grave of Grímkell, preserved in 1898. | | Pristine and diverse landscape and geolandical features; river gullies, a scoria cone, explosive crates and hot springs. Ponds and wetlands. |
| | Ölfusvatnsárglúfur west of Stapafell | Water supply by the river in wetlands by the camping site - water not safe for consumption. | A basaltic rock (olivín þóleit) fixed to the ground, carrying the inscription „VES+1736". Believed to be someone's initials and year. Protected in 1927. | | Pristine and diverse river gully and erosive formations. Archeological remnants in Seltún. |
| | Ölfusvatnsá, Villingavatnsá etc. | | | | Ölfusvatnsá and Villingavatnsá rivers along with adjacent wetlands and shore of lake Thingvalla-vatn. Meandering riverbeds, small deltas and brushy vegetated wetlands. |
| | Lambhagi | | | | A promontory that juts out into lake Thingvalla-vatn and connects to land via a low sand bar. High recreational value and a unique view over lake Thingvallavatn. An ancient wall lies across the sand bar. |
| | | | | | Due to its increasing popularity as a general outdoors recreation area, general guideline rules regarding orderliness and conduct are to be made. The building of huts will be forbidden, the traffic of automotive vehicles limited, grazing of horses prohibited along with all use of firearms. |
| Bakki | | | | Varmá and Ölfusforir - Ölfusforir are expansive, wet pastures and inhabited by a great a diverse birdlife. Varmá holds a high scientific value. | |

## Annex 7. **Species of birds (a) and plants (b) on the Red List of the Icelandic Institute of Natural History (NÍ) and the IUCN Red List of threatened species on land owned, rented or administered by OR and its subsidiaries**

7a) Bird species

| STATUS ON NÍ RED LIST | SPECIES | AREA, LAST SIGHTING | PREMISE FOR THE NÍ RED LIST | STATUS ON IUCN RED LIST |
|---|---|---|---|---|
| Extinct in the wild (EW) | Little Auk (Alle alle) | Heidmörk, Helluvatn, 2005 | Ceased nesting in Iceland around 1995 | LC (Least concern) |
| | Water Rail (Rallus aquaticus) | Heidmörk, 2013 | Ceased nesting in Iceland around 1970 | LC (Least concern) |
| Endangered (EN) | White-tailed Sea-eagle (Haliaeetus albicilla) | Heidmörk, 2015 | Small population, <250 individuals | LC (Least concern) |
| | Barnacle Goose (Branta leucopsis) | Heidmörk, by Bugda north of Raudhólar, 2011 / Ölfusforir 2011 | Small population, <250 individuals | LC (Least concern) |
| | Barrow's Goldeneye (Bucephala islandica) | Heidmörk, Helluvatn, 2013 | Small population, <250 individuals | LC (Least concern) |
| | Northern Shoveler (Anas clypeata) | Heidmörk, 2015 | Small population, <250 individuals | LC (Least concern) |
| Vulnerable (VU) | Short-eared Owl (Asio flammeus) | Heidmörk, 2015 | Small population, <1,000 individuals | LC (Least concern) |
| | Gyrfalcon (Falco rusticolus) | Heidmörk, 2015 Nesjavellir, (2009) | Small population, <1,000 individuals | LC (Least concern) |
| | Horned Grebe (Podiceps auritus) | Heidmörk, Ellidavatn, 2014 | Small population, <1,000 individuals | VU (Vulnerable) |
| | Gadwall (Anas strepera) | Heidmörk, Ellidavatn, 2013, Ölfusforir 2011 | Small population, <1,000 individuals | LC (Least concern) |
| | Greylag Goose (Anser anser) | Heidmörk, 2015 Ölfusforir, 2011, Hellisskard/Kolvidarhóll | Population reduction, >20% reduction in 10 years | LC (Least concern) |
| | Goosander (Mergus merganser) | Heidmörk, 2015 | Small population, <1,000 individuals | LC (Least concern) |
| | Common Loon (Gavia immer) | Heidmörk, Myllulækjartjörn, Hrauntúnstjörn, 2015 | Small population, <1,000 individuals | LC (Least concern) |
| | Common Raven (Corvus corax) | Heidmörk, 2015, Ölfusforir 2011, Hellisskard/Nesjavellir 2005 | Population reduction, >20% reduction in 10 years | LC (Least concern) |
| | Great Black-backed Gull (Larus marinus) | Heidmörk, 1999; hardly any sighting since 2000, Ölfusforir 2011 | Greatly reduced | LC (Least concern) |
| Lower risk (LR) | Harlequin Duck (Histrionicus histrionicus) | Heidmörk, 2012; Middalur/Fremstidalur/ Ölkelduháls, 2005; Bitra (2006) | Conservation dependent, Iceland is the only nesting site in Europe | LC (Least concern) |
| | Northern Pintail (Anas acuta) | Heidmörk, Helluvatn, 2005, Ölfusforir 2011 | Conservation dependent | LC (Least concern) |

Hafsteinn Björgvinsson's annual reports: Birds and other animals in water conservation areas of Reykjavík, available at: www.or.is
Categories and criteria of the International Union for Conservation of Nature (and Natural Recourses') (IUCN) Red List:
http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-catecories-criteria#categories
Válisti 2 Fuglar (see pages 12-13 í http://utgafa.ni.is/valistar/valisti-2.pdf). Náttúrufrædistofnun Íslands, 2000.

7b) Plant species

| STATUS ON NÍ RED LIST | SPECIES | AREA, AGE OF DATA | STATUS ON IUCN RED LIST |
|---|---|---|---|
| Vulnerable (VU) | Blue Water-speedwell | Hengill area, 2005 / Ölkelduháls, 2006 / Hellisheidi, 2006 | LC (Least concern) |
| | (Veronica anagallis-aquatica) | | |
| | Lesser smoothcap | Fremstadal, 2002, 2004 / near Ölkelduháls 2001, 2006 / Hellisheidi, 2006 | NE (Not evaluated) |
| | (Atrichum angustatum) | | |
| | Heath star moss | Fremstadal, 2002 / Hellisheidi 2006 / Ölkelduháls 2006 | NE (Not evaluated) |
| | (Campylopus introflexus) | | |
| Lower risk (LR) | Small adder's-tongue fern | Middalur, 2005 / Near Ölkelduháls, 2001, 2005, 2006 /Hellisheidi 2006 | NE (Not evaluated) |
| | (Ophioglossum azoricum) | | |
| | Campylopus moss | Fremstadal 2002 / Hellisheidi 2006 | NE (Not evaluated) |
| | (Campylopus flexuosus) | | |
| Near threatened (NT) Conservated species not Red Listed | Marsh cudweed | Near Ölkelduháls, 2005, 2006 / Fremstadal, 2005 / Hellisheidi, 2006 | NE (Not evaluated) |
| | (Filaginella uliginosa) | | |
| | Eggleaf twayblade | Heidmörk, 2006 | NE (Not evaluated) |
| | (Listera ovata) | | |
| Not applicable (NA) | Dickie's Bladder-fern | Heidmörk, 2006 | NE (Not evaluated) |
| | (Cystopteris fragilis f. dickieana) | | |

Categories and criteria of the International Union for Conservation of Nature (and Natural Resources') (IUCN) Red List:
http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria#categories

## Annex 8. **Measurement of microbes and chemical composition of potable water in Reykjavik 2015**

### MICROBES IN POTABLE WATER 2015

| | MAX. RECOMM-ENDED | MYLLULÆKUR V-13 | | | LAXALÓN LOKAHÚS | | | VATNSENDAKRIKI VK1 | | | LOKAHÚS KRINGLUMÝRARBRAUT | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | VALUE | AVERAGE | MAX | MIN | AVER-AGE | MAX | MIN | AVERAGE | MAX | MIN | AVER-AGE | MAX | MIN |
| Total microbes 22°C | 100/ ml | 0 | 0 | 0 | 0.88 | 3 | 0 | 0 | 0 | 0 | 0.96 | 4 | 0 |
| Escherichia coli (E. Coli) | 0/100 ml | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Enterococci | 0/100 ml | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### CHEMICAL COMPOSITION OF POTABLE WATER

| PHYSIOLOGICAL AND CHEMICAL PROPERTIES | UNIT | MAX. RECOMM-ENDED VALUE | CO. | LABORATORY | MYLLU-LÆKUR V-13 HEIÐMÖRK | EIRÍKSGATA DÆLUSTÖÐ | VATNSENDA-KRIKI VK-1 HEIÐMÖRK | ÁRBÆJAR-STÍFLA LOKAHÚS |
|---|---|---|---|---|---|---|---|---|
| SAMPLE NO. | | | | | R-15-1093-1/4991 | R-15-1093-2/4992 | R-15-2801-1/6701 | R-15-2801-2/6702 |
| SAMPLING MONTH | | | | | April 2015 | April 2015 | October 2015 | October 2015 |
| Colour of sample | mgPt/l | | | ALS | <5 | <5 | <5 | <5 |
| Turbidity | NTU | adequate | (1) | MATÍS | <0.10 | 0.18 | <0.10 | <0.10 |
| Temperature | °C | 25 | | MATÍS | 3.7 | 4.2 | 3.8 | 4.2 |
| pH | pH unit | | | MATÍS | 8.90 | 9.05 | 8.95 | 9.00 |
| Conductivity | µS/cm | 2500 | | MATÍS | 86 | 87 | 75 | 85 |
| Chloride (Cl) | mg/l | 250 | | ALS | 10 | 10.4 | 9.18 | 10.9 |
| Sulphate ($SO_4$) | mg/l | 250 | | ALS | 1.8 | 2.08 | 2.07 | 2.11 |
| Fluoride (F) | mg/l | 1.5 | | ALS | <0.200 | <0.200 | <0.200 | <0.200 |
| Nitrate ($NO_3$) | mg/l | 50 | | ALS | 0.195 | 0.168 | 0.261 | 0.19 |
| Nitrite ($NO_2$) | mg/l | 0.5 | | ALS | <0.01 | <0.01 | <0.01 | <0.01 |
| Ammonium ($NH_4$-N) | mg/l | 0.5 | | ALS | <0.020 | <0.020 | <0.026 | <0.026 |
| TOC | mg/l | no abnormal changes | | ALS | 0.52 | <0.50 | <0.50 | <0.50 |
| | | | | | | | | |
| Calcium (Ca) | mg/l | 100 | (3) | ALS | 4.78 | 4.47 | 5.4 | 4.96 |
| Iron (Fe) | mg/l | 0.2 | | ALS | <0.0004 | 0.001 | 0.001 | 0.003 |
| Potassium (K) | mg/l | 12 | (3) | ALS | <0.4 | <0.4 | 0.465 | <0.4 |
| Magnesium (Mg) | mg/l | 50 | (3) | ALS | 0.835 | 0.813 | 0.932 | 0.938 |
| Sodium (Na) | mg/l | 200 | | ALS | 11.3 | 12.4 | 10.00 | 12.5 |
| Sulphur (S) | mg/l | | (4) | ALS | 0.67 | 0.879 | 0.787 | 0.807 |
| Silica (Si) | mg/l | | (4) | ALS | 6.09 | 6.12 | 7.08 | 6.8 |
| Aluminium (Al) | µg/l | 200 | | ALS | 12.5 | 15.5 | 23.0 | 18.8 |
| Arsen (As) | µg/l | 10 | | ALS | <0.05 | <0.05 | 0 | <0.05 |
| Boron (B) | µg/l | 1000 | | ALS | <10 | <10 | <10 | <10 |
| Barium (Ba) | µg/l | 700 | (3) | ALS | <0.01 | 0.110 | 0.069 | 0.090 |
| Cadmium (Cd) | µg/l | 5.0 | | ALS | <0.002 | <0.002 | <0.002 | <0.002 |
| Cobalt (Co) | µg/l | | (4) | ALS | <0.005 | <0.005 | <0.005 | <0.005 |
| Chromium (Cr) | µg/l | 50 | | ALS | 0.868 | 0.859 | 0.97 | 0.961 |
| Copper (Cu) | µg/l | 2000 | | ALS | <0.1 | 0.103 | <0.1 | 0.276 |
| Mercury (Hg) | µg/l | 1.0 | | ALS | <0.002 | <0.002 | <0.002 | <0.002 |
| Manganese (Mn) | µg/l | 50 | | ALS | <0.03 | <0.03 | <0.03 | <0.03 |
| Molybdenum (Mo) | µg/l | | (4) | ALS | 0.090 | 0.088 | 0.080 | 0.069 |
| Nickel (Ni) | µg/l | 20 | | ALS | <0.05 | 0.087 | <0.05 | <0.05 |
| Phosphorus (P) | µg/l | 5000 | (3) | ALS | 17.6 | 14.8 | 21.4 | 15.3 |
| Lead (Pb) | µg/l | 10 | | ALS | 0.014 | 0.013 | <0.01 | <0.01 |
| Antimon (Sb) | µg/l | 5.0 | | ALS | <0.01 | <0.01 | <0.01 | <0.01 |

| PHYSIOLOGICAL AND CHEMICAL PROPERTIES | UNIT | MAX. RECOMM-ENDED VALUE | CO. | LABORATORY | | MYLLU-LÆKUR V-13 HEIÐMÖRK | | EIRÍKSGATA DÆLUSTÖÐ | | VATNSENDA-KRIKI VK-1 HEIÐMÖRK | | ÁRBÆJAR-STÍFLA LOKAHÚS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Selen (Se) | µg/l | 10 | | ALS | | <0.5 | | <0.5 | | <0.5 | | <0.5 | |
| Strontium (Sr) | µg/l | | (4) | ALS | | <2 | | 2.63 | | 3.13 | | 3.33 | |
| Zinc (Zn) | µg/l | 3000 | (3) | ALS | | 0.831 | | 0.93 | | 0.822 | | 11.7 | |
| Vanadium (V) | µg/l | | | ALS | | 13.3 | | 13.2 | | 18.2 | | 15 | |
| cyanide (CN total) | µg/l | 50 | | ALS | | <0.005 | | <0.005 | | <0.005 | | <0.005 | |
| dichloromethane | µg/l | | | ALS | | <2.0 | | <2.0 | | <2.0 | | <2.0 | |
| 1,1 - dichloroethane | µg/l | | | ALS | | <0.10 | | <0.10 | | <0.10 | | <0.10 | |
| 1,2 - dichloroethane | µg/l | 3.0 | | ALS | | <0.10 | | <0.10 | | <0.10 | | <0.10 | |
| trans 1,2 - dichloroethane | µg/l | | | ALS | | <0.10 | | <0.10 | | <0.10 | | <0.10 | |
| cis 1,2 - dichloroethane | µg/l | | | ALS | | <0.10 | | <0.10 | | <0.10 | | <0.10 | |
| 1,2 - dichloropropane | µg/l | | | ALS | | <1.0 | | <1.0 | | <1.0 | | <1.0 | |
| tetrachloromethane | µg/l | | | ALS | | <0.10 | | <0.10 | | <0.10 | | <0.10 | |
| 1,1,1 - trichloroethane | µg/l | | | ALS | | <0.10 | | <0.10 | | <0.10 | | <0.10 | |
| 1,1,2 - trichloroethane | µg/l | | | ALS | | <0.20 | | <0.20 | | <0.20 | | <0.20 | |
| trichloroethene | µg/l | 10 | (2) | ALS | | <0.10 | | <0.10 | | <0.10 | | <0.10 | |
| tetrachloroethene | µg/l | | (2) | ALS | | <0.20 | | <0.20 | | <0.20 | | <0.20 | |
| vinyl chloride | µg/l | | | ALS | | <1.0 | | <1.0 | | <1.0 | | <1.0 | |
| benzene | µg/l | 1.0 | | ALS | | <0.20 | | <0.20 | | <0.20 | | <0.20 | |
| toluene | µg/l | | | ALS | | <0.20 | | <0.20 | | <0.20 | | <0.20 | |
| ethylbenzene | µg/l | | | ALS | | <0.20 | | <0.20 | | <0.20 | | <0.20 | |
| sum xylener | µg/l | | | ALS | | <0.20 | | <0.20 | | <0.20 | | <0.20 | |
| trichloromethane | µg/l | | | ALS | | <0.30 | | <0.30 | | <0.30 | | <0.30 | |
| tribromomethane | µg/l | | | ALS | | <0.20 | | <0.20 | | <0.20 | | <0.20 | |
| dibromochloromethane | µg/l | | | ALS | | <0.10 | | <0.10 | | <0.10 | | <0.10 | |
| bromodichloromethane | µg/l | | | ALS | | <0.10 | | <0.10 | | <0.10 | | <0.10 | |
| sum trihalomethane | µg/l | | | ALS | | <0.35 | | <0.35 | | <0.35 | | <0.35 | |
| | | | | | | | | | | | | | |
| o-xylene | µg/l | | | ALS | | <0.20 | | <0.20 | | <0.20 | | <0.20 | |
| sum xylene | µg/l | | | ALS | | <0.20 | | <0.20 | | <0.20 | | <0.20 | |
| naphtalen | µg/l | | | ALS | | <0.20 | | <0.20 | | <0.20 | | <0.20 | |
| acenaphthylene | µg/l | | | ALS | | <0.10 | | <0.10 | | <0.10 | | <0.10 | |
| acenaphthene | µg/l | | | ALS | | <0.0070 | | <0.0070 | | <0.0070 | | <0.0070 | |
| fluorene | µg/l | | | ALS | | <0.010 | | <0.010 | | <0.010 | | <0.010 | |
| phenanthrene | µg/l | | | ALS | | <0.040 | | <0.040 | | <0.040 | | <0.040 | |
| anthracene | µg/l | | | ALS | | <0.0050 | | <0.0050 | | <0.0050 | | <0.0050 | |
| fluoroanthene | µg/l | | | ALS | | <0.0050 | | <0.0050 | | <0.0050 | | <0.0050 | |
| pyrene | µg/l | | | ALS | | <0.0050 | | <0.0050 | | <0.0050 | | <0.0050 | |
| *benz(a)anthracene | µg/l | | | ALS | | <0.0030 | | <0.0030 | | <0.0030 | | <0.0030 | |
| *chrysene | µg/l | | | ALS | | <0.0070 | | <0.0070 | | <0.0070 | | <0.0070 | |
| *benzo(b)fluoranthene | µg/l | 0.1 | (5) | ALS | | <0.0040 | | <0.0040 | | <0.0040 | | <0.0040 | |
| *benzo(k)fluoranthene | µg/l | | (5) | ALS | | <0.0020 | | <0.0020 | | <0.0020 | | <0.0020 | |
| *benzo(a)pyrene | µg/l | 0.01 | | ALS | | <0.0020 | | <0.0020 | | <0.0020 | | <0.0020 | |
| *dibenzo(ah) anthracene | µg/l | | | ALS | | <0.0020 | | <0.0020 | | <0.0020 | | <0.0020 | |
| benzo(ghi)perylene | µg/l | | (5) | ALS | | <0.0030 | | <0.0030 | | <0.0030 | | <0.0030 | |
| *indeno(123-cd)pyrene | µg/l | | (5) | ALS | | <0.0030 | | <0.0030 | | <0.0030 | | <0.0030 | |
| sum 16 EPA-PAH | µg/l | | | ALS | | <0.20 | | <0.20 | | <0.20 | | <0.20 | |
| *sum PAH cancerogene | µg/l | | | ALS | | <0.012 | | <0.012 | | <0.012 | | <0.012 | |
| sum PAH other | µg/l | | | ALS | | <0.20 | | <0.20 | | <0.20 | | <0.20 | |

Commentary:
(1) Adequate for consuption and no uncharacteristical changes
(2) Maximum value for sum of thrichlorethene and tetrachlorethene
(3) Maximum value in older Icelandic regulations 319/1995 (void)
(4) Maximum value not in Icelandic regulations
(5) Maximum value for the sum of the following substances:
benzo(b)fluoranten. benzo(k) fluoranten. benzo(ghi)perylen.indeno(123cd)pyren

Laboratories:
MATÍS: Matís ohf, Laboratory
ALS: ALS Scandinavia AB (Sweden)
* Iceland GeoSurvey

## Annex 9. **Measurement of microbes and chemical composition of potable water in West Iceland 2015**

### MICROBES IN POTABLE WATER IN WEST ICELAND 2015

| | MAX. RECOMM-ENDED | STYKKISHÓLMUR DÆLUHÚS | | | GRUNDARFJÖRÐUR DÆLUHÚS GRUNDAÁ | | | GRÁBRÓK LAGNAHÚS HAMRI | | | AKRANES GEISLAHÚS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | VALUE | AVERAGE | MAX | MIN | AVER-AGE | MAX | MIN | AVERAGE | MAX | MIN | AVER-AGE | MAX | MIN |
| Total microbes at 22°C | 100/ ml | 18.50 | 34 | 3 | 0.50 | 1 | 0 | 6.00 | 7 | 5 | 0.20 | 1 | 0 |
| Escherichia coli (E. Coli) | 0/100 ml | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Enterococci | 0/100 ml | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### CHEMICAL COMPOSITION OF POTABLE WATER IN WEST ICELAND

| PHYSIOLOGICAL AND CHEMICAL PROPERTIES | UNIT | MAX. RECOMM-ENDED VALUE | CO. | LABORATORY | STYKKIS-HÓLMUR DÆLUHÚS | GRUNDAR-FJÖRÐUR DÆLUHÚS GRUNDAÁ | GRÁBRÓK LAGNAHÚS HAMRI | AKRANES GEISLAHÚS |
|---|---|---|---|---|---|---|---|---|
| SAMPLE NO. | | | | | R15-1636-1/4657 | R15-1636-2/4657 | R15-1636-3/ | R15-1636-4/4657 |
| SAMPLING MONTH | | | | | June 2015 | June 2015 | June 2015 | June 2015 |
| Colour of sample | mgPt/l | | | ALS | 10 | 10 | 10 | 10 |
| Turbidity | NTU | adequate | (1) | MATÍS | <0.10 | 0.35 | 0.10 | 0.10 |
| Temperature | °C | 25 | | MATÍS | 5.2 | 3.1 | 4.2 | 6.3 |
| pH | pH unit | | | MATÍS | 7.25 | 6.85 | 7.05 | 7.30 |
| Conductivity | µS/cm | 2500 | | MATÍS | 56 | 68 | 76 | 110 |
| Chloride (Cl) | mg/l | 250 | | ALS | 9.1 | 11.3 | 11.6 | 16 |
| Sulphate ($SO_4$) | mg/l | 250 | | ALS | 2.57 | 1.67 | 2.62 | 3.52 |
| Fluoride (F) | mg/l | 1.5 | | ALS | <0.200 | <0.200 | <0.200 | <0.200 |
| Nitrate ($NO_3$) | mg/l | 50 | | ALS | 0.0841 | 0.102 | 0.164 | 0.31 |
| Nitrite ($NO_2$) | mg/l | 0.5 | | ALS | <0.01 | <0.01 | <0.01 | <0.01 |
| Ammonium ($NH_4$-N) | mg/l | 0.5 | | ALS | <0.026 | <0.026 | <0.026 | <0.026 |
| TOC | mg/l | no abnormal changes | | ALS | <0.50 | <0.50 | <0.50 | <0.50 |
| | | | | | | | | |
| Calcium (Ca) | mg/l | 100 | (3) | ALS | 2.07 | 3.17 | 3.82 | 5.81 |
| Iron (Fe) | mg/l | 0.2 | | ALS | 0.001 | 0.045 | 0.009 | 0.002 |
| Potassium (K) | mg/l | 12 | (3) | ALS | 0.63 | 0.622 | <0.4 | 0.429 |
| Magnesium (Mg) | mg/l | 50 | (3) | ALS | 1.38 | 1.73 | 1.67 | 2.22 |
| Sodium (Na) | mg/l | 200 | | ALS | 6.14 | 6.51 | 7.96 | 11 |
| Sulphur (S) | mg/l | | (4) | ALS | 0.49 | 0.591 | 0.743 | 0.971 |
| Silica (Si) | mg/l | | (4) | ALS | 4.54 | 4.03 | 3.94 | 6.6 |
| Aluminium (Al) | µg/l | 200 | | ALS | 2.64 | 2.82 | 3.62 | 1.93 |
| Arsen (As) | µg/l | 10 | | ALS | <0.05 | <0.08 | <0.08 | <0.1 |
| Boron (B) | µg/l | 1000 | | ALS | <10 | <10 | <10 | <10 |
| Barium (Ba) | µg/l | 700 | (3) | ALS | 0.441 | 0.912 | 0.437 | 0.026 |
| Cadmium (Cd) | µg/l | 5.0 | | ALS | 0.004 | <0.002 | <0.002 | <0.002 |
| Cobalt (Co) | µg/l | | (4) | ALS | 0.006 | 0.015 | 0.007 | 0.016 |
| Chromium (Cr) | µg/l | 50 | | ALS | 0.114 | 0.031 | 0.023 | 0.385 |
| Copper (Cu) | µg/l | 2000 | | ALS | 0.559 | 0.866 | 1.09 | 0.429 |
| Mercury (Hg) | µg/l | 1.0 | | ALS | <0.002 | <0.002 | <0.002 | <0.002 |
| Manganese (Mn) | µg/l | 50 | | ALS | <0.03 | 0.484 | 0.968 | 0.145 |
| Molybdenum (Mo) | µg/l | | (4) | ALS | 0.21 | 0.163 | 0.065 | <0.05 |
| Nickel (Ni) | µg/l | 20 | | ALS | 0.054 | 0.136 | <0.05 | 2.96 |
| Phosphorus (P) | µg/l | 5000 | (3) | ALS | 28.8 | 11.5 | 1.68 | 15.1 |
| Lead (Pb) | µg/l | 10 | | ALS | 0.064 | 0.988 | 0.21 | 0.035 |
| Antimon (Sb) | µg/l | 5.0 | | ALS | <0.01 | <0.01 | <0.01 | <0.01 |

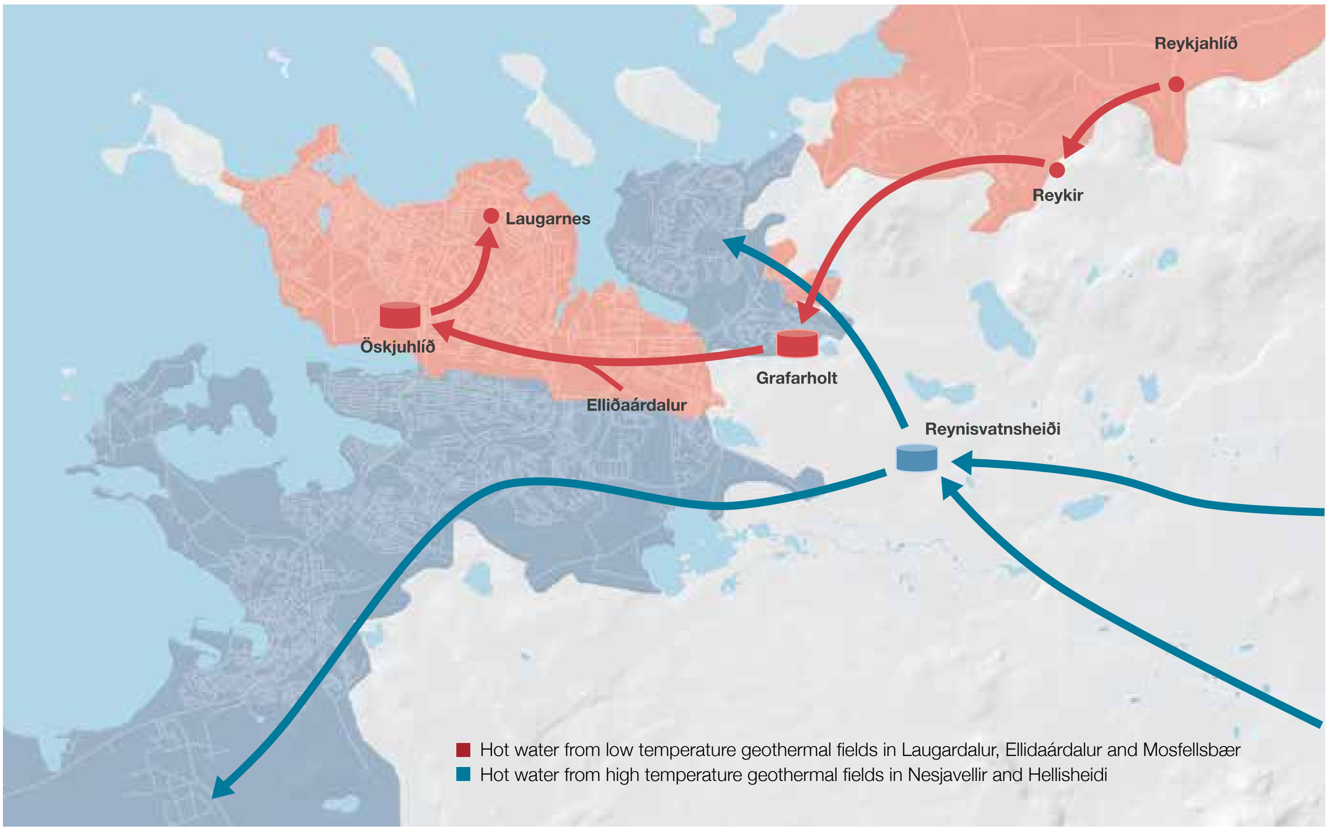
| PHYSIOLOGICAL AND CHEMICAL PROPERTIES | UNIT | MAX. RECOMM-ENDED VALUE | CO. | LABORATORY | STYKKIS-HÓLMUR DÆLUHÚS | GRUNDAR-FJÖRÐUR DÆLUHÚS GRUNDAÁ | GRÁBRÓK LAGNAHÚS HAMRI | AKRANES GEISLAHÚS |
|---|---|---|---|---|---|---|---|---|
| Selen (Se) | µg/l | 10 | | ALS | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium (Sr) | µg/l | | (4) | ALS | 9.04 | 13.1 | 10 | 3.26 |
| Zinc (Zn) | µg/l | 3000 | (3) | ALS | 4.89 | 2.92 | 1.03 | 2.9 |
| Vanadium (V) | µg/l | | | ALS | 10.9 | 0.52 | 0.474 | 3.42 |
| cyanide (CN total) | µg/l | 50 | | ALS | <0.005 | <0.005 | <0.005 | <0.005 |
| dichloromethane | µg/l | | | ALS | <2.0 | <2.0 | <2.0 | <2.0 |
| 1,1 - dichloroethane | µg/l | | | ALS | <0.10 | <0.10 | <0.10 | <0.10 |
| 1,2 - dichloroethane | µg/l | 3.0 | | ALS | <0.10 | <0.10 | <0.10 | <0.10 |
| trans 1,2 - dichloroethane | µg/l | | | ALS | <0.10 | <0.10 | <0.10 | <0.10 |
| cis 1,2 - dichloroethane | µg/l | | | ALS | <0.10 | <0.10 | <0.10 | <0.10 |
| 1,2 - dichloropropane | µg/l | | | ALS | <1.0 | <1.0 | <1.0 | <1.0 |
| tetrachloromethane | µg/l | | | ALS | <0.10 | <0.10 | <0.10 | <0.10 |
| 1,1,1 - trichloroethane | µg/l | | | ALS | <0.10 | <0.10 | <0.10 | <0.10 |
| 1,1,2 - trichloroethane | µg/l | | | ALS | <0.20 | <0.20 | <0.20 | <0.20 |
| trichloroethene | µg/l | 10 | (2) | ALS | <0.10 | <0.10 | <0.10 | <0.10 |
| tetrachloroethene | µg/l | | (2) | ALS | <0.20 | <0.20 | <0.20 | <0.20 |
| vinyl chloride | µg/l | | | ALS | <1.0 | <1.0 | <1.0 | <1.0 |
| benzene | µg/l | 1.0 | | ALS | <0.20 | <0.20 | <0.20 | <0.20 |
| toluene | µg/l | | | ALS | <0.20 | <0.20 | <0.20 | <0.20 |
| ethylbenzene | µg/l | | | ALS | <0.20 | <0.20 | <0.20 | <0.20 |
| sum xylene | µg/l | | | ALS | <0.20 | <0.20 | <0.20 | <0.20 |
| trichloromethane | µg/l | | | ALS | <0.30 | <0.30 | <0.30 | <0.30 |
| tribromomethane | µg/l | | | ALS | <0.20 | <0.20 | <0.20 | <0.20 |
| dibromochloromethane | µg/l | | | ALS | <0.10 | <0.10 | <0.10 | <0.10 |
| bromodichloromethane | µg/l | | | ALS | <0.10 | <0.10 | <0.10 | <0.10 |
| sum trihalomethane | µg/l | | | ALS | <0.35 | <0.35 | <0.35 | <0.35 |
| | | | | | | | | |
| o-xylene | µg/l | | | ALS | <0.20 | <0.20 | <0.20 | <0.20 |
| sum xylene | µg/l | | | ALS | <0.20 | <0.20 | <0.20 | <0.20 |
| naphtalen | µg/l | | | ALS | <0.20 | <0.20 | <0.20 | <0.20 |
| acenaphthylene | µg/l | | | ALS | <0.10 | <0.10 | <0.10 | <0.10 |
| acenaphthene | µg/l | | | ALS | <0.0070 | <0.0070 | <0.0070 | <0.0070 |
| fluorene | µg/l | | | ALS | <0.010 | <0.010 | <0.010 | <0.010 |
| phenanthrene | µg/l | | | ALS | <0.040 | <0.040 | <0.040 | <0.040 |
| anthracene | µg/l | | | ALS | <0.0050 | <0.0050 | <0.0050 | <0.0050 |
| fluoroanthene | µg/l | | | ALS | <0.0050 | <0.0050 | <0.0050 | <0.0050 |
| pyrene | µg/l | | | ALS | <0.0050 | <0.0050 | <0.0050 | <0.0050 |
| *benz(a)anthracene | µg/l | | | ALS | <0.0030 | <0.0030 | <0.0030 | <0.0030 |
| *chrysene | µg/l | | | ALS | <0.0070 | <0.0070 | <0.0070 | <0.0070 |
| *benzo(b)fluoranthene | µg/l | 0.1 | (5) | ALS | <0.0040 | <0.0040 | <0.0040 | <0.0040 |
| *benzo(k)fluoranthene | µg/l | | (5) | ALS | <0.0020 | <0.0020 | <0.0020 | <0.0020 |
| *benzo(a)pyrene | µg/l | 0.01 | | ALS | <0.0020 | <0.0020 | <0.0020 | <0.0020 |
| *dibenzo(ah) anthracene | µg/l | | | ALS | <0.0020 | <0.0020 | <0.0020 | <0.0020 |
| benzo(ghi)perylene | µg/l | | (5) | ALS | <0.0030 | <0.0030 | <0.0030 | <0.0030 |
| *indeno(123-cd)pyrene | µg/l | | (5) | ALS | <0.0030 | <0.0030 | <0.0030 | <0.0030 |
| sum 16 EPA-PAH | µg/l | | | ALS | <0.20 | <0.20 | <0.20 | <0.20 |
| *sum PAH cancerogene | µg/l | | | ALS | <0.012 | <0.012 | <0.012 | <0.012 |
| sum PAH other | µg/l | | | ALS | <0.20 | <0.20 | <0.20 | <0.20 |

Commentary:
(1) Adequate for consuption and no uncharacteristical changes
(2) Maximum value for sum of thrichlorethene and tetrachlorethene
(3) Maximum value in older Icelandic regulations 319/1995 (void)
(4) Maximum value not in Icelandic regulations
benzo(b)fluoranten. benzo(k) fluoranten. benzo(ghi)perylen.indeno(123cd)pyren

Laboratories:
MATÍS: Matís ohf, Laboratory
ALS: ALS Scandinavia AB (Sweden)
* Iceland GeoSurvey

## Annex 10. **Distribution of hot water in the capital area**

The figure shows how hot water is distributed in the capital area. Reykjavik residents west of Grafarvogur and in Úlfarsárdalur, Mosfellsbaer and Kjalarnes usually get low-temperature geothermal water from wells. On the other hand, Grafarholt, Grafarvogur, Kópavogur, Gardabaer and Hafnarfjördur get their heated groundwater from Nesjavellir and Hellisheidi. In some areas water from other sources can be used in certain periods.




## Annex 11. **Disposal water discharged via overflows at the Hellisheidi Geothermal Power Plant 2015**

**RELEASE OF SEPARATED WATER VIA OVERFLOW AT HELLISHEIDI**

| DATE | TYPE OF DISTURBANCE | 24-HOUR AVERAGE FLOW |
|---|---|---|
| 1-16 January | Malfunction | 55 l/s |
| 19-22 January | Malfunction | 17 l/s |
| 31 January - 9 February | Malfunction | 36 l/s |
| 14-15 February | Maintenance | 8 l/s |
| 17 February | Malfunction | 11 l/s |
| 9 March | Malfunction | 3 l/s |
| 15 -17 March | Malfunction | 24 l/s |
| 1-4 June | Testing | 12 l/s |
| 7 June - 8 July | Maintenance | 277 l/s |
| 10-16 July | Malfunction | 44 l/s |
| 15 August (8 hrs) | Malfunction | 178 l/s |
| 17-24 August | Maintenance/Malfunction | 147 l/s |
| 28 September - 15 October | Malfunction | 26 l/s |
| 17 October | Malfunction | 11 l/s |
| 18 October - 7 December | Maintenance/Malfunction | 156 l/s |
| 19-22 December | Malfunction | 55 l/s |

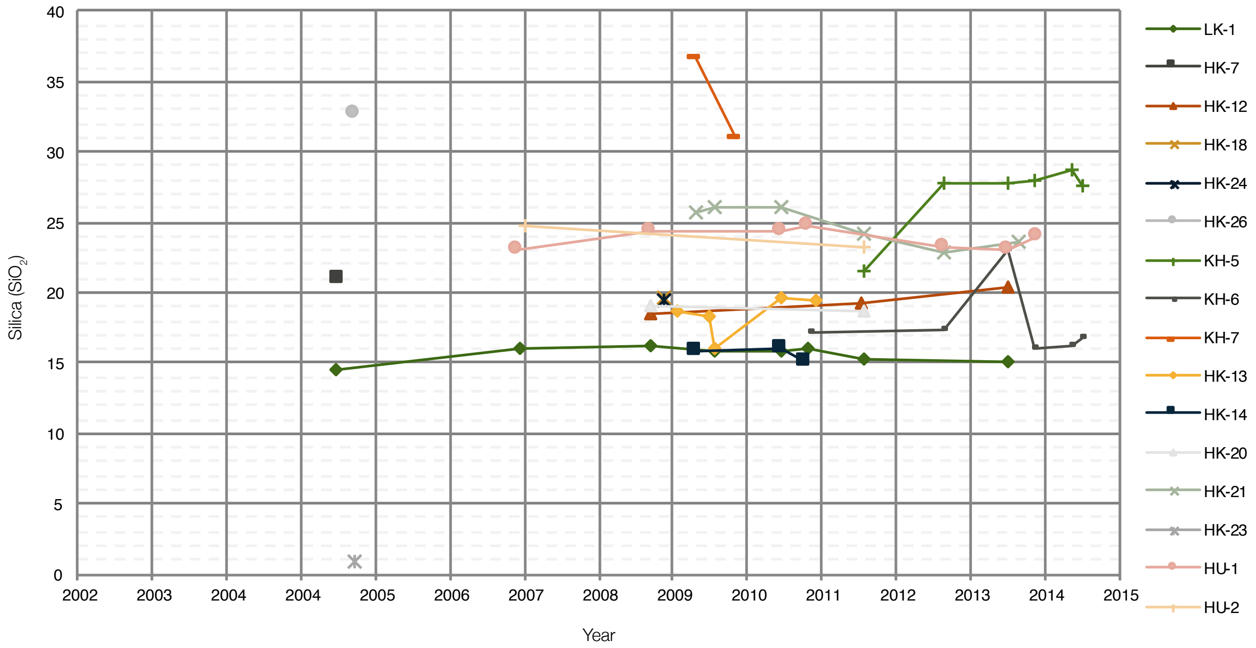
## Annex 12. **Chemical composition of groundwater from wells in the vicinity of the Hellisheidi Geothermal Power Plant 2015**

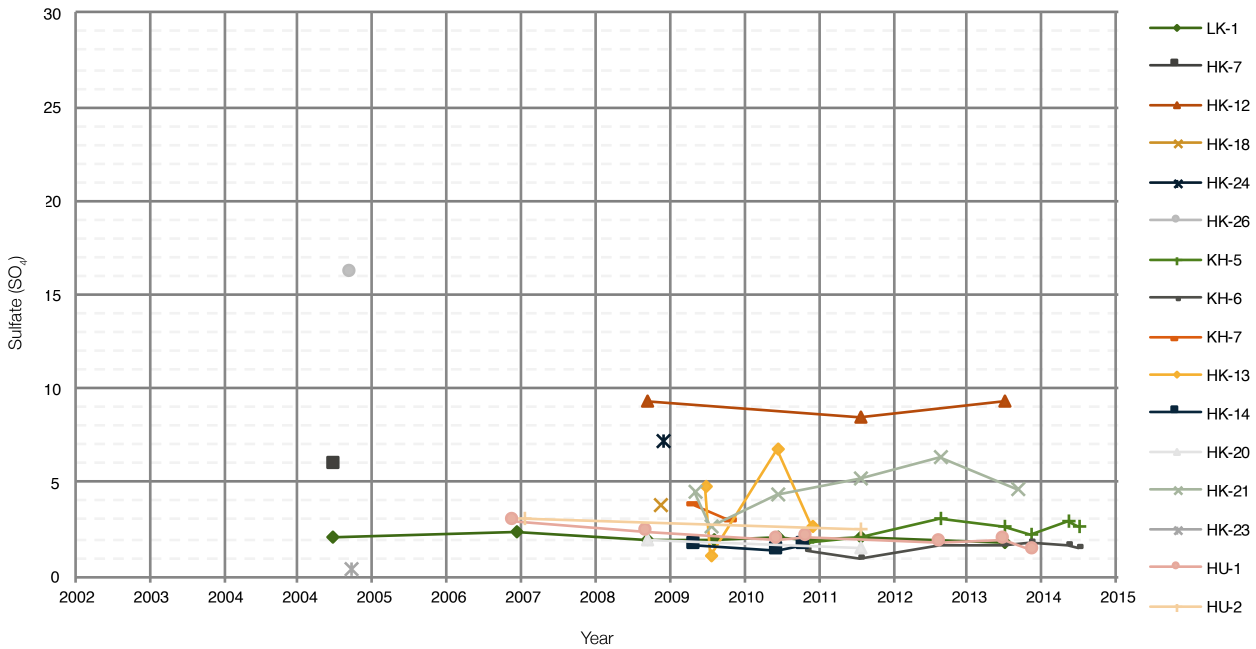
**CHEMICAL COMPOSITION OF GROUNDWATER IN WELLS NEAR HELLISHEIDI POWER PLANT 2015**

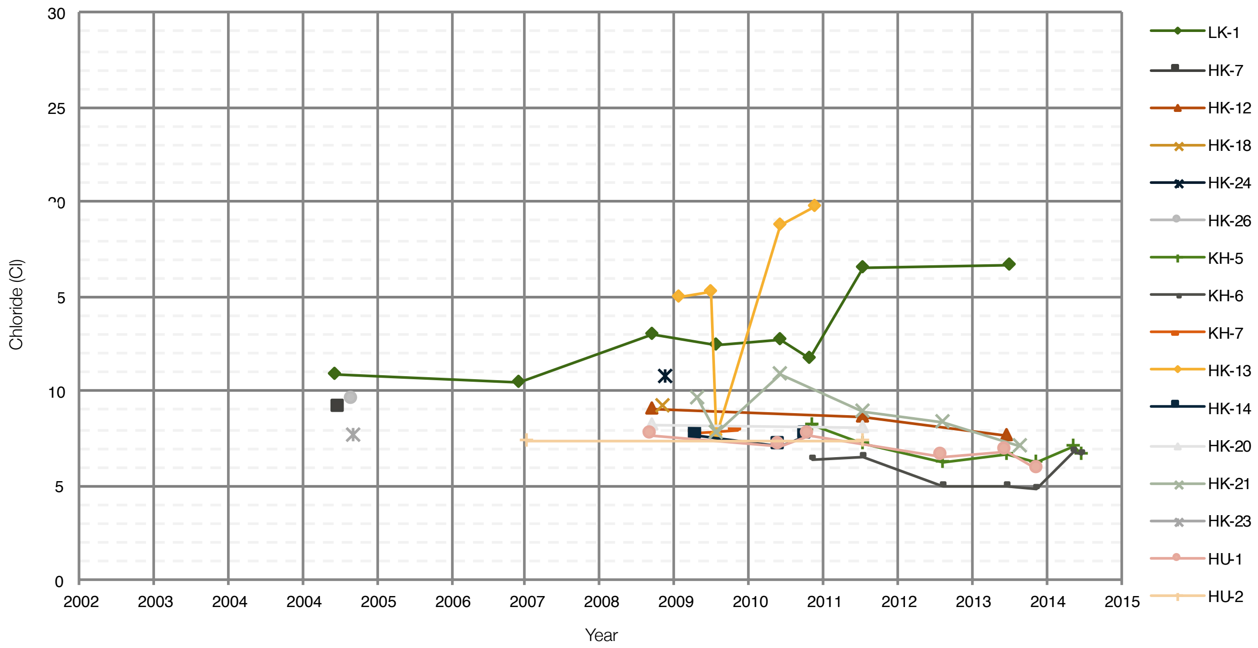
| WELL | | | KH-5 | KH-5 | KH-6 | KH-6 | HK-32 | HK-33 |
|---|---|---|---|---|---|---|---|---|
| GROUNDWATER FLOW | UNIT | MAX. RECOMM-ENDED VALUE | SELVOGSSTRAUMUR | | | | DRILL SITE 7 IN HELLISHEIDI | |
| Sample no. | | | 2015-5261 | 2015-5332 | 2015-5262 | 2015-5333 | 2015-5403 | 2015-5396 |
| Date | | | 5/11/2015 | 6/26/2015 | 5/11/2015 | 6/26/2015 | 9/3/2015 | 8/21/2015 |
| PHYSICAL AND CHEMICAL PROPERTIES | | | | | | | | |
| pH | | | 8.02 | | 7.33 | | | |
| T (pH) | °C | | 10 | | 6.6 | | | |
| Conductivity | µS/cm | 2,500 | 123.6 | 121.2 | 83.9 | 88.4 | 172.2 | 155.2 |
| T (conductivity) | °C | | 22.9 | 23.3 | 22.8 | 23.2 | 23.5 | 22.8 |
| $CO_2$ | mg/kg | * | 44.35 | 43.5 | 32.7 | 35 | 46 | 43.65 |
| F | mg/kg | 1.5 | 0.27 | 0.03 | 0.01 | 0.02 | 0.08 | 0.060 |
| $SiO_2$ | mg/kg | * | 28.77 | 27.57 | 16.25 | 16.81 | 26.34 | 27.40 |
| Na | mg/kg | 200 | 7.64 | 7.49 | 6.01 | 6.21 | 15.82 | 16.00 |
| K | mg/kg | 12 | 0.97 | 0.86 | 0.60 | 0.71 | 1.54 | 1.59 |
| Ca | mg/kg | 100 | 8.66 | 8.53 | 4.18 | 4.49 | 9.73 | 8.48 |
| Mg | mg/kg | 50 | 5.30 | 5.32 | 3.90 | 4.20 | 4.74 | 3.80 |
| Fe | mg/kg | 0.2 | 0.012 | 0.029 | 0.015 | 0.068 | <0.005 | <0.005 |
| Al | mg/kg | 0.2 | <0.0075 | <0.0075 | <0.0075 | <0.0075 | 0.016 | 0.014 |
| Sr | mg/kg | * | | | | | | |
| Mn | mg/kg | 0.05 | | | | | | |
| $SO_4$ | mg/kg | 250 | 2.90 | 2.60 | 1.60 | 1.50 | 7.30 | 5.60 |
| P | mg/kg | 5 | | | | | | |
| Li | mg/kg | * | | | | | | |
| Cl | mg/kg | 250 | 7.1 | 6.6 | 6.8 | 6.6 | 12.0 | 9.7 |
| B | mg/kg | 1 | <0.01 | <0.01 | <0.01 | <0.01 | 0.037 | 0.029 |

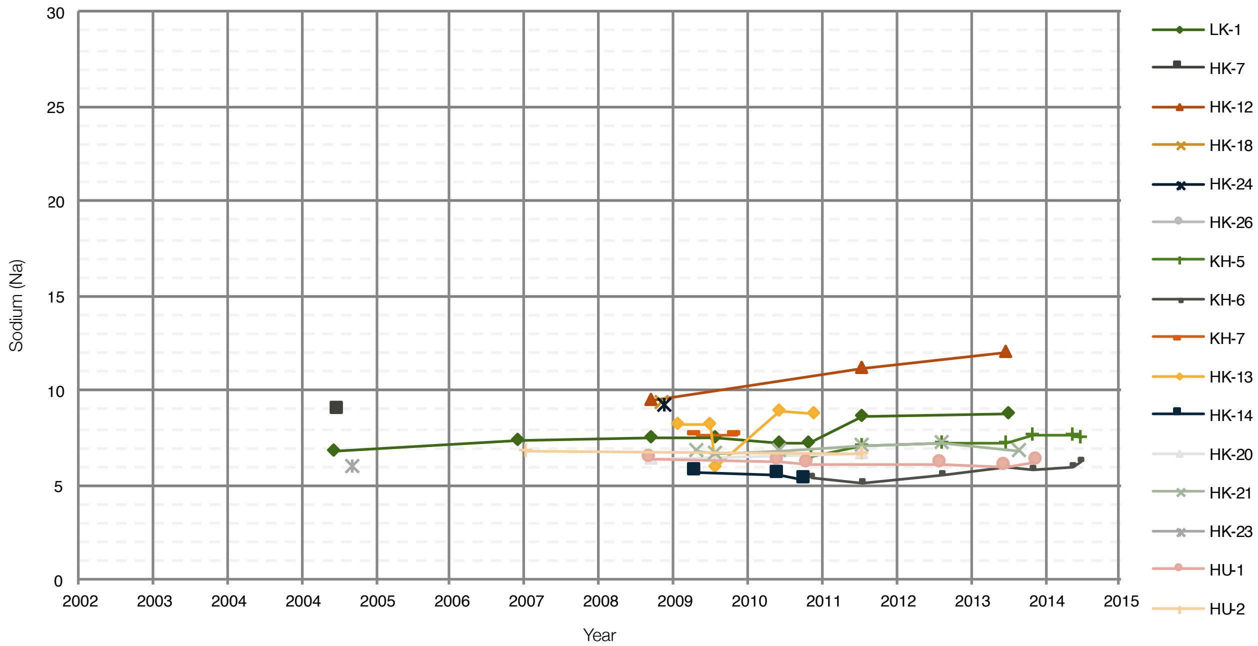
* Maximum value not found in Icelandic regulations

## Annex 13. **Chemical composition of groundwater from wells in the vicinity of the Hellisheidi Geothermal Power Plant 2005-2015**




Chloride (Cl)
30
25
20
5
10
5
0
2002
2003
2004
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year
LK-1
HK-7
HK-12
HK-18
HK-24
HK-26
KH-5
KH-6
KH-7
HK-13
HK-14
HK-20
HK-21
HK-23
HU-1
HU-2


Sodium (Na)
30
25
20
15
10
5
0
2002
2003
2004
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year
LK-1
HK-7
HK-12
HK-18
HK-24
HK-26
KH-5
KH-6
KH-7
HK-13
HK-14
HK-20
HK-21
HK-23
HU-1
HU-2

## Annex 14. **Trace elements in separated water from the Hellisheidi and Nesjavellir geothermal power plants**

Typical concentrations (mg/kg) of several trace elements in separated water from the Hellisheidi and Nesjavellir geothermal power plants and their maximum permissible concentrations (mg/kg) for potable water. When the chemical content of separated water is compared to potable water standards, one can see that in separated water from the Hellisheidi Geothermal Power Plant, the concentration of potassium is about three times higher, while the concentration of aluminium and arsenic is about ten times higher than permissible levels for potable water. In separated water from the Nesjavellir Geothermal Power Plant, the concentration of potassium is about three times higher, the concentration of aluminium about ten times higher, and the concentration of arsenic is about twelve times higher than permissible levels for potable water. The concentration of other substances in separated water is lower than the given limits for potable water.

**TRACE ELEMENTS IN SEPERATED WATER FROM POWER PLANTS IN HENGILL**

| ELEMENT | UNIT | MAX. RECOMMENDED VALUE FOR POTABLE WATER | SEPERATED WATER HELLISHEIÐI | SEPERATED WATER NESJAVELLIR |
|---|---|---|---|---|
| Aluminium (Al) | mg/kg | 0.2 | 1.7 | 2 |
| Arsenic (As) | mg/kg | 0.01 | 0.09 | 0.12 |
| Barium (Ba) | mg/kg | - | 0.078 | * |
| Cadmium (Cd) | mg/kg | 0.005 | 0.000 | 0.000 |
| Chrome (Cr) | mg/kg | 0.05 | 0.000 | * |
| Copper (Cu) | mg/kg | 2 | 0.002 | 0.001 |
| Mercury (Hg) | mg/kg | 0.001 | 0.000 | 0.000 |
| Potassium (K) | mg/kg | 12 | 38.4 | 31.5 |
| Nickel (Ni) | mg/kg | 0.02 | 0.000 | 0.001 |
| Lead (Pb) | mg/kg | 0.01 | 0.004 | 0.000 |
| Zinc (Zn) | mg/kg | 3 | 0.010 | 0.001 |

* Values for Br and Cr have not been measured

## Annex 15. **Emissions of carbon dioxide ($CO_2$), hydrogen sulphide ($H_2S$), hydrogen ($H_2$) and methane ($CH_4$) from Hellisheidi and Nesjavellir 2003-2015**

**HELLISHEIDI**

| YEAR | $CO_2$ [tons/yr] | $H_2S$ [tons/yr] | $H_2$ [tons/yr] | $CH_4$ [tons/yr] |
|---|---|---|---|---|
| 2003 | 3,602 | 1,283 | 76 | 0 |
| 2004 | 1,943 | 748 | 38 | 0 |
| 2005 | 4,581 | 819 | * | * |
| 2006 | 0 | 0 | * | * |
| 2007 | 24,210 | 6,902 | 276 | 20 |
| 2008 | 32,937 | 10,323 | 407 | 30 |
| 2009 | 35,325 | 8,581 | 269 | 36 |
| 2010 | 41,722 | 13,340 | 389 | 46 |
| 2011 | 39,479 | 12,212 | 401 | 57 |
| 2012 | 43,158 | 12,044 | 417 | 51 |
| 2013 | 44,934 | 12,374 | 529 | 72 |
| 2014 | 38,861 | 8,484 | 459 | 81 |
| 2015 | 33,077 | 6,384 | 386 | 80 |

* Data not available for 2005 and 2006

**NESJAVELLIR**

| YEAR | $CO_2$ [tons/yr] | $H_2S$ [tons/yr] | $H_2$ [tons/yr] | $CH_4$ [tons/yr] |
|---|---|---|---|---|
| 2003 | 11,058 | 5,941 | 313 | 14 |
| 2004 | 11,551 | 5,084 | 317 | 21 |
| 2005 | 13,259 | 8,918 | 410 | 29 |
| 2006 | 12,673 | 8,650 | * | * |
| 2007 | 15,412 | 10,275 | 410 | 26 |
| 2008 | 20,904 | 12,114 | 658 | 24 |
| 2009 | 19,918 | 12,175 | 640 | 24 |
| 2010 | 28,396 | 9,384 | 481 | 111 |
| 2011 | 14,800 | 9,414 | 470 | 47 |
| 2012 | 18,612 | 8,640 | 456 | 28 |
| 2013 | 14,794 | 8,709 | 481 | 46 |
| 2014 | 16,579 | 9,275 | 491 | 55 |
| 2015 | 14,726 | 8,359 | 497 | 54 |

* Data not available for 2006

Commentary 2015 for Hellisheidi:

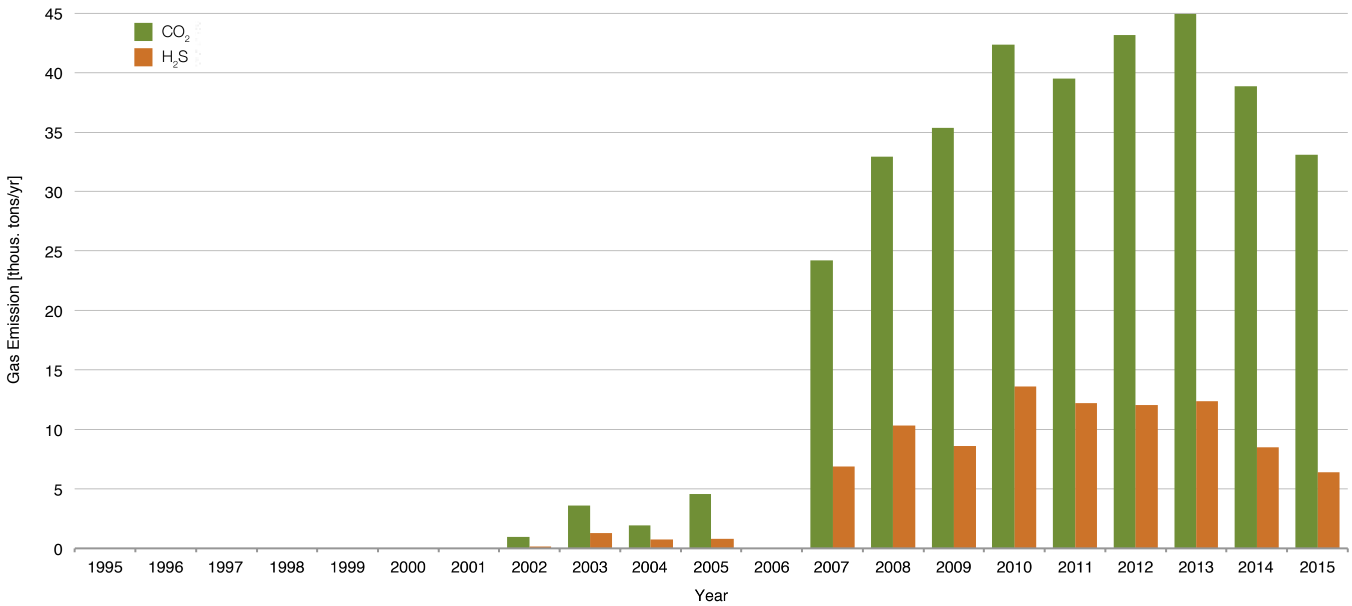
1) Approx. half a million tons less steam were processed in the power plant than in 2014.

2) $CO_2$ and $H_2S$ dissolved and reinjected in condensate water subtracted

3) Approx. 3,900 tons of $CO_2$ and 2,200 tons of $H_2S$ were reinjected in the SulFix project.

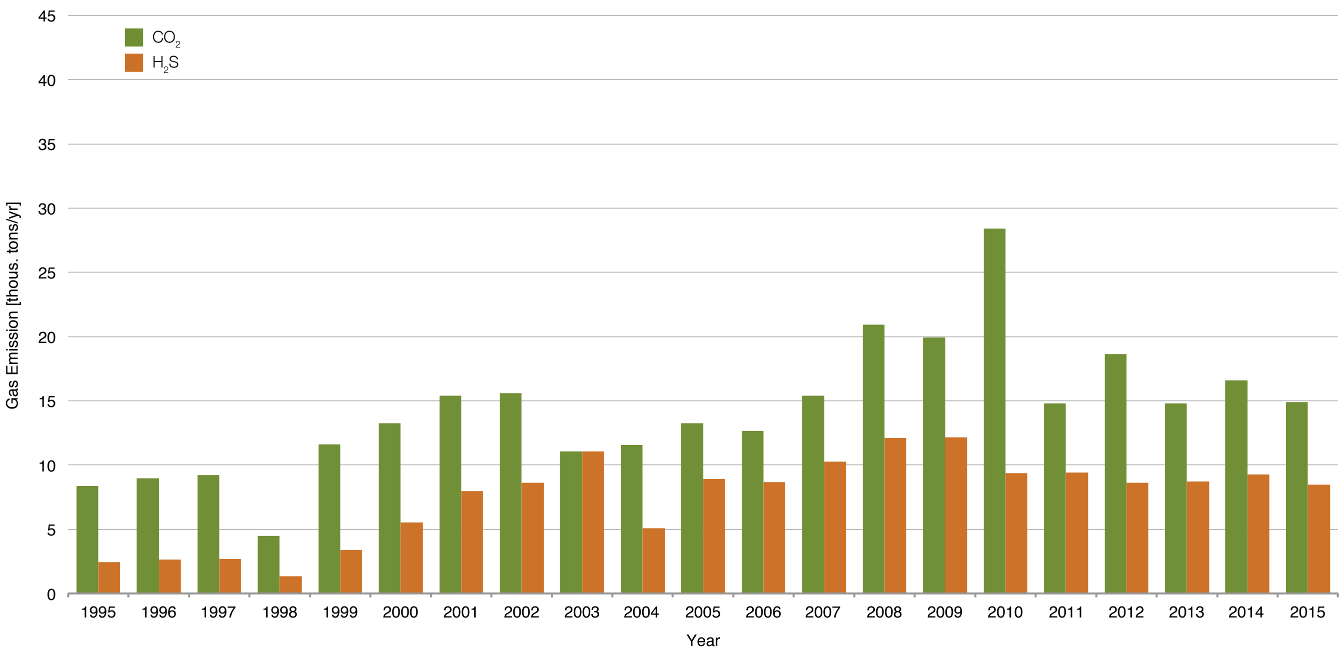
## Annex 16. **Emissions of carbon dioxide ($CO_2$) and hydrogen sulphide ($H_2S$), from Hellisheidi and Nesjavellir 1995-2015**

**HELLISHEIÐI**




Commentary 2015:
1) Approx. half a million tons less steam were processed in the power plant than in 2014.
2) $CO_2$ and $H_2S$ dissolved and reinjected in condensate water subtracted.
3) Approx. 3,900 tons of $CO_2$ and 2,200 tons of $H_2S$ were reinjected in the SulFix project.

**NESJAVELLIR**



## Annex 17. **Comparison between regulatory limits of hydrogen sulphide in µg/m³ and ppm**

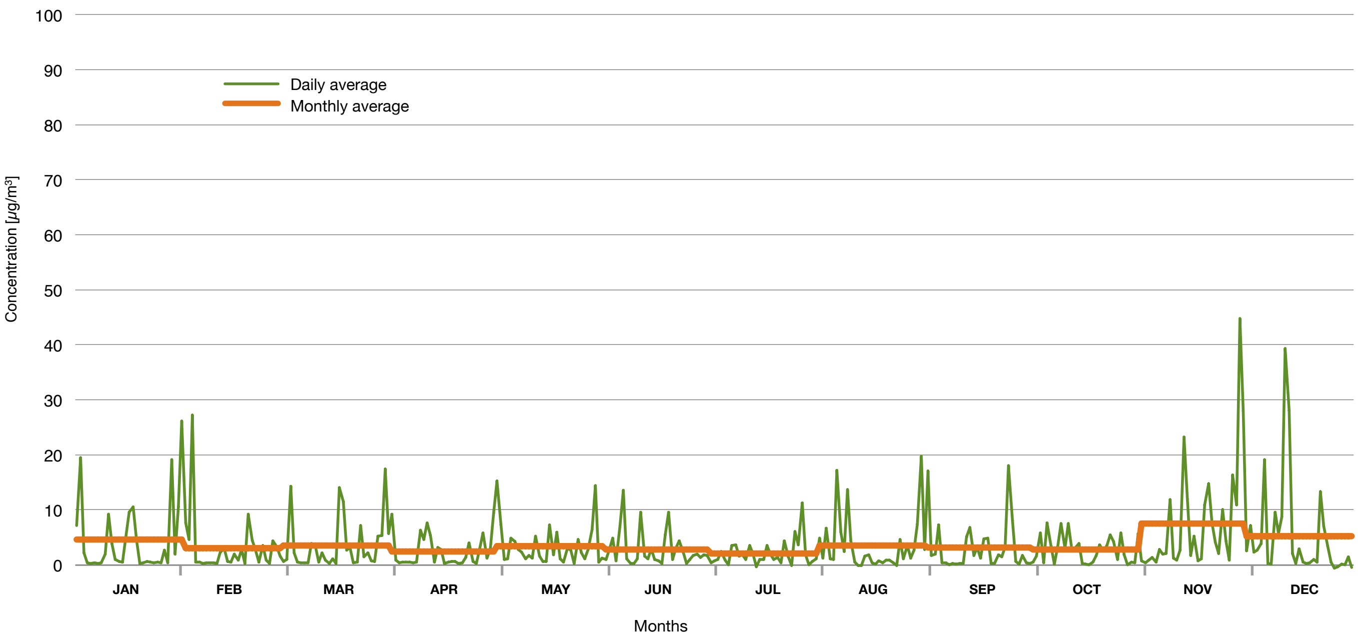
Under Regulation no. 514/2010 regarding the Concentration of Hydrogen Sulphide in the Atmosphere, environmental limits are set at 50 µg/m³, based on the maximum daily running 24-hour average. The concentrations may exceed those limits three times per annum. Other environmental limits are that the maximum annual average shall be 5 µg/m³ and the environmental authorities shall be notified when the concentration measured exceeds 150 µg/m³ for three consecutive hours. Regulation no. 514/2010 does not apply to the industrial areas of the Hellisheidi and Nesjavellir geothermal power plants. There Regulation no. 390/2009 on Pollution Limits and Methods to Reduce Pollution in Workplaces applies. The pollution limit in a work environment is 7,000 µg/m³ and depends on the average of an eight-hour workday, and 14,000 µg/m³ when based on the average over a 15-minute period.

**COMPARISON OF $H_2S$ CONCENTRATION µg/m³ AND ppm**

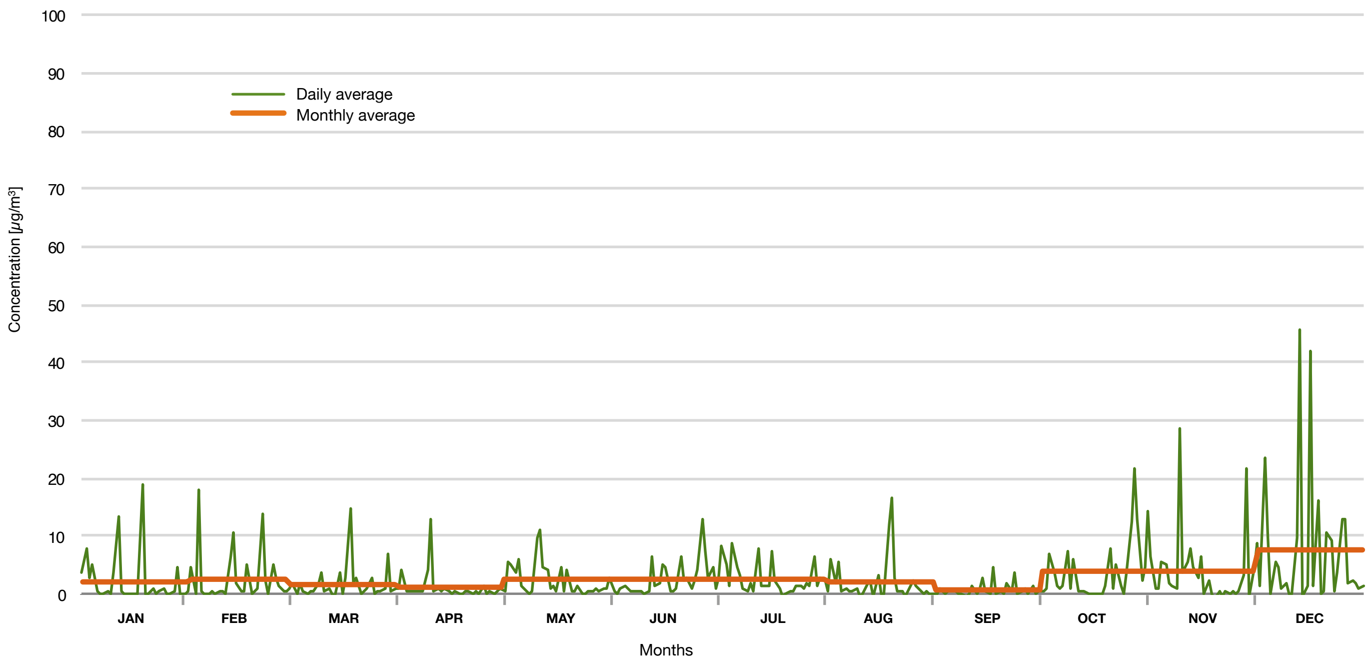
| µg/m³ | ppm | COMMENTS |
|---|---|---|
| 5 | 0.004 | Maximum annual average |
| 7 -15 | 0.0054 - 0.012 | Odour threshold |
| 50 | 0.039 | Maximum daily average |
| 150 | 0.12 | Notification limitis (three continuous hours) |
| 7,000 | 5.41 | Limit in a work environment for an eight-hour workday |
| 14,000 | 10.8 | Limit in a work environment for a fifteen-minute period |

## Annex 18. **Daily and monthly averages for the concentration of hydrogen sulphide in Hveragerdi and Nordlingaholt in 2015**

**HYDROGEN SULPHIDE ($H_2S$) IN HVERAGERÐI**



#### HYDROGEN SULPHIDE ($H_2S$) IN NORÐLINGAHOLT




## Annex 19. **30 highest hourly averages for the concentration of hydrogen sulphide in Hveragerdi and Nordlingaholt and timing in 2015**

#### $H_2S$ MONITORING IN HVERAGERDI

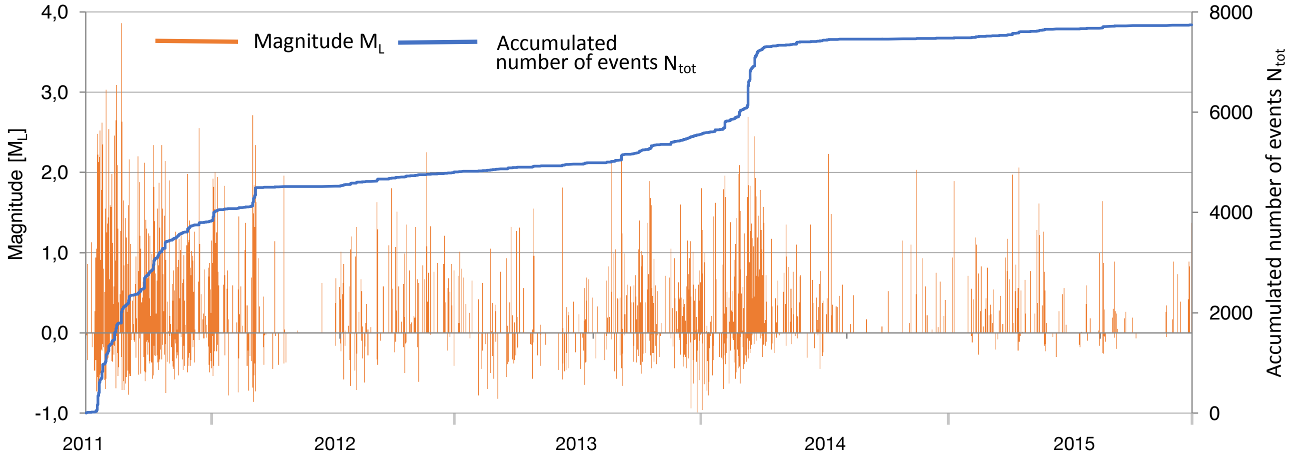
| HYDROGEN SULPHIDE 2015 - 30 HIGHEST HOURLY AVERAGES | | | | | |
|---|---|---|---|---|---|
| CONCENTRATION [µg/m³] | DATE & TIME | CONCENTRATION [µg/m³] | DATE & TIME | CONCENTRATION [µg/m³] | DATE & TIME |
| 195 | 11/29/2015 8:59 | 80 | 2/3/2015 7:59 | 71 | 9/12/2015 22:59 |
| 172 | 11/29/2015 5:59 | 79 | 8/30/2015 10:59 | 69 | 11/29/2015 10:59 |
| 143 | 12/12/2015 2:59 | 76 | 11/29/2015 9:59 | 69 | 8/6/2015 19:59 |
| 128 | 12/6/2015 14:59 | 76 | 12/6/2015 12:59 | 68 | 12/12/2015 4:59 |
| 112 | 11/29/2015 4:59 | 75 | 5/16/2015 2:59 | 67 | 11/29/2015 7:59 |
| 96 | 12/22/2015 12:59 | 74 | 1/28/2015 11:59 | 66 | 12/13/2015 4:59 |
| 93 | 5/29/2015 2:59 | 73 | 3/30/2015 19:59 | 65 | 9/24/2015 4:59 |
| 90 | 12/12/2015 3:59 | 73 | 1/2/2015 4:00 | 65 | 12/12/2015 1:59 |
| 87 | 2/3/2015 8:59 | 72 | 8/30/2015 9:59 | 64 | 11/12/2015 23:59 |
| 82 | 2/3/2015 9:59 | 72 | 12/6/2015 13:59 | 63 | 5/29/2015 1:59 |

#### $H_2S$ MONITORING IN NORDLINGAHOLT

| HYDROGEN SULPHIDE 2015 - 30 HIGHEST HOURLY AVERAGES | | | | | |
|---|---|---|---|---|---|
| CONCENTRATION [µg/m³] | DATE & TIME | CONCENTRATION [µg/m³] | DATE & TIME | CONCENTRATION [µg/m³] | DATE & TIME |
| 147 | 12/16/2015 12:59 | 75 | 11/28/2015 5:59 | 69 | 12/25/2015 20:59 |
| 147 | 12/13/2015 7:59 | 74 | 12/16/2015 2:59 | 68 | 12/3/2015 14:59 |
| 117 | 12/13/2015 6:59 | 73 | 10/27/2015 4:59 | 67 | 12/13/2015 12:59 |
| 116 | 12/13/2015 8:59 | 72 | 5/17/2015 1:59 | 67 | 11/9/2015 14:59 |
| 113 | 4/10/2015 8:59 | 72 | 12/16/2015 17:59 | 67 | 8/19/2015 7:59 |
| 96 | 11/28/2015 6:59 | 71 | 12/13/2015 3:59 | 65 | 12/21/2015 3:59 |
| 88 | 12/13/2015 5:59 | 70 | 1/18/2015 10:59 | 65 | 12/4/2015 6:59 |
| 87 | 11/28/2015 7:59 | 70 | 12/1/2015 0:59 | 64 | 12/26/2015 6:59 |
| 79 | 12/16/2015 11:59 | 69 | 10/27/2015 3:59 | 64 | 12/4/2015 7:59 |
| 76 | 12/13/2015 2:59 | 69 | 12/13/2015 11:59 | 60 | 2/3/2015 2:59 |

## Annex 20. **Development of seismic activity at the Hellisheidi Geothermal Power Plant from the autumn of 2011 to the end of 2015**

On one hand, the figure shows the magnitude of seismic activity and, on the other hand, the accumulated number of seismic tremors during the period. The seismic data are obtained from the national seismometer network of the Icelandic Meteorological Office. Intense induced seismicity followed the commission of the Húsmúli reinjection field in September 2011, and it peaked in mid-October when two magnitude ML 4 events occurred. At the end of 2011/beginning of 2012, seismic activity gradually decreased and, by the summer of 2012, had almost faded out. Activity increased again in the autumn of 2012, but was nothing like what it was when it started. The reason for this was that production at the district heating utility started again after a summer break. This cooled the disposal water somewhat and its flow subsequently increased, which in turn resulted in a rise in the capacity of the reinjection wells and in seismic activity. In early 2014 there was some seismic activity related to the testing and launching of the SulFix project. This activity was within acceptable limits and had mostly faded by the summer. Since then seismic activity by the Hellisheidi Geothermal Power Plant has been low.




## Annex 21. **Trace elements from sewage treatment plants in Reykjavik in 2015**

Discharge of pollutants (mg/l) from sewage treatment plants in Reykjavik in 2015. The average flow in Klettagardar was 1,421 l/sec, and in Ánanaust it was 1,180 l/sec.

**SAMPLING RESULTS**

| | MARCH | JUNE | SEPTEMBER | DECEMBER | AVERAGE VALUE |
|---|---|---|---|---|---|
| **KLETTAGARDAR** | **mg/l** | **mg/l** | **mg/l** | **mg/l** | **mg/l** |
| Total nitrogen (N) | 7.8 | 14.7 | 13.6 | 9.6 | 11.4 |
| Total phosphorus (P) | 1.4 | 3.1 | 2.4 | 1.6 | 2.1 |
| Arsen (As) | <0.050* | | <0.020* | | Below the detection limit |
| Cadmium (Cd) | <0.0010* | | <0.0010* | | Below the detection limit |
| Cromium (Cr) | 0.011 | | 0 | | 0.008 |
| Copper (Cu) | 0.024 | | 0.006 | | 0.015 |
| Mercury (Hg) | <0.00050* | | <0.00050* | | Below the detection limit |
| Nickel (Ni) | 0.035 | | <0.0050* | | Below or near the detection limit |
| Lead (Pb) | <0.0050* | | 0.010 | | Below or near the detection limit |
| Zinc (Zn) | 0.031 | | 0.047 | | 0.039 |
| | **MARCH** | **JUNE** | **SEPTEMBER** | **DECEMBER** | **AVERAGE VALUE** |
| **ANANAUST** | **mg/l** | **mg/l** | **mg/l** | **mg/l** | **mg/l** |
| Total nitrogen (N) | 8.3 | 15.6 | 18.9 | 10.9 | 13.4 |
| Total phosphorus (P) | 2.1 | 3.1 | 3.6 | 2 | 2.7 |
| Arsen (As) | <0.050* | | <0.020* | | Below the detection limit |
| Cadmium (Cd) | <0.0010* | | <0.0010* | | Below the detection limit |
| Cromium (Cr) | <0.0050* | | 0 | | Below or near the detection limit |
| Copper (Cu) | 0.015 | | <0.0050* | | Below or near the detection limit |
| Mercury (Hg) | <0.00050* | | <0.00050* | | Below the detection limit |
| Nickel (Ni) | 0.010 | | <0.0050* | | Below or near the detection limit |
| Lead (Pb) | <0.0050* | | <0,0050* | | Below the detection limit |
| Zinc (Zn) | 0.093 | | 0.053 | | 0.073 |

* Below detection limits
- When both samples collected 2015 are below the detection limits, the column "mean value" states " below the detection limit"
- When one of two samples collected 2014 is below the detection limits the column and the other sample is just over the detection limit, mean value is not calculated. In the column "mean value" states "below on near the detection limit"

## Annex 22. **Sewage discharge reporting - Ánanaust 2015**

The sewage discharge reporting is based on the average values of each polluting factor according to the results from samples collected twice a year for trace elements and four times for nitrogen and phosphorus (see Annex 21) and the average flow of the plant, which was 1,180 l/sec.

**REFERENCE YEAR 2015**

| **INFORMATION ON THE OPERATIONAL UNIT** | |
|---|---|
| Name of parent corpany | Reykjavik Energy |
| Name of the operational unit | Veitur Utilities - Sewerage treatment plant Ananaust |
| National ID of the operational unit | 501213-1870 |
| Address | Ananaust 10 |
| Town/location | Reykjavik |
| Postal code | 101 |
| Country | Iceland |
| Location coordinates | 354,566.305/412,477.62 |
| Catchment area district | |
| Code for occupational category under EC/EU law | 90.01 |
| Most Important Occupational Activitie | Collection and treatment of sewage |
| **OPTIONAL INFORMATION** | |
| Production quantity | |
| Number of plants | 1 |
| Number of operational hours per year | |
| Number of employees | |

**ALL OPERATION OF THE OPERATIONAL UNIT ACCORDING TO ANNEX I (according to the coding system in Annex I and the IPPC code, if available)**

| **OPERATION NO.** | OPERATION | IPPC-CODE | |
|---|---|---|---|
| 5.(f) | Sewage treatment plants for urban areas | - | |

**DISPOSAL OF EACH POLLUTANT EXCEEDING THE QUANTITY OF THE CRITERION VALUE (IN ACCORDANCE WITH ANNEX II)**

| **POLLUTANTS ACCORDING TO ANNEX II** | | **PROCEDURE** | | **DISPOSAL IN WATER** | |
|---|---|---|---|---|---|
| no. | Name | M/C/E | Procedure | Total [kg/yr] | Incident [kg/yr] |
| 12 | Total nitrogen | M | ALT - EN ISO 11905-1 | 499,710 | |
| 13 | Total phosphorus | M | ALT - EN 1189 | 100,500 | |
| 17 | As and compounds | M | EPA 200.8 K(ICP-MS) | Below the detection limit | |
| 18 | Cd and compounds | M | EPA 200.8 K(ICP-MS) | Below the detection limit | |
| 19 | Cr and compounds | M | EPA 200.8 K(ICP-MS) | Below or near the detection limit | |
| 20 | Cu and compounds | M | EPA 200.8 K(ICP-MS) | Below or near the detection limit | |
| 21 | Hg and compounds | M | ALT - EN ISO 17852:2006 | Below the detection limit | |
| 22 | Ni and compounds | M | EPA 200.8 K(ICP-MS) | Below or near the detection limit | |
| 23 | Pb and compounds | M | EPA 200.8 K(ICP-MS) | Below the detection limit | |
| 24 | Zn and compounds | M | EPA 200.8 K(ICP-MS) | 2,717 | |

**COMPETENT AUTHORITY TO WHICH THE PUBLIC CAN TURN**

| | |
|---|---|
| Name | The Environment Agency of Iceland |
| Address | Sudurlandsbraut 24 |
| Town/location | Reykjavik |
| Telephone | 591 2000 |
| Fax | 591 2020 |
| E-mail address | ust@ust.is |

## Annex 23. **Sewage discharge reporting - Klettagardar 2015**

The sewage discharge reporting is based on the average values of each polluting factor according to the results from samples collected twice a year for trace elements and four times for nitrogen and phosphorus (see Annex 21) and the average flow of the plant, which was 1,421 l/sec.

**REFERENCE YEAR 2015**

| **INFORMATION ON THE OPERATIONAL UNIT** | |
|---|---|
| Name of parent corpany | Reykjavik Energy |
| Name of the operational unit | Veitur Utilities - Sewerage treatment plant Klettagardar |
| National ID of the operational unit | 501213-1870 |
| Address | Klettagardar 14 |
| Town/location | Reykjavik |
| Postal code | 104 |
| Country | Iceland |
| Location coordinates | 354,566.305/412,477.62 |
| Catchment area district | |
| Code for occupational category under EC/EU law | 90.01 |
| Most Important Occupational Activitie | Collection and treatment of sewage |
| **OPTIONAL INFORMATION** | |
| Production quantity | |
| Number of plants | 1 |
| Number of operational hours per year | |
| Number of employees | |

**ALL OPERATION OF THE OPERATIONAL UNIT ACCORDING TO ANNEX I (according to the coding system in Annex I and the IPPC code, if available)**

| OPERATION NO. | OPERATION | IPPC-CODE | |
|---|---|---|---|
| 5.(f) | Sewage treatment plants for urban areas | - | |

**DISPOSAL OF EACH POLLUTANT EXCEEDING THE QUANTITY OF THE CRITERION VALUE (IN ACCORDANCE WITH ANNEX II)**

| POLLUTANTS ACCORDING TO ANNEX II | | PROCEDURE | | DISPOSAL IN WATER | |
|---|---|---|---|---|---|
| no. | Name | M/C/E | Procedure | Total [kg/yr] | Incident [kg/yr] |
| 12 | Total nitrogen | M | ALT - EN ISO 11905-1 | 511,897 | |
| 13 | Total phosphorus | M | ALT - EN 1189 | 95,211 | |
| 17 | As and compounds | M | EPA 200.8 K(ICP-MS) | Below the detection limit | |
| 18 | Cd and compounds | M | EPA 200.8 K(ICP-MS) | Below the detection limit | |
| 19 | Cr and compounds | M | EPA 200.8 K(ICP-MS) | 358 | |
| 20 | Cu and compounds | M | EPA 200.8 K(ICP-MS) | 681 | |
| 21 | Hg and compounds | M | ALT - EN ISO 17852:2006 | Below the detection limit | |
| 22 | Ni and compounds | M | EPA 200.8 K(ICP-MS) | Below or near the detection limit | |
| 23 | Pb and compounds | M | EPA 200.8 K(ICP-MS) | Below or near the detection limit | |
| 24 | Zn and compounds | M | EPA 200.8 K(ICP-MS) | 1,747 | |

**COMPETENT AUTHORITY TO WHICH THE PUBLIC CAN TURN**

| | |
|---|---|
| Name | The Environment Agency of Iceland |
| Address | Sudurlandsbraut 24 |
| Town/location | Reykjavik |
| Telephone | 591 2000 |
| Fax | 591 2020 |
| E-mail address | ust@ust.is |

## Annex 24. **Waste sorting 2011-2015**

Most of the asphalt used in construction for OR and its subsidiaries is sent to the asphalt station in Höfdi for recycling. In 2014 Höfdi started to produce asphalt which contains recycled asphalt and in total accounts for 28% of the annual production. Generally the percentage of old asphalt used in recycled production is 20-30%.

**WASTE CATEGORIES 2011-2015**

| CATEGORY | UNIT | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| General waste | kg | 86,590 | 57,640 | 52,770 | 53,210 | 55,300 |
| Bulk waste | kg | 84,950 | 40,430 | 27,550 | 10,129 | 19,400 |
| Asbestos | kg | 1,264 | 8,620 | 35,700 | 11,700 | 18,260 |
| Sludge (solid constituents from sewage) | kg | 1,181,610 | 1,369,210 | 1,131,500 | 1,325,860 | 722,280 |
| **Total for landfilling** | **kg** | **1,354,414** | **1,475,900** | **1,247,520** | **1,400,899** | **815,240** |
| Green bin | kg | 8,900 | 6,420 | 5,870 | 6,860 | 8,220 |
| Metals | kg | 58,680 | 72,230 | 46,430 | 59,390 | 81,280 |
| Timber - unpainted | kg | 33,650 | 17,050 | 5,760 | 18,160 | 23,340 |
| Timber - painted | kg | 21,260 | 13,790 | 11,540 | 8,800 | 19,490 |
| Garden waste | kg | | | | 3,320 | 13,580 |
| Glass and minerals | kg | | | | | 12,680 |
| Plastic | kg | 5,100 | 2,610 | 4,810 | 3,140 | 3,340 |
| Corrugated cardboard | kg | 12,600 | 6,480 | 9,850 | 7,520 | 13,230 |
| Office paper | kg | 3,120 | 2,280 | 3,510 | 3,010 | 2,950 |
| Newspapers and magazines | kg | 760 | 670 | 1,530 | 110 | 140 |
| Organic waste | kg | 27,030 | 17,550 | 22,560 | 25,740 | 26,120 |
| **Total for recycling** | **kg** | **171,100** | **139,080** | **111,860** | **136,050** | **204,370** |
| Unknown materials | kg | 4,253 | 1,180 | 93 | 170 | 3,237 |
| Light bulbs | kg | | 1,310 | 1,309 | 649 | 1,158 |
| Batteries | kg | | | 29 | 10 | 18 |
| Car batteries | kg | | 1,546 | 500 | 1,394 | 683 |
| Electronic equipment | kg | | | 77 | 771 | 1,413 |
| Paint and print waste | kg | | 118 | 98 | 420 | 93 |
| Oil and oil contaminated waste | kg | | | | 1,901 | 2,103 |
| Solvents | kg | | | | 154 | 51 |
| Organic pollutants, cooking oil | kg | | | 408 | 273 | 327 |
| Inorganic pollutants | kg | | | | | 68 |
| Plaster | kg | | | 150 | | |
| **Total hazardous waste** | **kg** | **4,253** | **4,154** | **2,664** | **5,742** | **9,151** |
| **Total waste** | **kg** | **1,529,767** | **1,619,134** | **1,362,044** | **1,542,691** | **1,028,761** |
| Earthmowing * | tons | | | | 5,027 | 4,733 |
| Asphalt** | tons | | | | 440 | 800 |

* When calculating the weight of earthmowing due to constructions it is assumed that every cubic meter contain

** Asphalt is mostly recycled

## Annex 25. **Sorting of waste by worksites in 2015**

**WASTE CATEGORIES 2015 BY WORKSITES**

| CATEGORY | UNIT | NESJA-VELLIR | HELLIS-HEIDI | REYKJAVIK | ELLIDAÁR-STATION | AKRANES | BORGAR-NES | ÁNA NAUST | KLETTA-GARDAR | PUMPING STATIONS IN THE METROPOLITAN AREA | SEWERAGE TREATMENT PLANTS IN BORGAR-FJÖRDUR | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| General waste | kg | 3,230 | 14,120 | 33,040 | 780 | 1,660 | 230 | | 2,240 | | | 55,300 |
| Bulk waste | kg | | 6,460 | 12,940 | | | | | | | | 19,400 |
| Asbestos | kg | | | | | | 18,260 | | | | | 18,260 |
| Sludge (solid constituents from sewage) | kg | 51,940 | 16,000 | | | | | 217,480 | 321,380 | 86,720 | 28,760 | 722,280 |
| **Total for landfilling** | **kg** | **55,170** | **36,580** | **45,980** | **780** | **1,660** | **18,490** | **217,480** | **323,620** | **86,720** | **28,760** | **815,240** |
| Green bin | kg | | | 8,100 | | | | | 120 | | | 8,220 |
| Metals | kg | 3,020 | 28,160 | 50,100 | | | | | | | | 81,280 |
| Timber - unpainted | kg | | 16,320 | 7,020 | | | | | | | | 23,340 |
| Timber - painted | kg | 2,280 | 4,740 | 11,890 | | | 580 | | | | | 19,490 |
| Garden waste | kg | | | 13,580 | | | | | | | | 13,580 |
| Glass and minerals | kg | | | 12,680 | | | | | | | | 12,680 |
| Plastic | kg | | | 2,930 | | 350 | 60 | | | | | 3,340 |
| Corrugated cardboard | kg | 970 | 1,300 | 10,450 | | 500 | 10 | | | | | 13,230 |
| Office paper | kg | | | 2,950 | | | | | | | | 2,950 |
| Newspapers and magazines | kg | | | | | 140 | | | | | | 140 |
| Organic waste | kg | | | 26,120 | | | | | | | | 26,120 |
| **Total for recycling** | **kg** | **6,270** | **50,520** | **145,820** | **0** | **990** | **650** | **0** | **120** | **0** | **0** | **204,370** |
| Unknown materials | kg | 1,224 | 2,013 | | | | | | | | | 3,237 |
| Light bulbs | kg | 18 | 102 | 1,038 | | | | | | | | 1,158 |
| Batteries | kg | 1 | | 17 | | | | | | | | 18 |
| Car batteries | kg | 113 | 189 | 381 | | | | | | | | 683 |
| Electronic equipment | kg | | | 1,413 | | | | | | | | 1,413 |
| Paint and print waste | kg | 1 | | 92 | | | | | | | | 93 |
| Oil and oil contaminated waste | kg | 1,561 | 471 | 71 | | | | | | | | 2,103 |
| Solvents | kg | 2 | | 49 | | | | | | | | 51 |
| Organic pollutants, cooking oil | kg | 212 | 115 | | | | | | | | | 327 |
| Inorganic pollutants | kg | | 68 | | | | | | | | | 68 |
| Plaster | kg | | | | | | | | | | | 0 |
| **Total hazardous waste** | **kg** | **0** | **2,958** | **3,061** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **9,151** |

Wastes from the worksite Reykjavík includes offices of OR and its subsidiaries and tenants.

## Annex 26. **Number of cars of the OR Group, based on energy sources and emission values at the end of each year for the period 2011-2015**

**NUMBER OF CARS**

| VEHICLES | ENERGY SOURCE | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| Traditional | Gasoline >99 g $CO_2$/km | 29 | 24 | 21 | 14 | 5 |
| | Diesel >99 g $CO_2$/km | 85 | 76 | 83 | 91 | 110 |
| Environmentally friendly | Diesel <99 g $CO_2$/km | | | | 5 | 4 |
| | Hybrid | | | | 17 | 19 |
| | Plug-in hybrid | | | | 2 | 2 |
| | Electricity | 1 | 2 | 5 | 5 | 12 |
| | Methane | 21 | 16 | 14 | 11 | 17 |
| Total | | **136** | **118** | **123** | **145** | **169** |

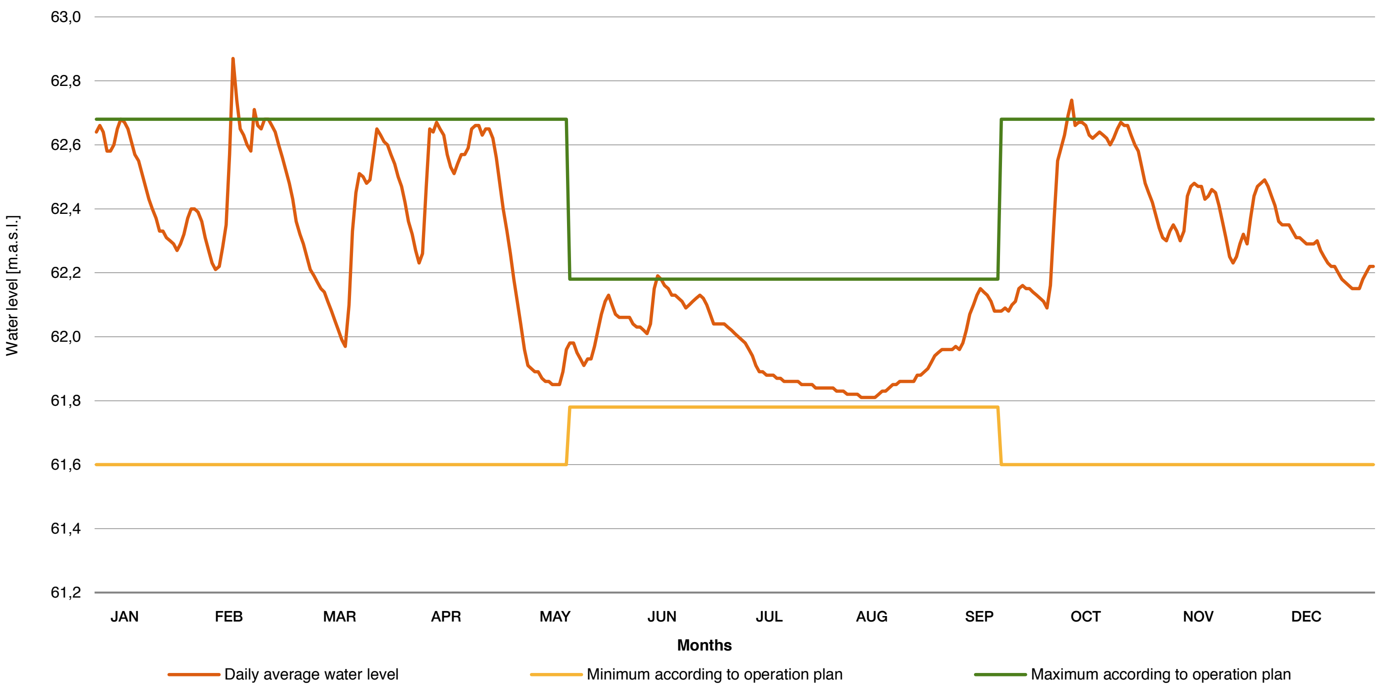
## Annex 27. **Fuel consumption of vehicles used by the OR Group 2011-2015**

**VEHICLE FLEET'S FUEL CONSUMPTION**

| ENERGY SOURCE | Unit | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| Gasoline | Liters | 60,181 | 44,499 | 33,347 | 34,088 | 27,509 |
| Diesel | Liters | 297,644 | 174,164 | 168,326 | 156,529 | 200,523 |
| Methane | $m^3$ | 28,010 | 20,522 | 19,542 | 10,110 | 8,968 |
| Hydrogen | $m^3$ | 181 | 0 | 0 | 0 | 0 |

## Annex 28. **Water level in Lake Skorradalur 2015**

**WATER LEVEL IN LAKE SKORRADALSVATN 2015**



## Annex 29. **Greenhouse gas emissions from the activities of OR and its subsidiaries 2011-2015**

**EMISSIONS OF GREENHOUSE GASSES**

| GREENHOUSE GAS | ORIGIN | UNIT | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| Carbon dioxide($CO_2$) | Nesjavellir | tons | 14,800 | 18,612 | 14,794 | 16,579 | 14,726 |
| | Hellisheidi | tons | 39,479 | 43,158 | 44,934 | 41,242 | 36,988 |
| | Hverahlíd | tons | 0 | 0 | 0 | 0 | 0 |
| | Backup power generators | tons | 29 | 75 | 5 | 25 | 5 |
| | Vehicle fleet | tons | 775 | 550 | 511 | 482 | 582 |
| | Heating station | tons | 1 | 0 | 0 | 0 | 0 |
| | Air flights ($CO_2$-equivalence) | tons | 33 | 39 | 72 | 88 | 100 |
| | Waste ($CO_2$-equivalence) | tons | 1,744 | 1,846 | 1,664 | 1,759 | 1,173 |
| | **Total $CO_2$** | **tons** | **56,861** | **64,280** | **61,979** | **60,174** | **53,573** |
| Methane ($CH_4$) | Nesjavellir | kg | 46,620 | 28,000 | 46,200 | 53,453 | 53,538 |
| | Hellisheidi | kg | 57,000 | 51,000 | 72,000 | 80,829 | 79,601 |
| | Hverahlíd | kg | 0 | 0 | 0 | 0 | 0 |
| | Backup power generators | kg | 2 | 5 | 0 | 2 | 0 |
| | Vehicle fleet | kg | 50 | 56 | 48 | 47 | 50 |
| | Heating station | kg | 0 | 0 | 0 | 0 | 0 |
| | **Total $CH_4$** | **kg** | **103,672** | **79,061** | **118,249** | **134,330** | **133,190** |
| Nitrous oxide ($N_2O$) | Backup power generators | kg | 0 | 1 | 0 | 0 | 0 |
| | Vehicle fleet | kg | 7 | 5 | 5 | 5 | 6 |
| | Heating station | kg | 0 | 0 | 0 | 0 | 0 |
| | **Total $N_2O$** | **kg** | **7** | **6** | **5** | **5** | **6** |
| Sulphur hexafluoride ($SF_6$) | Nesjavellir | kg | 0 | 0 | 0.527 | 0 | 0 |
| | Hellisheidi | kg | 0 | 0.527 | 0 | 0.527 | 0 |
| | Utility systems | kg | 0 | 0 | 0 | 0 | 0 |
| | **Total $SF_6$** | **kg** | **0** | **0.527** | **0.527** | **0.527** | **0** |

## Annex 30. **Carbon sequestration of OR and its subsidiaries 2011-2015**

**CARBON SEQUESTRATION**

| CARBON SEQUESTRATION | UNIT | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| Land reclamation $CO_2$ sequestration | tons | 1,238 | 1,086 | 1,110 | 1,149 | 1,202 |
| Forestry $CO_2$ sequestration | tons | 3,700 | 3,626 | 3,626 | 3,626 | 3,626 |
| Sequestration in CarbFix and SulFix projects | tons | | 110 | 3 | 2,381 | 3,911 |
| **Total carbon sequestration per year** | **tons** | **4,938** | **4,822** | **4,739** | **7,155** | **8,739** |