Hellisheiði Power Plant
Environmental Impact Assessments (EIA's)

Two EIA's have been issued for Hellisheiði Power Plant. The first one was issued in April 2002. That covered 120 MW_e electricity production and 400 MW_{th} thermal production. The second EIA coverd the enlargement of the power plant and was issued in June 2005. The conclusion of the two EIAs is that the project will not have a significant impact on the environment. The power plant will have some negative but reversible impact on geothermal resources, some negative impact on landscape and noise, besides it is believed to have some positive and negative effect on land use, tourism and recreation in the area. The project will affect to some degree both the municipal plan and the local development plan and nature conservation areas. The project is believed to have negligible effect on water, air, flora, fauna, and biota of hot springs, cultural remains, residential development and transport. The following summary contains:

- General information about the environment at Hellisheiði (chapter 1)
- Extraction from both EIA's (chapter 2)
- Information about consultation and public participation (chapter 3)
- Extraction from the ruling of the Planning Agency (chapter 4)

1 Environment

The Hengill region is a rural mountainous area in the middle of the western volcanic zone in Iceland that runs from Reykjanes in a northerly direction to Langjökull. The bedrock consists mostly of palagonite formed by volcanic eruptions below glaciers during the last ice age. Basalt is present on the fringes of the area. The Hengill region is one of the most extensive geothermal areas in the country. Surface measurements and heat distribution indicate an area of around 112 km^2. The high temperature geothermal area at Hengill covers two central volcanoes and their surroundings. The Hveragerði central volcano is extinct and eroded. The other one is active and splits into two volcanic systems, one at Hengill and the other at Hrómundartindur.

Areas, that are already utilized by Orkuveita Reykjavíkur or are under construction, lie on the active fault zone of the Hengill which reaches from Nesjavellir in the north to Hellisheiði in the south. A fault zone which is part of the Hengill Volcano cuts through the
volcanic zone from south west to north east. The most important areas for productions in the Hengill area are connected to this fault zone, i.e. Nesjavellir in the north and Hellisheiði in the south. Three recent volcanic fissures are among the features that characterize these areas. They erupted 10, 6 and 2 thousand years ago. The two most recent ones can be found all the way from Hellisheiði to Þingvallavatn. These volcanic fissures are considered the main sources of geothermal energy at Nesjavellir and the same is considered true for Hellisheiði.

The groundwater system in the area is very complicated. The main characteristic of the groundwater system in the investigated area is that it is divided from southwest to northeast by a range of mountains formed by Hengill, Stóra-Reykjafell, Stórimeitill and Litlimeitill. On the eastern side water flow is to the east from Hellisheiði. Hydrology is a little more complex on the western side, with a characteristic area of 15 km2 west of Hengill where the level of the groundwater table is around 172 m above sea level. From there, groundwater flows in three directions: West to the Elliðaá catchment area, northeast to Þingvallavatn and to the south until it reaches the sea at Selvogur. Apart from small streams in Sleggjubeinsdalur, from Draugatjörn and in Engidalur there is little surface water in the development area. The river Hengladalsá runs out of Innstadalur in the eastern part of the Hengill region.

Vegetation in the development area is mostly moss, grass and small shrubs. Grassland is less widespread than the moss-covered areas. The land in which the plants fresh water supply, fresh water pipe and hot-water transmission pipe will be installed is well vegetated, mostly mossy hillocks and low hills with grass and heather in hollows. About a quarter of the area is lava with a moss covering wetlands are found only in two places; around Draugatjörn and near the derelict settlement Elliðakot. A big part of the upper development area on Skarðsmýrarfjall has little or no vegetation. The little

vegetation there is mostly moss. Plants that can be associated with geothermal heat have not been found on the upper development area.

Animal life is rather scarce, possibly because of shortage of surface water in the area. Fifteen to seventeen breeding bird species have been recorded at Kolviðarhóll, some of which seem to be found only at Kolviðarhóll and surroundings. Raven, which is an endangered species, has bred at Hellisskarð. Five to six breeding bird species were found, on Skarðsmýrarfjall golden plover being the most common one.

The Hengill region is unusual for Icelandic highlands, because of many cultural remains from summer grazing and even more remains linked to transport, such as old trails that cross the area. No cultural remains have been found on Skarðsmýrarfjall.

Cultural remains in the area are particularly linked to transportation and many old trails crossing the area. There are no residential houses but two sports clubs have had skiing facilities in this area for years. It was decided that they would move to other locations
before the winter 2006 – 2007. The Hengill area is popular for recreation and marked hiking trails and publication of maps have increased its accessibility. Some old trails are also used for horseback riding.

The air temperature is on average 2.6°C lower than in Reykjavík. Humidity is higher and the wind speed on Hellisheiði is generally 70% higher than that in the capital area. Rainfall is three times that of Reykjavík.

2 Environmental Impact

The conclusion of the two EIAs is that the project will not have a significant impact on the environment. The power plant will have some negative but reversible impact on geothermal resources, some negative impact on landscape and noise, besides it is believed to have some positive and negative effect on land use, tourism and recreation in the area. The project will affect to some degree both the municipal plan and the local development plan and nature conservation areas. The project is believed to have negligible effect on water, air, flora, fauna, and biota of hot springs, cultural remains, residential development and transport. The following is a summary of the results of the two EIAs for the power plant and it's proposed extension of the Hellisheiði.

Geothermal resources
The project is regarded as an optimal choice with regard to possible effects on the geothermal reservoir and energy resources, according to numerical reservoir modelling. Exploitation of the Hellisheiði geothermal field is not expected to affect the nearby geothermal areas in Hveragerði, at Ölkelduháls or at Nesjavellir. The numerical reservoir model predicts low financial risk in constructing a 40 MW_e electric and a 133 MW_{th} thermal power plant on Hellisheiði. The financial risk increases if construction stages are larger because of uncertainty in the number of production wells needed. Discharge of separated geothermal water will not increase over the prediction period according to the model.

The reservoir model predicts increase in enthalpy from the wells until 2036. The total discharge and steam discharge is predicted to decrease slowly from the wells the power plant in full operation. The decrease in electrical production will be maximum 20% at the end of the prediction time (30 years), while the total steam output decreases about 6%. The model has to be re-evaluated when data from more wells will be available. The model predicts that if all production will be stopped in the Hengill areas (Nesjavellir and Hellisheiði) in 2036, it will take 50 – 60 years for the pressure in the reservoir to increase to almost its initial value. This means that it will take the reservoir about as long to recover as the production period will last. The mass balance of the reservoir is therefore considered sustainable and renewable. The prediction of the model calculations performed for the whole power plant is about the same as the one performed in 2003 for a smaller power plant, i.e the pressure will take about the same time to recover with or without the extension of the Hellsiheiði power plant. The temperature in the reservoir on the other hand needs 500 – 1000 years to reach its initial state after production stops with or without the extension. The temperature decrease is mostly less than 10°C, while the initial temperature at the Hellisheiði reservoir is 240 – 280°C. The geothermal area will be extensively monitored since the effect of production and injection in the reservoir model on the reservoir will not be

certain until production and injection has started. With more knowledge on the behaviour of the reservoir with production and injection more accurate predictions for the reservoir can be made and they compared to the initial assessment of the geothermal area and its resources. The amount of fluid injected into the reservoir from the wells at Hellsiheiði is predicted to make little difference on the overall performance of the reservoir utilized by the two fields. The size of the power plants and production from the wells has much more effect. It is predicted that the production from Hellisheiði will have some negative effect on the reservoir, but that it is renewable and that the reservoir will recover after production is stopped. The effect of the extension is negligible in the recovery.

Water
As is described above the hydrology of the area proved to be rather complex and the area investigated was therefore extensive. Numerical modelling, among other techniques, was performed to analyze the data and assess the effects on hydrology. This analysis shows that condense water contains no substances exceeding allowed limits. However, levels of three substances in the separated geothermal water were found to be above limits for drinking water and amounts of arsenic were considered unacceptable for the biota in surface waters. For this reason surface discharge of separated geothermal water is not considered as an option because of possible effects on water supplies and biota.

The environmental studies included a search for a suitable fresh water supply for producing hot-water in the thermal power plant. An assessment was conducted of the possible effects this extraction of groundwater could have on hydrology of surrounding areas. Sufficient freshwater for hot water production in the power plant can be obtained from the proposed water supply at Engidalskvísl west of Húsmúli. An area surrounding the fresh water supply will be defined as a protected water catchments area.

To prevent scaling on the surface from geothermal fluid during drilling and testing the discharge water will be disposed into fissures or shallow boreholes. Discharge fluid during testing can affect temperature and chemical content of groundwater, for short periods close to the discharge spots.

Orkuveita Reykjavíkur seeks ways to inject the discharge fluid from the power plant back into the geothermal reservoir in order to maintain the pressure in the system and because of the aluminium and arsenic content in the fluid discharge above the limits for potable water. The total discharge water from the Hellisheiði power plant will be approximately 1100 l/s.

According to groundwater investigations and numerical modelling, the most appropriate location for injection of geothermal separated water is into 800-1000 m deep wells is in the a proposed discharge area in Svínahraun southwest of the main powerhouse. Deep wells at the discharge area have shown that there is a non permeable tuff layer that separates cold groundwater from the natural discharge from the geothermal area. In this way the water supplies of Þorlákshöfn, of the power plant on Hellisheiði and for the capital area will not be affected by this discharge. Temporary discharge of geothermal separated water into shallow sinkholes near the main powerhouse due to possible closure of discharging operations does not appear to have any effect on groundwater.

By drilling deep wells in Svínahraun an attempt is made to make a pressure connection with the reservoir. The plan is to drill 800 – 1000 m deep injection wells with casings reaching below the tuff layer. By doing this the discharge water will not be injected into the cold groundwater stream above 400 m depth. Injection into wells in other areas, with good connection to the production field and permeable rocks are also being considered. A realistic plan for injection of the discharge water is therefore to start by injecting part of it into the natural geothermal discharge at Svínahraun, but with better knowledge of the system to strive to find a way to inject it into the reservoir itself.

Assessment of the projects impact on water is based on the best knowledge available. The data is constantly being revised and added to with more investigations and observations. Because there are some uncertainties concerning the effect of injection the ground water will be heavily monitored. The monitoring will be consolidated and increased in the area where impact is possible. The baseline for the monitoring was set by taking samples from 15 wells and 6 springs in the area in 2005. The analysis of these samples will be used for comparison and monitoring of possible changes linked to production and injection. Samples will be taken at different depths from two deep monitoring wells located to the south of the discharge area. This makes it possible to monitor different water flow and to

verify the predicted impact of injecting discharge fluid into the 800-1000 deep wells. The mitigating measure taken by injecting the discharge water into the natural discharge of the geothermal reservoir is considered to have a negligible effect on water.

Landscape
The landscape in this part of the Hengill region is not highly valued and the area is already considerably disturbed. For this reason it is considered that the project will not have a significant effect on the landscape. Construction in recently formed lava fields, will affect a type of landscape that is protected according to nature conservation legislation. As far as possible, construction sites have been chosen to avoid affecting protected areas. Certain geological features in the area have been defined and will not be disturbed. Grouping production wells on each specified drilling site will reduce the number of transmission pipes and service roads needed and minimizes the disturbance of land. Excavated material that is discarded will be used for filling up old quarries at. Mitigating measures will help to minimize any effect on the landscape and areas of geological interest.

The estimated area outside the building plot that will be affected is 950.000 m^2, 300.000 m^2 for the hot water pipe and 110.000 m^2 for the building plot for both developments. The total area affected will be 1.360.000 m2 for Hellisheiði power plant. The project will have some direct negative effect on landscape at the construction site. The surroundings of the proposed power plant will be subject to some changes. Buildings such as the powerhouse, cooling towers and steam exhaust chimneys will be clearly visible, as will surface transmission pipes, borehole housings and new roads. In most cases these effects will be permanent, although some will be temporary such as steam exhaust from wells while testing and during construction of transmission pipes as well as quarrying. For the most part, the visible effects of buried pipes will be temporary. Proposed mitigating measures will reduce these effects.

This will cause some indirect permanent impact. Steam from wells being tested will be rather prominent, especially during the next 4 – 5 years or until commissioning of the fifth 180 MW_e stage. The project will therefore have some temporary, indirect negative effect. The project will also have some temporary direct effect because of excavation during installation of steam transmission pipes and at the quarry sites during construction. Unique geological features will be avoided if possible when deciding the location of structures.

Air
The power plant on Hellisheiði will cause increase in carbon dioxide emission in Iceland of around of 57.000 tonnes carbon dioxide and 48 tonnes methane annually. Greenhouse gas emission per produced kWh will not change. Some scientists claim that utilization does not change the total amount of naturally emitted carbon dioxide in geothermal areas. Green house gas emission from geothermal power plants is not included in Iceland's inventory of total emission. The estimated emission of hydrogen sulphide will be about 11.000 tonnes per year. A negligible fraction of this is expected to oxidize to form sulphur oxides while most will end on the ground during rainfall and form sulphate or sulphur. Because of the high precipitation and strong winds in the area hydrogen sulphide will be washed out of the atmosphere. The risk of hydrogen sulphide affecting the environment is considered low, although under certain conditions a sulphurous smell is expected. Concerning green house gases emission from the Hellisheiði power plant it is in concurrence with the governmental policy. Emission of hydrogen sulphide is not considered to cause any risk. The project will have very little effect on air quality. Efficient use of natural resources in the power plant through cogeneration of electric and thermal power leads to very low greenhouse gas emissions per produced kWh.

Noise
Noise levels during construction and operation periods may exceed recommended levels for industrial sites, especially during drilling and testing of production wells. The noise level will increase during the next two years during drilling and testing of 16 wells for the third 90 MW_e stage to be completed in 2008, and again when wells will be added before commissioning of later stages of the electric power station. During these periods it is possible that 2 - 3 wells are being tested at the same time in the development area at as has been the fact for the past few years for the present plant since few months after completion of the first well. Make up wells will be drilled during the power plant's operation period temporarily increasing noise level close to the drill sites. The noise level during the operation period could increase close to the present power plant especially close to the main power house, but will be within the limits for industrial sites. Silencers will be installed at each well to reduce

noise. The extension will temporarily have some negative impact regarding noise in recreation areas close to the production field on Skarðsmýrarfjall especially because of drilling and testing of the production wells, but no permanent impact is expected. The extension will have very little noise effect at the current construction site and injection area.

Tourism and recreation
The general public opinion of exploiting geothermal resources in the Hengill region is positive. The extension can affect some tourist agencies' operations in the area. A survey indicated the possibility of both negative and positive impact. Improved accessibility and a road up to Skarðsmýrarfjall can give people the opportunity to travel in the area and enjoy outdoor live. Results of surveys indicate that the construction of a power plant will not reduce the number of visitors coming to the Hellisheiði and Hengill areas. On the contrary, the results indicate that the number of visitors pursuing outdoor activities in the area will increase rather than decline. Some negative impact is expected closest to the well fields at Skarðsmýrarfjall because they are closer to popular hiking trails than the present production field.

Flora
The project's effect on vegetation is limited to excavation for constructions such as drill sites, transmission pipes, roads, quarries and buildings and the immediate vicinity of these. It is considered unlikely that the project will have any significant impact on vegetation in the area. No great disturbance is expected to areas of vegetation or to sites of special interest, nor will any rare species disappear from the flora of the area. The wetlands around Húsmúli will be spared. Mitigation measures planned during construction of the hot water transmission pipe at Elliðakotsmýrar will prevent it affecting water levels and the wetlands will in that way be preserved.

Fauna
The project will have little impact on animal life. The breeding grounds of some birds may at times be disrupted during the construction period. Permanent effects on bird life are unlikely and effects on invertebrates in the area are expected to be minimal.

Land use
The Hellisheiði power plant will have some effect on land use outside the present development area. The project will affect planning and land use and a local development plan is being prepared. The project complies with the publicized proposed municipal plan of the Ölfus Municipality. Changes are necessary to the municipal plans of Mosfellsbær and Reykjavík as the hot-water transmission pipe is not included. Footpaths and bridle trails will be diverted during the construction period if needed. It is proposed that trails will be open to hikers or horseback riding when construction work is complete. Proposed mitigating measures are expected to minimize the impact on land use, particularly use of the skiing area, footpaths and bridle-trails.

Cultural remains
No known cultural remains are at risk in the development area. A steam transmission pipe will cross the ancient Hellisheiði Trail but it will be kept open and cairns along trail the will be preserved. The hot-water transmission pipe to Reykjavík lies close to one cairn and permission will be sought to move the cairn if necessary.

Planning and protection
The project will affect the municipal plan for the Ölfus municipality and the local development plan for the power plant, and changes needed to be made before the construction starts. The way construction is planned at the upper area at Skarðsmýrarfjall it will not affect protected water catchments areas. The project will affect a part of the Hengill area which is listed as an area of special interest as are volcanic crater rows that will be crossed in one place by steam transmission pipes. The Hellisheiði power plant's injection area is located in a lava field which is protected by the nature conservation law. On the upper area at Skarðsmýrarfjall areas have been defined around craters that will be protected if possible. These and other special features will be suggested for protection and included in the local development plan for the Hellisheiði power plant.

Other effects

During the year 2006 the number of employees on the construtcion site have varied from 300 and up to 500 the most. Overnight accommodation will not be provided for and there will not be any residential housing in the development area, exept for accommodation for two employees on the night shift. The project is expected to have a small impact on employment and residential development within the municipality of Ölfus.

The general public opinion of exploiting the geothermal resources in the Hengill region is positive. Results of surveys indicate that the construction of a power plant will not reduce the number of visitors coming to the Hellisheiði and Hengill areas. On the contrary, the results indicate that the number of visitors pursuing outdoor activities in the area will increase rather than decline.

The project is not expected to lead to increased traffic on Hellisheiði. The most likely impact will be that traffic will increase at the junctions of the National Highway and the two roads used to access the development area.

Monitoring
As is stated in the first EIA report for the Hellsiheiði power plant the monitoring of possible effects of the geothermal installation on Hellisheiði will be, where appropriate, carried out in a similar manner to that employed in the company's geothermal power plant at Nesjavellir. The frequency and analysis will be according to the plan for monitoring for the Hellsiheiði power plant, that was introduced during the EIA process. The control system software of the power plant collects information on principal factors of production. Additionally, the geothermal area will be monitored and inspected regularly, this includes possible land deformation due to exploitation, impact on fauna, flora and hydrology and changes to discharges.

3 Consultation and public participation

General
The Planning Agency, statutory consultees, grantors of permits and licences plus the general public have been informed and consulted during the two EIA processes according to the Icelandic Environmental Assessment Act No. 106/2000. The first process was in 2003 for 150 MW_e and 400Wth. The second EIA process was in 2005 for the 120 MW_e enlargement of the power plant.

The proposed projects were publicised on the websites of Orkuveita Reykjavíkur www.or.is and VGK Consulting Engineers LTD www.vgk.is.

Orkuveita Reykjavíkur has presented the company's projects at the Hengill area to the public and especially the Hellisheiði power plant during the last few years. News and educational material are published on the company website.

The project and its possible impacts have been presented to travel agencies, tour organizers and sport clubs in the Hengill area because of tourism and recreation in the Hengill area.

Orkuveita Reykjavíkur receives many guests every year. Around 17.000 guests visiting the Nesjavellir power plant each year are all presented with information on the geothermal utilization and other parts of the company's activities. The project at Hellisheiði has systematically been explained during these introductions. Many guests visit Orkuveita Reykjavíkur at the company's water works at Gvendarbrunnar and at its head quarters in Reykjavík. They are introduced to the company's service area and the Hellisheiði power plant project. Many groups have been invited to visit the development site at Hellisheiði for the sole purpose of introducing them to the project.

An information centre for the Hellisheiði power plant project was open in Hveradalir in the summers of 2004 and 2005 offering brochures and posters on environmental matters, geology and technical aspects of the power plant. A video on the activity of Orkuveita Reykavíkur was also displayed. The company's representative was always available at the information centre for further information. The number of guests in the summer of 2004 was 1111, 862 Icelanders and 249 foreigners. The number of guests from June to August 2005 was 859, 727 Icelanders and 132 foreigners. Many guests attended guided tours on offer.

Publication and consultation on EIA Proposals

Both of the preliminary EIA proposals were presented to the main consultees, grantors of permits and licences and interested parties. The respective parties were asked to comment on the proposal and point out the main issues of environmental impact assessment of the project. Meetings were held with the following parties:

- Planning Agency
- Ölfus Municipality
- Environment and Food Agency
- Environmental Protection Agency, now the Environment and Food Agency
- Environmental and Food Agency, now the Environment and Food Agency
- Environment and Food Agency, Municipal Control Unit of South-Iceland
- Environment and Food Agency, Municipal Control Unit of Hafnarfjörður and Kópavogur
- Environmental and Technical Sector of the City of Reykjavik
- Archaeological Heritage Agency of Iceland
- Orkustofnun, the National Energy Authority
- Reykjavík Sports- and Youth Council, ÍR-sports club and Víkingur-sports club, skiing divisions
- Public Roads Administration
- Landmótun eHF, in connection with preparation of the Ölfus Municipal Plan

The preliminary EIA proposals were published by advertising in both local and national newspapers and two weeks were given for remarks and comments. There also was an open house in Þorlákshöfn in the Ölfus Municipality on February 2002 and March 2005 regarding the preliminary EIA proposals.

All the parties contacted gave either verbal or written comments on what might be improved, and what should be added to the reports. All comments were taken into considerations and acted upon when possible.

The main subjects of concern for the power plant were: The effect of discharge water on the ground water, sustainability, reversibility and renewability of the geothermal reservoir, visual effect, effect on flora, fauna and protected surface manifestations and cultural remains, tourism and cumulative effect of all power plants in the Hengill area.

After the consideration of the comments received at meetings, the final reviewed first EIA proposal was submitted to the Planning Agency on in February, 2002. The Planning Agency accepted the proposal, with comments, in April 2002.

The final reviewed second EIA proposal was concluded and submitted to the Panning Agency April 2005. The remarks and comments received during the introduction had been taken into consideration. The Planning Agency approved the second EIA proposal in June 2005.

The Planning Agency announced the two EIA proposals on its website and issued a press release. Two weeks were given for comments. The proposal was also sent to consulting authorities.

The EIA proposals are published on the websites of Orkuveita Reykajvíkur's www.or.is and VGK Consulting Engineers LTD www.vgk.is.

Both reports on the Planning Agency's conclusion can be assessed on the website www.skipulag.is.

Publication and consultation on EIA Statements
Formal and informal collaboration has been received from the Planning Agency, other interested parties, granters of permits and licences and specialists on various topics during the whole EIA process. See the chapter above for information on the publication and consultation on the EIA proposals.

Because changes had to be made to municipal and development plans, cooperation has been shared between Orkuveita Reykjavíkur, the Ölfus Municipality and the planning consultants, trough the whole development process. The Planning Agency, the Municipal Control Unit of the Environment and Food Agency in South-Iceland, the Public Roads Administration, the Environment and Food Agency, Orkustofnun and the Archaeological Heritage Agency of Iceland, were also consulted on various issues of the EIA.

The Planning Agency received the first preliminary environmental impact statement (EIS) for inspection in September 2003. Respective chapters were also sent to the specialists who contributed material to the environmental report for review. At the same time the results of the environmental impact assessment in respective fields were presented at meetings with the following authorities:

- Mosfellsbær Municipality
- Ölfus Municipality
- The Suðurland Division of the Environmental and Food Agency
- The Environmental and Food Agency
- Orkustofnun, the National Energy Authority

The Planning Agency received the second preliminary environmental impact statement (EIS) for inspection in September 2005. Respective chapters were also sent to the specialists who contributed material to the environmental report for review. At the same time the results of the environmental impact assessment in respective fields were presented at meetings with the following authorities:

- Ölfus Municipality
- The Suðurland Division of the Environmental and Food Agency
- The Environmental and Food Agency
- Orkustofnun, the National Energy Authority

In the final edition of the environmental impact statements, comments and remarks of specialists, the Planning Agency and from meetings with the above mentioned authorities have been taken into account. Following is a summary of the main subjects commented on at meetings and by the Planning Agency when inspecting the EIA statements: The project's objective, estimated capacity, alternatives regarding power plant design, access to the project site, routes of pipes, comparison of buried and surface pipes, gravel pits, impacts from drilling and testing, impact on the geothermal reservoir, natural discharge from geothermal area, plans on re-injection, effect on cold ground water, visual impact, geothermal gas emission and sulphurous smell, increased noise level, monitoring and strategy for reaction to impacts, connection to power grid, effects on development plans and cumulative impacts of the present power plant and the proposed extension.

For its final appraisal the first final EIA statement was sent to the Planning Agency in November 2003 and the Planning Agency approved it in February 2004. The second final EIA statement was sent to the Planning Agency in December 2005 and the Planning Agency approved it in March 2006.

The results of the two EIAs and the statements were presented at separate public meetings held in Þorlákshöfn and Reykjavík. The EIA statement is published on the websites of Orkuveita Reykjavíkur www.or.is and VGK Consulting Engineers LTD www.vgk.is.

4 Conclusions of the planning agency

The Planning Agency has concluded its review of Orkuveita Reykjavíkur's environmental impact statement (EIS) and delivered a ruling on the development of the CHP geothermal power plant on Hellisheiði. The Planning Agency has also concluded its review of Orkuveita Reykjavíkur's second EIS and delivered a ruling on the extension of Hellisheiði Power Plant. Following are translations of the Agency's conclusions and rulings on the first and second EIS (Chapters 5.6 and 6 in the Planning Agency's rulings).

First EIS

A power plant on Hellisheiði is an extensive project consisting of many components such as: A 15 m high powerhouse and cooling towers, separator stations and fresh water tanks, steam gathering pipes from a number of defined drilling sites on Hellisheiði, geothermal steam and water transmission pipes, road construction and quarrying, besides this the installation of a 18 km long hot water transmission pipe, a 5 km long fresh water supply pipe and a 3,5 km long discharge water transmission pipe to a re-injection area by Lambafell (Has been moved closer to the Power house). The development ranges over a large area from Hellisheiði to Lambafell and down to Reynisvatnsheiði and will affect many

environmental factors. Part of the development area is already disturbed by constructions such as power lines, road tracks, skiing facilities and gravel pits and the landscape is therefore not untouched. Non the less it is the Planning Agency's opinion that in light of the project's extent that it will lead to considerable changes in the areas landscape. The Planning Agency considers that the project will change the way tourists and hikers experience the area and that it will cause disturbance to those visiting the area and its surroundings during construction, especially because noise impact during periods of drilling and testing of production wells, also because of disturbance from civil works and traffic. It is the Planning Agency's opinion that all proposed mitigation measures considered described here in chapter 4 and 5 of this ruling that they will reduce the proposed project's impact on landscape, geology, flora, fauna, cultural remains and tourists and hikers the extent of the effects will be acceptable. The Planning Agency emphasizes that the developer will recover an equal area of wetlands in SW-Iceland to that disturbed by the project in Elliðakotsmýrar. The Planning Agency considers that organizing the project according to Option I will have less impact on landscape, geology, flora and hikers and tourists than construction according to Option II but the impact of the two options will be similar regarding the geothermal reservoir, surface and groundwater, cultural remains, fauna and air quality.

The Planning Agency considers apparent from the information submitted by the developer that although numerical models indicate that the geothermal reservoir on Hellisheiði is a great energy resource that there are many uncertainties regarding the effect utilisation of the reservoir will have on natural resources, among other things because of lack of knowledge and experience of running geothermal power plants. The planning Agency considers the proposed exploitation to be aggressive to the extent that natural recharge from the exteriors of the geothermal field will not keep up with production from the reservoir, but proposed re-injection of discharge water into the reservoir aims to mitigate depletion in the system, that is the geothermal resource will not be wasted as quickly. The planning Agency considers the planned exploitation of geothermal resources as renewable with regard to pressure, fluid content, heat content and well temperature of the field but that the time scale for recovery of the geothermal resources is a bit uncertain, that is one lifetime to 1000 years.

About 900 l/s of condense water and geothermal separated water will be discharged from the complete Hellisheiði power plant. The Planning Agency considers important to protect ground water and avoiding contamination. The Agency considers that the arrangement of the proposed re-injection of discharge water must secure that the discharge water will not enter the Selvogsstraumur groundwater flow, one of the largest of the country. It is the Planning Agency's opinion that re-injection of discharge water will reduce the odds of groundwater contamination and depletion of the geothermal reservoir both at the same time. Considering the many uncertainties concerning the proposed utilisation's effect on the geothermal reservoir and the positive effect of re-injection and the fate of discharge water it is the Planning Agency's opinion that Orkuveita Reykjavíkur must carry out intensive inspection and monitoring of the geothermal reservoir and groundwater.

The Planning Agency considers that it is uncertain what effect the water supply at Engidals will have on the Elliðaárstraumur groundwater flow, water supply systems of the capital area and the hydrology of rivers and lakes in the vicinity of Reykjavík. On the other hand the results are based on a vast research on the groundwater system in the area affected by the proposed water supply and the Planning Agency considers that in light of these results and numerical modelling based on those results that the impact of the water supply on the Elliðaárstraumur groundwater flow will neither be significant nor irreversible. It is the Planning Agency's opinion that Orkuveita Reykjavíkur must carry out an intensive inspection of groundwater flow after commissioning of the water supply system and monitoring its possible impact on groundwater flow.

The Planning Agency emphasizes the importance consulting with municipalities and licensors in the monitoring and inspection process because of the above mentioned uncertainties regarding the proposed project.

The Planning Agency emphasizes that the agency's assessment of the proposed projects environmental impact is based on the fact that organization of the project will be as described in the material submitted by the developer because the consulting authorities' opinions are based on this organization. If changes are to be made to the proposed project among other tings if the re-injection area or the water supply have to be moved to different locations, this must be dealt with according to Environmental Assessment Act No. 106/2000.

The conclusion is that the Planning Agency accepts a power plant on Hellisheiði, of a capacity of 120 MW_e and 400 MW_{th} thermal power production by Option I and II with the conditions described in chapter 6 of this ruling and that if these conditions are fulfilled the power plant will not have a significant environmental impact as defined in Act No. 106/2000 on Environmental Impact Assessment.

1. Changes have to be made to the municipal plans for Mosfellsbær 2002-2024 and Reykjavík 2001-2024 due to the hot water transmission pipe's location. The proposed pipe partly crosses an area west of the Ölfus municipality's boundary south of Lyklafell where development plans were postponed. A current plan on a water protection for the capital area was adopted in 1999. According to a regional plan 2001-2024 for the capital area the above mention area is shown as unclassified and undeveloped.
2. The proposed project must conform on the final implementation of the publicized municipal plan for Ölfus municipality.
3. A local development plan must be made for the project area of the proposed power plant on Hellisheiði, considering all components of the project, including the power house, separator stations, cooling towers, control pressure stations, exhaust stacks, steam/separated geothermal water transmission pipes, fresh water transmission pipe, hot water transmission pipe, discharge transmission pipe, drilling area/sites, steam gathering pipes, switchgear, road construction, quarries, wells for fresh water supply and wells in re-injection area.
4. The project needs permits from the municipalities of Ölfus, Reykjavík and Mosfellsbær according to the Planning and Building Act. A utilisation license from the ministry of industry for utilisation of geothermal resources and ground water according to Act No. 57/1998 on Research and Use of Underground Resources and an operation license from the Public Health Authority according to Regulations No. 785/1999 on Operation Licenses for Activity that might lead to Pollution and No. 797/1999 on Protection of Groundwater. A plan must be made in consultation with Environment and Food Agency for quarrying before a development permit is granted.

Based on the information submitted by Orkuveita Reykjavíkur during review, comments, criticism and the developer's replies to these it is the Planning Agency's conclusion that the proposed power plant on Hellisheiði, a of a capacity of 120 MW_e and 400 MW_{th} power production by Option I and II will not have a significant impact on the environment if the Planning Agency's conclusion in this chapter and the conditions reported in the 6th chapter of this ruling are acted on.

Ruling
In Accordance to Article 11 of the EIA Act , No 106/2000 the Planning Agency has examined the materials submitted by Orkuveita Reykjavíkur when notification of the proposed project was made under Article 10 of the same act, along with comments, criticism and replies to these from the developer.

With reference to the Planning Agency's conclusions, which are presented in Section 5 of this ruling, the agency accepts the planned geothermal power plant on Hellisheiði, in the Ölfus Municipality, of a capacity of 120 MWe electric and 400 MWth thermal with the following conditions:

1. Orkuveita Reykjavíkur must recover wetlands in SW-Iceland in consultation with concerned landowners and municipalities, an area at least as large as the wetlands that will be disturbed or affected by the proposed project in Elliðakotsmýrar. Before implementation the developer shall present a plan of recovering wetlands to the Environment and Food Agency.
2. Orkuveita Reykjavíkur shall carry out the inspection and monitoring of groundwater flow discussed in chapters 4.2.1 and 4.2.2 of this ruling. Possible changes in groundwater flow and groundwater level in wells of the investigation area must be monitored and the operations discussed in chapter 4.2.1 carried out if inspection indicates that the planned fresh water supply system at Engidalskvísl has a different and greater impact than expected on the Elliðaárstraumur groundwater flow, among other things by moving the water supply by Engidalskvísl so that a greater quantity will be extracted from the Þingvallastraumur groundwater flow.

3. Orkuveita Reykjavíkur must ensure that geothermal discharge water will be injected into the geothermal reservoir, but not into the groundwater flow and that this must be taken into consideration regarding dept and casing of boreholes.
4. Orkuveita Reykjavíkur shall carry out the inspection and monitoring of groundwater because of injection of discharge water as discussed in chapter 4.2.2 of this ruling. This meaning that Orkuveita Reykjavíkur must measure temperature regularly, take samples twice a year in selected inspection wells and analyse all main components in water samples, also every five years samples are to be analysed for trace elements.
5. Orkuveita Reykjavíkur shall carry out the inspection and monitoring of the geothermal area and geothermal reservoir in the same way as described in chapter 4.1 in this ruling. This meaning that Orkuveita Reykjavíkur must monitor how the geothermal reservoir reacts to re-injection of discharge water in general, carry out weakly measurements of well head pressure and water level, monitor the output of production wells, analyse geothermal fluid from production wells and monitor the pressure and temperature in of the geothermal reservoir at least once a year. Orkuveita Reykjavíkur must also monitor changes in land elevation by precise ground level measurements, measure gravity changes and monitor changes in geothermal surface activity.

Deadline for appealing
According to article 12 of Act No. 106/2000 the Planning Agency's ruling may be appealed to the minister of Environment. Deadline for appeal was March 26th 2004.

Second EIS
Extending the Hellisheiði Power Plant requires a massive development in nearly untouched areas of the mountain Skarðsmýrarfjall and its slopes. This includes construction of steam transmission pipes from a number of defined drilling sites, road construction and quarrying. Structures will be added in the present development area and the extent of shared structures will increase. The total size of the impact area will increase by one third compared to the present development area. The proposed well field on Skarðsmýrarfjall is within an area listed for its special value and closer to the centre of the Hengill area that is valued for its landscape and for attracting outdoor activities. Due to visual and noise impact in the vicinity of Skarðsmýrarfjall, from the testing of wells, the Planning Agency considers that the area's value for recreational activity, mainly hiking and cross country skiing, will be devalued especially for the next 2 – 3 years when up to 16 wells will be drilled on the mountain. The proposed development area is positioned higher above sea level than the present area. The structures, especially on the slopes of Skarðsmýrarfjall, will therefore be more visible from more viewpoints i.e. from the main highway in Svínahraun and at Hellisheiði. According to the Planning Agency it is clear that the extension of Hellisheiði power plant will have a significant negative visual impact and cause still more changes to the landscape at the south western part of the Hengill area than have already been brought on by the present power plant. The steam transmission pipes down the slopes of Skarðsmýrarfjall will be particularly visible from many viewpoints. The Planning Agency emphasises that to minimise the negative visual impact Orkuveita Reykjavíkur needs, in cooperation with the Environment and Food Agency, to look into the possibility of burying parts of the steam transmission pipes in areas where they are most pronounced on the slopes of Skarðsmýrarfjall or seek other ways, than choice of colour for the pipes to reduce their visual impact. Orkuveita Reykajvíkur has to administer the development on the mountain in such a way that drill sites will be placed away from the mountain edges. The same applies to road constructions and the quarry, i.e. concerning the distance form mountain edges.

The Planning Agency considers it clear that the proposed production for the extension of the Hellisheiði power plant is an agressive production strategy. The planned exploitation of the geothermal reservoir is greater than the inflow of mass from its boundaries according to the numerical modelling of the extension of Hellisheiði power plant. The Agency considers that this kind of utilization will cause negative impact on the geothermal system during the production period and for some decades after the production has stopped, but that the planned utilization can be looked upon as sustainable when it is at equilibrium with the natural recharge to the system. According to Planning Agency the intended extension's impact on the geothermal reservoir and resources is considerably uncertain both because no wells have been drilled at Skarðsmýrarfjall and because production from the existing wells at Hellisheiði up until now has been limited. Considering the outcome of the numerical modelling, it is the Planning Agency's opinion that the impact on the geothermal system and other factors are unlikely to

be significantly negative or irreversible in the long run after production stops. The pressure in the reservoir and its stored mass, i.e. water, steam and gasses are expected to be renewed in a few decades, but the temperature i.e. the energy content of the reservoir will take much longer to recover or up to 1000 years and can therefore hardly be considered a reversible impact. The decrease in temperature will on the other hand be small and therefore not of great concern regarding the impact that utilization will have on the geothermal system.

The Planning Agency considers, in accordance with the data from Orkuveita Reykajvíkur that the geothermal system might not profit from injection of geothermal separated water into the system, although the Agency concludes that the aim should be to inject all separated water into the reservoir i.e. to help maintain its pressure during production time. The present uncertainty of what impact the extension of Hellisheiði power plant will have on the geothermal system makes it difficult for the Agency to assess its impact on the geothermal reservoir as a natural resource. It is clearly stated in the Icelandic Environmental Assessment Act no. 106/2000, that the impact on a natural resource, here the geothermal energy, must be discussed and the impact of utilization assessed in the EIAprocess. The Planning Agency considers that further discussion on what impact the extension of Hellisheiði power plant will have on the geothermal resource should be carried out when Orkuveita Reykjavíkur applies for the extension of utilization and development permits. The Planning Agency considers that there is some uncertainty concerning what impact the production for the complete power plant, with planned capacity of 270 MW electric, will have on surface manifestations at Ölkelduháls, Reykjadalur and Grændalur. The Agency therefore places emphasis on regular monitoring of possible changes in geothermal surface activity by Orkuveita Reykjavíkur and that the company shall submit a program for monitoring surface manifestations in the above mentioned areas, when applying for utilization and development permits.

Some of the fields at Skarðmýrarfjall, where well sites are intended, are within a water protection zone. The Planning Agency considers that discharge water from drilling and testing of wells within this area must be piped on the surface and injected into boreholes outside the water catchment to prevent possible pollution of groundwater within the protection zone.

All the geothermal separated water from the Hellisheiði Power Plant and its extension, total about 1100 l/s shall be disposed of by injection into wells. The Planning Agency places emphasis on the Agency's opinion that ground water should be protected as pure as possible. Since the time of the Planning Agency's ruling on Hellisheiði Power Plant in 2004, where the condition was set that all discharge water should be injected into the geothermal reservoir to prevent possible pollution of ground water, additional information indicates two separate ground water systems of the Selvogur flow and that an impermeable layer prevents interconnection between them. Drinking water originates from the cold water system above this layer, but below it is the natural discharge from the Hellisheiði geothermal area. In the beginning Orkuveita Reykjavíkur intends to inject the geothermal separated water into this lower system through up to 1000 m deep wells. On the other hand the extent of this layer is neither known, especially to the south, nor is it certain how distinct the boundaries are between the two systems. Orkuveita Reykjavíkur believes that within few years it will be possible to inject all the discharge water into the geothermal reservoir based on further research. It is the Planning Agency's opinion that injecting discharge water into 1000 m deep wells will unlikely have a significant negative or irreversible impact on the cold ground water system. Although the Agency considers that further investigation on the possible pollution of the cold ground water system should be carried out by drilling more exploration wells and by the regular monitoring and inspection intended, and the mitigation measures and reaction plan discussed in chapters 4.2.2, 5.2.2 and 5.2.3 in this ruling.

The Planning Agency places emphasis on the importance of Orkuveita Reykjavíkur consulting the Ölfus Municipality and other grantors of permits in the monitoring and inspection process because of the above mentioned uncertainties related to the proposed development.

If the injection area is to be extended or relocated the Planning Agency places emphasis on the fact that it needs to be dealt with according to the Environmental Impact Assessment Law nr 106/2000. In the case, as discussed in chapters 4.2.2 and 5.2.3 in this ruling, that discharge water needs to be piped to the coast, either to the Capital Area or Þorlákshöfn this also needs to be dealt with according to the same law.

The Planning Agency's conclusion is that it accepts the extension of the Hellisheiði Power plant with the conditions described in chapter 6 of this ruling and that the environmental impact will not be significant as defined by the environmental impact law nr 106/200 if these conditions will be fulfilled.

Concerning the status of planning and permits for the intended extension of the Hellsiheiði power plant, the Planning Agency points out:

1. The development does not conform to the Municipal Plan of Ölfus for 2002 – 2014 Changes are therefore required.
2. The proposed development of the new well field and changes in the present industrial area because of the extension of the Hellisheiði power plant call on changes to be made to the local development plan for Hellisheiði power plant.
3. The project needs permits from the Municipality of Ölfus according to the Planning and Building Act. No 73/1997. A utilisation license from the Ministry of Industry for utilisation of geothermal resources and ground water according to Act No. 57/1998 on Research and Use of Underground Resources and an operation license from the Environment and Food Agency according to Regulations No. 785/1999 on Operation Licenses for Activity that might lead to Pollution and No. 797/1999 on Protection of Groundwater. A plan must be made in consultation with Environment and Food Agency for quarrying before a development permit is granted, according to the Nature Conservation Act No. 44/1999.

Based on the information submitted by Orkuveita Reykjavíkur during review, comments, criticism and the developer's replies to these it is the Planning Agency's conclusion that the proposed extension of the power plant on Hellisheiði, will not have a significant impact on the environment if the Planning Agency's conclusion in this chapter and the conditions reported in the 6th chapter of this ruling are acted on.

Ruling
In Accordance to Article 11 of the EIA Act, No. 106/2000 the Planning Agency has examined the materials submitted by Orkuveita Reykjavíkur when notification of the proposed project was made under Article 10 of the same act, along with comments, criticism and replies to these from the developer.

With reference to the Planning Agency's conclusions, which are presented in Section 5 of this ruling, the agency accepts the planned extension of Hellisheiði power plant, with the following conditions:

1. Orkuveita Reykjavíkur must in consultation with the Environment and Food Agency, look into the possibility of burying steam transmission pipes in selected areas, where they are most pronounced on the slopes of Skarðsmýrarfjall. If not Orkuveita Reykjavíkur needs to seek a different approach, than just to choose a colour for the pipes to reduce their visual impact.
2. Orkuveita Reykjavíkur shall administer the development on Skarðsmýrarfjall in such a way that drill sites will be placed away from the mountain edges to reduce Orkuveita Reykjavíkur Hellisheiði power plant visual impact. The same applies to quarrying. Boundaries around areas for the protection of craters and faults that shall not be disturbed should be defined in consultation with the Environment and Food Agency.
3. Orkuveita Reykjavíkur shall monitor the possible changes in surface activity of geothermal manifestation at Ölkelduháls, in Reykjadalur and Grændalur and shall outline the intended plan for monitoring geothermal surface manifestations in above mention areas when applying for utilization and operation permits.
4. Orkuveita Reykjavíkur shall in consultation with Ölfus Municipality drill 4 – 6 research wells in addition to wells HK-25 and HK-26 and the deepening of well HK-12 within the main impact area of the Selvogur ground water flow from Þrengsli to the coast by Þorlákshöfn. This needs to be done in order to analyse the chemical composition of ground water in a larger area than up until now to get a better picture of the area's hydrology.
5. As is discussed in chapters 4.2.2 and 5.2.2 of this ruling Orkuveita Reykjavíkur shall carry out the inspection and monitoring of the groundwater affected by the injection of the discharge fluid, in consultation with the Ölfus Municipality. This meaning that Orkuveita Reykjavíkur shall monitor ground water level in wells, regularly measure temperature, take samples for chemical analyses twice a year in the monitoring wells and sample water regularly form the cold ground water system, i.e. Elliðaár groundwater flow. Orkuveita Reykjavíkur shall yearly inform the

Management Board for Water Protection in the Capital Area about the implementation and outcome of inspection and monitoring, as well as measurements on ground water flow. Besides this Orkuveita Reykjavíkur shall analyse all main chemical components of water from predefined wells twice a year and trace elements every 5 years.

6. Orkuveita Reykjavíkur shall carry out the inspection and monitoring of the geothermal area and geothermal reservoir in the same way as described in chapter 4.1 and 5.1.1 in this ruling. This meaning that Orkuveita Reykjavíkur must monitor how the geothermal reservoir reacts to injection of discharge fluid in general, carry out weakly measurements of well head pressure and water level, monitor the output of production wells, analyse chemical composition of geothermal fluid from production wells and monitor the pressure and temperature of the geothermal reservoir at least once a year. Orkuveita Reykjavíkur must also monitor changes in land elevation by precise ground level measurements, and measure gravity changes.
7. Orkuveita Reykjavíkur shall pipe discharge water on the surface from drilling and testing of wells inside a water protection zone into boreholes outside the area to prevent possible pollution of the groundwater within the protection zone.

Deadline for appealing

According to article 12 of Act No. 106/2000 the Planning Agency's ruling may be appealed to the Minister of Environment. Deadline for appeal was May 2nd 2006.