Landsvirkjun

The founding of Landsvirkjun in 1965 may be traced to the Icelandic government's interest in increasing the utilisation of energy resources by attracting foreign investors for power-intensive industry in Iceland. At this point, Landsvirkjun was established for the purpose of constructing and operating power plants which could both sell electricity to power-intensive industries and provide the general market with electricity at reasonable prices. Up to this time, the electrification of Iceland had been managed by government and municipalities around the country; however, these utilities were incapable of financing new energy projects.

Landsvirkjun has developed its power system since 1965, with installed capacity expanding from about 90 MW to over 1900 MW with the Kárahnjúkar Hydro Station. At the same time, electricity prices on the general market have declined in real terms, while electricity sales in foreign currency to power-intensive industries have increased up to about 80% of the company's electricity production. Furthermore, the quality and security of supply from Landsvirkjun's ranks among the best in the world.

Production and demand of electricity

From the time the company was first started until the end of the 1970s, the company built three power stations on the rivers Thjórsá and Tungnaá. During these early years, electricity sales were increasing to aluminium and ferrosilicon production. Towards the end of the period, weather conditions and mushrooming demand resulted in a power shortage in Iceland, making construction of the Sigalda and Hrauneyjafoss plants in the late seventies a race against time.

In 1983, Landsvirkjun became a national electricity company, whereas its operation up till then had been limited to the south and west of Iceland. The period of 1982 to 1996 was characterized by only a small increase in electricity demand and no success in attracting foreign investors to power-intensive industry projects in Iceland. It was in those years that Landsvirkjun built the Blanda Hydro Station, with many criticising the resulting surplus supply of electricity.

In 1995-96, however, circumstances became favourable for attracting foreign investors in heavy industry. Landsvirkjun negotiated contracts for increased energy purchases by the Straumsvík aluminium plant, Icelandic Alloys and a new aluminium plant, Nordurál. All those contracts were completed in just under a year. This introduced a period of intense development at Landsvirkjun, which increased its production by about 60% in five years. The power plants at Blanda, Búrfell and the geothermal plant, Krafla, initieally built by the Icelandic State, were enlarged, and new plants were constructed at Sultartangi and Vatnsfell in south Iceland.

In 2002 negotiations were concluded for electricity sales to Alcoa Fjardaál at Reydarfjördur. Construction therefore began on Kárahnjúkar Power Plant at the beginning of 2003, which resulted in another 60% increase in Landsvirkjun's electricity production.

Environment

Plentiful electricity supplies are one of the cornerstones of the living standards that a modern society requires. Iceland is more fortunate than most countries in being able to produce its electricity by harnessing hydropower, a renewable and nonpolluting source. It has no need to produce electricity from energy sources that cause atmospheric pollution or ecological damage, such as the burning of fossil fuels, or involve the risk of radioactive contamination that accompanies nuclear reactors. Construction of hydropower plants nonetheless inevitably results in some disruption of land and vegetation. Hydropower development generally calls for the creation of reservoirs to level out daily and seasonal fluctuations in water flow, along with canals to carry the water to and from power houses. Landsvirkjun strives to plan its development projects so as to minimize environmental impact and maintain the existing ecological balance.

Main consultants and contractors:

Main designers:
Kárahnjúkar Engineering JV – Iceland, Switzerland, USA

Architects:
Arkitektastofan OÖ – Iceland

Design Ufsarstífla dam and Hraunaveita diversion:
Ufsarstífla and Hraunaveita JV – Iceland

Construction Supervision Kárahnjúkar dams and Headrace Tunnels:
Káraborg JV – UK, Iceland, Sweden, Norway, France

Construction Supervision Power Station civil and tunnels:
Kárahnjúkar Supervision JV – Germany, Iceland

Cunstruction Supervision Ufsastífla dam and Hraunaveita diversion:
Hraun JV – Iceland

Main contractors:

Kárahnjúkar dam and Headrace Tunnels:
Impregilo – Italy

Saddle dams at Kárahnjúkar:
Suðurverk – Iceland

Power Station civil and tunnels:
Fosskraft JV – Germany, Denmark, Iceland

Electromechanical Equipment:
VA-Tech Escher Wyss – Germany and Austria

Steel Linings:
DSD Stahlbau – Germany

Gates and trash racks:
ATB Riva Calzoni – Italy

Main transformers:
Ganz Transelectro – Hungary

Ufsarveita and Hraunaveita diversions:
Arnarfell – Iceland

Key figures and specifications:

Total head	599 m
Rated discharge (maximum discharge)	144 m^3/s
Average discharge	110 m^3/s
Installed capacity:	690 MW
Generating capacity:	approx. 4,600 GWh/year
Turbines	[Francis turbines, vertical axis]
Quantity	6
Rated discharge per unit	24 m^3/s
Rated output per unit	115 MW
Hálslón reservoir:	
Area	57 km^2
Length	25 km
Live storage	2,100 Gl
Catchment area	1,806 km^2
Average inflow	107 m^3/s
Kárahnjúkar dam	
Height	198 m
Length	700 m
Desjarárstífla dam	
Height	68 m
Length	1,100 m
Sauðárdalsstífla dam	
Height	29 m
Length	1,100 m
Ufsarlón intake:	
Area	1 km^2
Catchment area	420 km^2
Average inflow	31 m^3/s
Ufsarstífla dam	
Height	37 m
Length	600 m
Kelduárlón reservoir:	
Area	7.5 km^2
Kelduárstífla dam	
Height	26 m
Length	1,700 m
Tunnels:	Total approx 72 km
Headrace from Hálslón (dia 7.2-7.6m)	39.6 km
Headrace from Ufsarlón (dia 6.5m)	13.3 km
Surge tunnel (dia 4.5m)	1.7 km
2 vertical pressure tunnels (dia 4.0m)	0.8 km
Access tunnel to power station (dia 4.5m)	1.0 km
Tailrace tunnel (dia 9.0m)	1.3 km
Cable tunnel(dia 4.0m)	1.0 km

www.landsvirkjun.com

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Kárahnjúkar HEP
and Fljótsdalur Power Station

Landsvirkjun

Kárahnjúkar HEP

Historical

Earlier plans had two separate developments for the harnessing of the two glacial rivers Jökulsá í Fljótsdal and Jökulsá á Dal. Both rivers originate at the north-eastern region of Vatnajökull ice cap and run through the Jökuldalur and Fljótsdalur valleys to their common estuary at the coast. This development would have required two separate storage reservoirs, one at the more westerly Háls area. The current development includes both rivers simultaneously and interconnected, and thereby the disputed reservoir, Hálslón, handles the seasonal storage for both rivers.

A very extensive Environmental Impact Assessment (EIA) was completed in year 2001 with a final positive ruling by the Ministry for the Environment. A permitting law was passed at the Icelandic Parliament, Alþingi, with a significant majority in 2002 and the Ministry for Industry issued the respective harnessing permit later the same year. The local municipalities issued a construction permit in February, 2003.

The energy production at the Kárahnjúkar Station is transmitted to the Fjarðaál aluminium smelter at Reyðarfjörður on the East Coast of Iceland. A contract with the US based company Alcoa was signed in March 2003. Road construction and other preparatory works started in the second half of 2002 and the project construction started in spring of 2003 when the power contract had been signed.

Project design and construction

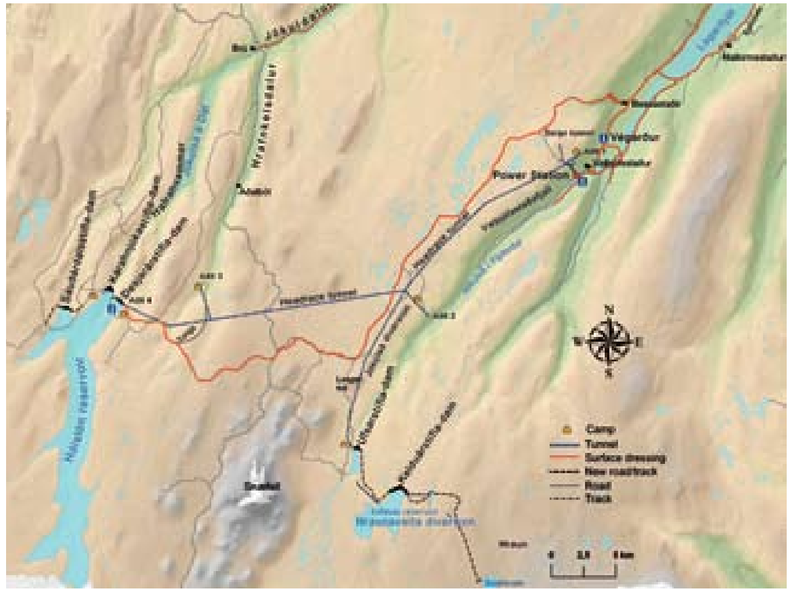
The key to economical development of the two glacial rivers is the geographical condition. The Fljótsdalur valley lies very low and cuts the highland plateau north of Vatnajökull. Thereby a very high head for power production is made possible and the project is based on a head of approximately 600 metres.

Installed power is 690 MW, maximum flow is 144 m^3 pr. second and the annual generating capacity is about 4,500 GWh pr. year.

Jökulsá á Dal is dammed at Fremri Kárahnjúkur with three dams. The largest one, Kárahnjúkastífla dam is at the southern (upper) end of the Hafrahvammar canyon, about 700 m long and 198 m high. This dam is a concrete faced rockfill dam (CFRD), and is among the highest in the world of this type and the highest CFED in Europe. The rockfill is quarried just upstream of the dam within the reservoir area and placed in compacted layers. During construction the river was diverted through two diversion tunnels under the western bank of the dam. Two smaller saddle dams were built at Kárahnúkar, Desjarárstífla dam on the east side and Sauðárdalsstífla on the west side.

These dams are rockfill dams with earth core. The three dams form the main storage reservoir for the project, Hálslón, 57 km^2. The water level at full reservoir is 625 m above sea level and the reservoir then reaches the edge of the Brúarjökull glacier.

It is estimated that the Hálslón reservoir will fill in late summer most years. Surplus water is diverted through a spillway chute at the west-



ern end of the Kárahnjúkastífla dam down to the edge of the canyon and from there in a 90 metres high waterfall into the Hafrahvammar canyon.

Jökulsá í Fljótsdal on the east side of the Snæfell mountain is dammed about 2 km downstream of the Eyjabakkafoss waterfall on the north side of the Eyjabakkar wetlands. The intake thus created has been named Ufsarlón. Water from three side rivers on the eastern side of Jökulsá is also diverted to the Ufsarlón intake.

From the Hálslón reservoir, the water runs through a tunnel under the Fljótsdalsheiði moor to a juncture with another tunnel from Ufsarlón. The water then runs trough one combined headrace tunnel north-east to an intake at the Valþjófsstaðafjall escarpment. Total length of headrace tunnels is 53 km and the tunnels are generally at depth 100 to 200 meters.

Two pressure shafts lead the water from the intake to the underground powerhouse, Fljótsdalsstöð. The total head at the project is 599 metres and the steel lined pressure shafts are 420 metres high. The powerhouse contains six generating units, 115 MW each. A tailrace tunnel and a tailrace canal take the water to the course of the glacial river Jökulsá í Fljótsdal just east of the farm Valþjófsstaður at 26 m above sea level.

The total length of tunnels is about 72 km. The headrace tunnels and parts of access adit tunnels were drilled with three full-face tunnel boring machines (TBM) other tunnels are excavated by drilling and blasting. The TBM machines required about 3 MW electrical power each and the crushed rock was transported on electrically driven conveyor belts to disposal areas near the adits. Average advance for each machine was 25 metres pr. day. Best performance during construction was 115 metres in one day.

Impounding of the Hálslón reservoir started in September, 2006. Electricity supply from the first generating unit was delivered in April 2007. The Fljótsdalur station had come into full opertation by the end of the same year.

Tourism

Landsvirkjun supports the resent founding of the Vatnajökull national park. The power project and a national park in the area do not exclude each other. Hydroelectric projects and national parks are operated side by side in many areas of the world.

New roads in the project area provide easier access to the highlands in the Snæfell area and connect the areas on the east side and the west side of the glacial rivers. The operation of the Kárahnjúkar Power Station also ensures access to the area for a longer period of the year.

Information center at Végarður

Landsvirkjun operates an information center at Végarður in the Fljótsdalur Valley, where the public can obtain further information on the Kárahnjúkar Hydroelectric Project and information on the roads and hiking routes. Végarður is about 42 km drive to the south from the town of Egilsstadir. Telephone: 471 2044

www.karahnjukar.is

The project website, *www.karahnjukar.is*, contains general information on the project and news on the progress is updated regularly. Questions about the project can be put forth through the website.