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Energy in East Iceland

A case study report from the ESPON project:
BRIDGES – Territories with geographical specificities

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1. The BRIDGES project

In late 2017 the project BRIDGES – Territories with geographical specificities was granted support from the ESPON program (European Territorial Observatory Network). The final report was delivered to ESPON in April 2019 (https://www.espon.eu/geographical-specifities).

The BRIDGES focuses on regions with specific territorial features who have received increasing attention in recent years, most notably in article 174 of the Treaty on the Functioning of the European Union (TFEU). The main purpose of this project is to address the opportunities and challenges of specific types of territories implies that these territories need to be considered in context rather than 'singled out'. These types of territories constitute the main focus for this project: sparsely populated regions; mountain regions; Islands, including island-states and coastal areas. A central question is: "How can place-based, smart and integrated approaches support the challenges encountered by territories with geographic specificities"?

In the project there are 15 different case study areas in Europe working with different tasks as examples of territories with geographical specificities: 1. Specificity of innovation processes 2. Perspectives and strategies for sustainable tourism 3. Accessibility and transport 4. Social innovation in the provision of SGI 5. Social development 6. Social and economic patterns 7. Residential economy as a component of development strategies 8. Physical environment, natural resources and Energy 9. Biodiversity conservation and sustainable development 10. Energy provision and production 11. Climate change.

In this paper we present one of the case studies on one of the topics (**8. Physical environment, natural resources and Energy**), which also is a case report in the project: Energy in East Iceland.

2. Introduction and regional background data

This case study focuses on renewable energy in Eastern Iceland. Different types of energy projects and from different periods will be studied. The region is an interesting case in the Icelandic context and on a larger geographical scale due to a large and debated energy project, Kárahnjúkar hydro power project, that was carried out in the region in the beginning of this century. We will put a particual emphasis on this project which also relates to regional development of this remote region. The case also sheds a light on the energy- and industrial policy in Iceland as it has developed during the past decades. Iceland places high importance on renewable energy and has the natural conditions to do so, in Eastern Iceland some of these natural conditions are excellent. This case study was carried out as a desk research using available data but it was also based on several interviews with stakeholders and experts. University of Akureyri Research Institute which is a part of this research had previously carried out comprehensive reseach on the megaprojects that were undertaken in the region during the first decade of this century and this partly provides basis for the case study.

2.1. Geographical characteristics

Eastern Iceland is the region furthest away from Reykjavík, the capital city which together with its neigbouring communities has around 63% of the Icelandic population and is the centre of the government and economy in the country. Access from Eastern Iceland to the capital region is costly and time-consuming. By air the travel time is about one hour and by road the drive is up to 8 hours. The region is characterized by many fjords surrounded with high mountains, which makes road transportation within the region challenging. The size of the region is 15,700 km^2 and 15.2% of the size of the country.

Figure 1.Regions in Iceland (East Iceland in yellow).

The population of Eastern Iceland is around 12.500 and is divided between a number of small towns and rural areas. There is a two tier government system in Iceland, the state and municipalities but no regional government. There are eight municipalities in the region. Basic industries are traditionally fishing and agriculture but jobs have declined in both industries due to rationalization and quotas. Fishing quotas are transferable in Iceland and can be “sold away” from local fishing communities, which can lead to job losses. As a result of out-migration, younger people and females have been underrepresented in the region. Reykjavík and neighbouring municipalities in the south-western part of the country have been growing rapidly during the past decades and this is traditionally the main destination for migrants from other regions.

The geography of the region has importance for production of renewable energy. Vatnajökull glacier, Europes largest icesheet og 8,100 km^2 is located in the highland just west of Eastern Iceland. The glacier is usually 400-600 m thick but up to 900 m (Baldursson et al., 2018). The glacier therefore stores huge amounts of water and this creates conditions for harnessing the large glacial rivers flowing from the glacier and the highland with a peak in the summer. Large dams and reservoirs are however needed when harnessing glacial rivers to store water and make the flow more even through the tubines in the power houses over the span of the year. When Iceland’s largest hydroelectric project Kárahnjúkar was constructed in the region in the beginning of this century it made use of these special natural conditions.

3. Overview of the energy sector and the renewable energy production and consumption in Eastern Iceland

3.1. Energy production and and consumption in þeastern Iceland

The total electricity production in Eastern Iceland was 5,350,592 MWh in 2016 according to the Icelandic Energy Authority. This is entirely hydro power and can thus be termed as renewable[1]. Another important source of renewable energy is geothermal which is widely used for heating purposes in Iceland and is less costly than heating with electricity which is used in “cold” regions outside the main volcanic active area that runs diagonally SW/NE through the country.

[1] See table in appendix with some energy indicators for Eastern Iceland.

The Eastern region is one of these cold regions in this sense, however substantial geothermal water has been found in two locations so that both Egilsstaðir and Eskifjörður towns have geothermal heating.

Renewable energy consumption (total) was 222,6 PJ in 2015. Of total energy consumption, hydro was 19%, geothermal 66,3%, oil 13,1% and coal was 1,6%. Majority of the oil is used in transportation. Geothermal is both used for heating and electricity production and coal is only used in industrial processes such as aluminium and silicium plants. The uses of electricity in Iceland is an interesting case as heavy industry, mainly aluminium, uses 79% of the total production but general households only use 5% (Orkustofnun, 2018). Selling energy to heavy industry was a policy that began in the 1960s to diversify the economy and exports.

Table 1. Utilization of electricity in Iceland by different groups of users.

Utilization category	MWh	GWh	Percentage within groups	Percentage of total
Regular use	**3.725.786**	**3.726**	**100%**	**21%**
Services	1.305.881	1.306	35%	7%
Other industries	504.330	504	14%	3%
Residential	843.525	844	23%	5%
Utilities	777.325	777	21%	4%
Agriculture	237.541	238	6%	1%
Fisheries	57.184	57	2%	0%
Heavy industry	**14.334.185**	**14.334**	**100%**	**79%**
Aluminium smelters	12.595.205	12.595	88%	70%
Ferroalloy industry	1.034.919	1.035	7%	6%
Aluminium foil industry	476.676	477	3%	3%
Other	227.385	227	2%	1%
Total	**18.059.971**	**18.060**		**100%**

Share of energy sector in employment for Iceland as a whole was 1,500 persons or 0.9% in 2016[2] and its contribution to GDP is 3.8%. Increase in public investment in renewables was 122% during 2000-2010 compared with the

[2] There is not data for individual regions

previous decade. Investment is very different between years and these are very expensive projects.

Cost of energy is modest in Iceland. In 2015 it was on average 11,97 c€/kWh for electricity and 2 c€/kWh for household heating by distict heating (equivalent of kWh in geothermal water).

There is one major electricity transmission grid with over head lines that circles the island built largely in the 1970s and 1980s. There is in general good energy security but in some regions there are weak links in the main grid since electricity production and its use has increased much sine lines were designed and built. Smaller local grids connect to this main grid and in some rural regions there are still some old overhead lines where icing can cause energy disturbances during winter. These lines are increasingly being replaced by underground cables.

Energy poverty is not a common concept for Icelanders due to relatively low energy prices. However, there are some “cold” areas where geothermal heating is not available due to geological conditions and heating with electricity is needed which is more expensive.

According to an expert in renewable energy there is increased interest in looking at the energy system as a whole and to integrate different sources of energy. One way of doing this might be to be the use (warm) water as a medium to store energy until it is needed and change into different forms of energy. This method might also be used to reclaim and store waste energy from heavy industry. The interviewee is working on such a project with the Alcoa Fjarðaál aluminium plant in Eastern Iceland. In that case warm water reclaimed this way might be used for district heating in Fjarðabyggð, the municipality where the Alcoa plant is located. In this context it has be kept in mind that the regions is a part of the “cold” regions in Iceland as far as access geothermal water is concerned.

Conditions for using electricity in the transportation sector and making contribution to minimize greenhouse gas from the sector are good in Iceland since electricity is either produced with hydro power or geothermal steam.

According to the interviewee large users of electricity have better capabilities for R&D in this field.

Regarding the availability of renewable energy in Iceland we can refer to an interview with the first manager of Fljótsdalsstöð power plant who said: “I met a lot of foreign people when I was working in the east. When they stood on top of the Kárahnjúkar dam, they admired how rich nation we were to be able to do this. And they asked – did you have to relocate some inhabitants? Reindeer and geese had to relocate, which they did, but e.g. the Dutch and the Germans they were amazed by this”.

This short remark sheds a light on the special situation of Iceland, and also the Eastern region in this case study. These conditions may even be considered as being enviable by some. A valuable part of Iceland’s pristine nature was however sacrificed for the construction but on the other hand, due to the conditions and settlement pattern of Iceland and this region, making the reservoirs did not impact negatively the settlement of people.

3.2. Renewable energy projects in Eastern Iceland

Renewable energy in Eastern Iceland is of three types, hydropower energy, geothermal energy (for heating) and biomass energy. As was mentioned previously conditions are excellent in Eastern Iceland to provide hydro power energy on a large scale. However, as the region is located outside the main volcanic area of Iceland there are not high temperature geothermal sources (steam) but those natural conditions are used for electricity production in a number of places in Northern and Southwestern Iceand.

3.2.1. Hydropower plants

There are 5 hydro powerplants in East Iceland. One of them, the newest one Kárahnjúkavirkjun/Fljótsdalsvirkjun, is by far the biggest one, 690 MW. This is due to the fact that the power plant serves power to a huge aluminium smelter plant at the town Reyðarfjörður, which also is in the region of East Iceland.

Fljótsdalur Power Station (Kárahnjúkar)[3]

The Fljótsdalur Power Station or Kárahnjúkar power station as it is also called reached full operational capacity in 2007. Concurrent with the construction work at Kárahnjúkar, an aluminium plant was built in Reydarfjördur and most of the energy generated is sold to that plant. The project as a whole was thought by Icelandic government as means to strengthen socio-economic development in the region and stop outmigration of people.

On its long journey from the reservoirs in the highlands to the station's intake, the water drops approximately 200 m. Two-thirds of the total head runs through an approximately 400 m high vertical pressure tunnel near the Fljótsdalur Station.

Kárahnjúkar power station was formally opened 30 November 2008. In December 2008 all six dams and 54 km of waterway tunnels of the project were finished. In addition there are access tunnels and similar, so in total there were 73 km of tunnels in the project. The water drives six powerful turbines in the powerhouse and then flows through a tailrace tunnel and canal into the river Jökulsá in Fljótsdalur at an altitude of 26 metres. Electricity is transmitted from the station through a separate cable tunnel to the switchgear house and from there through high-voltage lines to Alcoa's aluminium plant in Reydarfjördur.

Table 2. Technical specifiactions of Fljótsdalur Power Station

Installed capacity	690 MW
6 Francis turbines	6 x 115 MW
Generation capacity	4.800 GWh p.a.
Total head	599 m
Maximum flow	144 m^3/s
Brought online	2007
Ownership	Landsvirkjun (Public company)

[3] See: Landsvirkjun.

Lagarfossvirkjun power station[4]

This hydro power station brought online in 1974 is located in Fljótsdalshérað, north of Egilsstaðir and takes the water from the river of Lagarfljót. It was initiated and started in order to produce cheaper power for the neighboring towns of Egilsstaðir and Fellabær. Until then electricity production was not renewable – oil was used and rising oilprices was one of the main drivers. The power station is run by RARIK (Orkusalan, n.d.) which is a state-owned company.

Table 3. Technical specifiactions of Lagarfossvirkjun Power Station

Installed capacity	27,2 MW
Maximum flow	115 m^3/s
Brought online	1974
Ownership	Orkusalan RARIK (public)

Bjólfsvirkjun power station[5]

Along with Gúlsvirkjun (see below) this power station is a part of a power station complex called Fjarðarárvirkjun. Fjarðará is a river running from the highland mountain of Fjarðarheiði down to the town of Seyðisfjörður at the east coast. The power station produces electricity for the town Seyðisfjörður but also power that goes out to the RARIK transmission network. It is run by the private company Íslensk orkuvirkjun6.

Table 4. Technical specifications of Bjólfsvirkjun Power Station

Installed capacity	6,4 MW
Maximum flow	1,3 m^3/s
Brought online	2008
Ownership	Íslensk orkuvirkjun ehf. (private)

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[4] See: Orkusalan.

[5] https://orkustofnun.is/gogn/Orkumal-arsrit/Orkumal-Raforka-2011-6-1.pdf

[6] The webpage of the company is partly inactive. Fortunately we got valuable help with information from Benedikt Guðmundsson manager for governmental support at Orkustofnun (National Energy Authority).

Gúlsvirkjun power station[7]

Along with Bjólfsvirkjun (Orkustofnun, 2011) this power station is a part of a power station complex called Fjarðarárvirkjun. Fjarðará is a river running from the highland mountain of Fjarðarheiði down to the town of Seyðisfjörður at the east coast. It produces electricity for the town Seyðisfjörður but also power that goes out to the RARIK transmission network. It is run by the private company Íslensk orkuvirkjun.

Table 5. Technical specifiactions of Gúlsvirkjun Power Station

Installed capacity	3,4 MW
Maximum flow	1,1 m^3/s
Brought online	2009
Ownership	Íslensk orkuvirkjun ehf. (private)

Grímsárvirkjun power station

This hydro power station brought online in 1958 is located in Fljótsdalshérað, south of Egilsstaðir and takes the water from the river of Grímsá before it runs into Lagarfljót close to Egilsstaðir. The public company RARIK (Orkusalan) built and runs this power station.

Table 6. Technical specifiactions of Gúlsvirkjun Power Station

Installed capacity	2,8 MW
Maximum flow	300 m^3/s
Brought online	1958
Ownership	Orkusalan RARIK (public)

3.2.2. Geothermal power

There are two geothermal power grids in the region. In both cases hot geothermal water from below is used for district heating. Geothermal district heating in Iceland is cheap compared with using other energy sources. Hot water is pumped up from the earth and is at that stage warm enough to be

[7] https://orkustofnun.is/gogn/Orkumal-arsrit/Orkumal-Raforka-2011-6-1.pdf

pumped further in to the district heating system. This is widespread in the country but some regions have more hot water in the earth than others. Eastern Iceland is in that comparison a “cold area” and only in two locations enough of warm water can be utilised.

Egilsstaðir and Fell district heating[8]

Egilsstaðir and Fell district heating (Hitaveita Egilsstaða og Fella, 2018) is a company owned by the municipality of Fljótsdalshérað. It started its operation in 1979. It serves heating for about 3,000 inhabitants, the urban places of Egilsstaðir and Fellabær as well as part of the countryside within the municipal boundaries. Additionally they provide heating for industies in the area. Three holes have been drilled and they provide 51 l/s. Geothermal primary energy is 1,597,787 m^3.[9]

Fjarðabyggð district heating[10]

Fjarðabyggð district heating (*Fjarðabyggð*, 2018) started its operation in 2005. It is owned by the municipality of Fjarðabyggð. However, since geothermal water has only been found in Eskifjörður one of the five villages in Fjarðabyggð, the distribution area is limitied to that village only, that is serving less than 1000 people. Two wells in Eskifjörður provide a total of 9 l/s. Geothermal primary energy is 272.010 m^3.

3.2.3. Biomass power

Wood chips power station (Skógarorka á Hallormsstað)[11]

This biomass power station started in November 2009 and is the first and only biomass power station in Iceland, built as an experimental station (Skógarorka, 2016). It is located in the biggest forest in Iceland, Hallormsstaðaskógur. Woodchips are burnt in a boiler to create power. The wood chips are sourced from the state forest service in Hallormsstadur and forests of surrounding farms. The heat value of wood chips (960 kWh/m^3) is low compared to the one of fuel (9,960 kWh/m^3). For that reason the transport costs´ share of total costs

[8] See: Hitaveita Egilsstða og Fella (hef.is) and Orkustofnun

[9] See: Orkustofnun (National Energy Authority).

[10] See: Fjarðabyggd.is and orkustofnun.is

[11] See: Skógarorka.

increases rapidly with each kilometre that the chips have to be transported. Long transport distances therefore prevent the economic provision of wood chips. Burning wood chips is however a CO^2 neutral energy source, the amount of carbon dioxide emitted during the combustion of the chips is similar to the amount of CO^2 emitted if the tree was to let die and rot. In the beginning the power was used to warm up private houses close to the station as well as two schools, sportshall and a swimming pool. The running of this power station has not been easy and in 2017 it was sold to an entrepreneur. This soon 9 years old experimental project is still ongoing but it is very small in comparison with other power production. Time will have to tell whether this will survive into the future.

4. Policies and governance of the renewable energy in Eastern Iceland.

Most of energy in Iceland has for a long time been from renewable sources and this is largely due to special natural conditions. In fact, access to renewable energy is something that Icelanders take for granted. Due to environmental concerns (protection of pristine nature), there are increasingly debates on how extensive harnessing of the rivers, waterfalls and geothermal areas should be and whether to install wind turbines, even if there are still many opportunities to further exploit these renewable energy sources.

The main tool for decision making on which energy projects shall be undertaken is *The Master Plan for Nature Protection and Energy Utilization* (Rammaáætlun, n.d.). This planning tool was created to try and reconcile conflicting interests of nature conservation and energy utilization on a national scale at early planning stage. This planning tool materialized in 1999 and the idea behind it was sustainable development. The master plan is now in its fourth phase, which is due to be completed in 2021. There is a steering committee which comprises six members and according to the homepage of the master plan it is still unclear what power options will be evaluated in the fourth phase. Thus we can not see to what degree Eastern Iceland will be in the focus of the planning process during this period. The recommendations of the steering committee comprise the list of power plant options that will fall into one of these categories: “energy utilisation", "on hold" or "protection". During the third phase the recommendations of the steering committee were not fully processed by the Parliament.

Kárahnjúkar hydro power plant was planned and carried out before the planning process according to The Master Plan for Nature Protection and Energy Utilization was initiated. The power plant however was decided by the Parliament as the owner of the power plant is Landsvirkjun, the national power company. It went subsequently through *Environmental Impact Assessment* as any other project above certain size limit (10 MW). However, the process was especially complex and there were many hurdles that had to be overcome until the project was finally allowed.

The main purpose behind this big power station and the reason for the interest on behalf of the state authorities in Iceland were that it should produce power for a big aluminium smelter plant in the town Reyðarfjörður at the east coast. This was a part of the government plan which was to have positive impact on regional development in East Iceland. This by creating hundreds of jobs in the smelter plant and in related industries. The East Iceland region had suffered from continous downturn in the economy with loss of jobs and loss of people to other parts of the country. Additionally, by increasing export from Iceland, which historically has primarily stood one one feet – fish export. Due to this intended regional and local socio-economic impact, the municipalities in the region and their association had of course great interest in this and played a significant role in the process. This example of this huge power plant and industry project is however not typical in this sense. Smaller power projects in the country and the east region have had much more limited socio-economic impact.

5. Evidences from a project in the area: Fljótsdalur Power Station

The Kárahnjúkar or Fljótsdalur hydro power station is located in the eastern part of the central highland just off Vatnajökull glacier. When it was planned is was an important part of the regional development in Eastern Iceland (Jóhannesson et al., 2011; Jóhannesson Hjalti and Sigurbjarnarson Valtyr, 2010). When finished it became the largest power plant in the country and important driver of the social and economic development of the region.[12]

Figure 2. The location of Kárahnjúkar and Alcoa Fjarðaál.

The highland is uninhabited and important for tourism during the summer, Vatnajökull national park covers a large part of it. The hydro power project consisted of large dams, reservoirs, diversion of rivers, water tunnels, and a powerhouse. Most of the electricity is used for the Alcoa Fjarðaál aluminium plant which was built during the same period 2003-2008. It is the biggest aluminium plant in the country. This was an important change for the region, created over 800 new jobs and changed the economic structure of the region (Jóhannesson, 2010). Alcoa Fjarðaál is located near the town Reyðarfjörður which has around 1,200 inhabitants and doubled in size since the megaproject started. It can be said that the conditions for harnessing large amounts of energy was the precondition for dramatically change the economic development of the region. This however came with cost which is sacrificing a large part of the uninhabited and untouched part of highland for reservoirs and dams.

[12] See Technical specifications in Table 1. in chapter 2.1.1 above.

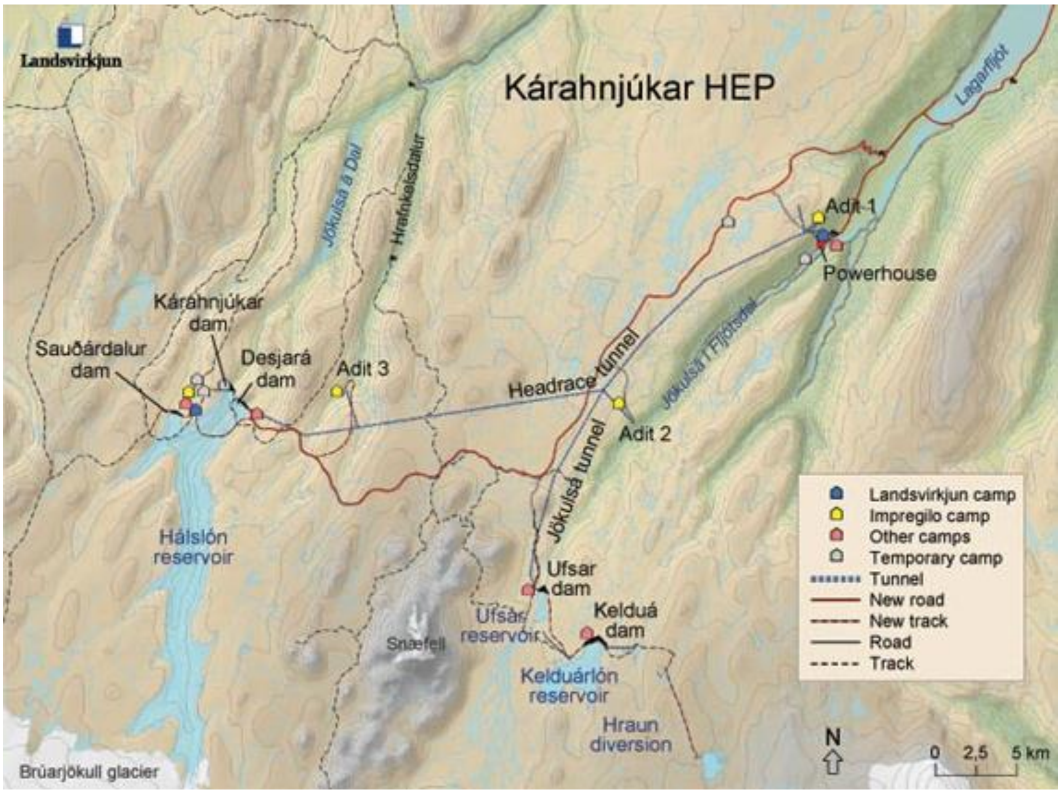

Figure 3. Overview of the Kárahnúkar project.

The Kárahnjúkar project was hugely debated both within Iceland as well as abroad. This caused much unrest and in a report from the Minister of justice in the Parliament 2008 it was said that during the period 2005-2007 there were 40 cases in the files of the police connected to the construction of the Kárahnjúkar project. 83 individuals were suspects, thereof 14 Icelanders and 69 foreign nationals (Jóhannesson, 2010).

Figure 4. Demonstration at the site of Alcoa's aluminium plant.

Protestors' camps were set up in the eastern highland during construction and attempts made to disturb the project. A number of public figures were prominent in protesting the project and one of them organized a demonstration in Reykjavík 2006 with participation of some 10,000. This sheds a light on how divied the public in Iceland was on the issue.

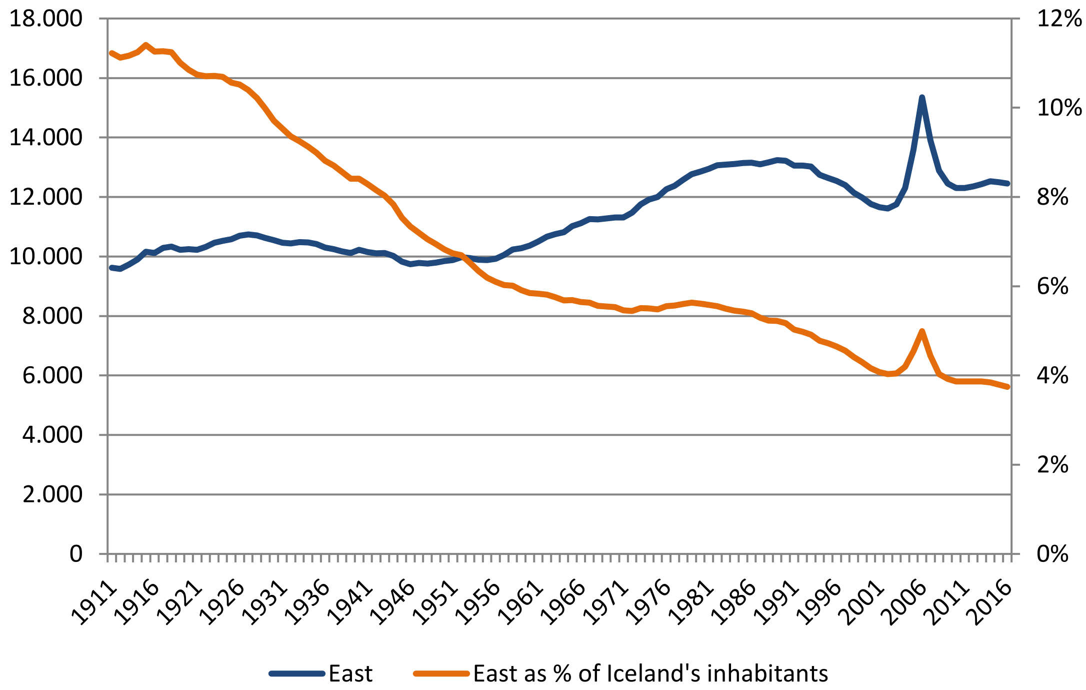

Figure 5. Population development of Eastern Iceland 1911-2016 (Statistics Iceland, n.d.).

In Eastern Iceland the general public had been waiting for the project to materialize and had high hopes that it would reverse the negative development of the region for several decades. There was a great influx of foreign workers during the construction period but after that it was apparent that population decline had reversed, this was especially true for the central Eastern Iceland and the two largest municipalities, Fjarðabyggð where the aluminium plant is located and Fljótsdalshérað. According to an interview with project manager at Austurbrú, collaborative initiative of municipalities in the region there is no noticeable criticism on the project now 10 year after it was finished. According to the former station manager of Fljótsdalsstöð power station, fulfilling the 21 conditions in the environmental impact assessment was quite demanding (Jóhannesson et al., 2011). These conditions and several indicators had to be monitored and measurements that had to be carried out regularly. Municipalities, land owners and farmers were among those who were following this closely. This large power station came into the community and to many it represented some kind of threat. However the power station represented an experiment in regional development.

6. Final remarks

This case study has focused on Eastern Iceland which is interesting both in Icelandic context as well as international. Available energy is abundant for the society of Iceland and mostly renewable, both hydropower and geothermal. Conditions vary from one region to the other depending on geological conditions. In Eastern Iceland conditions for large scale hydropower production are good but there is limited geothermal power compared to regions closer to the active volcanic area that cuts diagonally SW/NE through the island. In Iceland the ownership of energy resources and energy companies has for a long time been mostly in the hands of public bodies such as the municipality and the state and this is the case in Eastern Iceland.

For this remote and sparsely populated region the construction of Iceland´s largest power station by the National Power Company ten years ago brought about great changes for the region. Even if hydro power energy is usually termed as being renewable there are sacrifices to be made in nature such as when making dams and reservoirs and this was heavily criticized. The remote region thus became the centre of attention for nature conservationists both within Iceland and abroad but today there is no noticeable criticism on the project. Harnessing this energy provided the foundation for the largest workplace in the region, had considerable socio-economic impacts and was linked to regional policy and export policy of Iceland. The decision for the megaproject has to be looked at against that background.

Debates concerning new energy projects are increasing due to the perceived environmental impacts they have since these are often in locations where the natural environment has not been disturbed. The debates are often between residents of the capital region and residents in the regions where the projects are located. The planning tool which has since 1999 been used to try and reconcile conflicting interests of nature conservation and energy utilization on a national scale at early planning stage is the Master Plan for Nature Protection and Energy Utilization. Despite of this there are ongoing debates concerning energy harnessing, especially in remote regions, even if these energy-options have been passed by the steering committee of this master plan. Transmission lines are also heavily criticized and underground cables are often spoken for instead.

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Interviews

Benedikt Guðmundsson, Manager in Governmental support at Orkustofnun (16th April 2018).

Georg Pálsson, Former station manager at Fljótsdalur power station. (13 March 2018).

Jón Steinar Mýrdal, Special advisor, Austurbrú. (21 March 2018).

Signý Ormarsdóttir, Senior Project Manager at Austurbrú (28 March 2018).

8. Appendix

Energy indicators for Eastern Iceland

Topic / Indicator	Data	Year	Indicator	Comments
Total energy production (all)	5.350.592	2016	MWh	Elecritcity production
Renewable energy production (total)	5.350.592	2016	MWh	Elecritcity production
Wind power production				None in E-Iceland
Hydro power production	5,350,592	2016	MWh	Elecritcity production
Solar power production				Negligible - some summer cottages outside the grid
Geothermal power production	373,1	2015	TJ	Geothermal wells and grids for heating of two towns
Biomass energy production				Minimal, experimental project only for heating
Employment in energy sector	1600	2016	Persons, main job	Data only available for Iceland as a whole or capital region vs. all other regions
Contribution of the energy sector to GDP	3,8%	2016	% of GDP	D. Electricity, gas, steam and air conditioning supply (data for Iceland as a whole)
Total energy consumption	5.128.010	2016	MWh	Elecritcity consumption
Total energy consumption by sector				Only data available for Iceland as a whole. See breakdown by sector below. Note that heavy industries are separate 1)
Household energy consumption	5%	2016	%	Note the special situation in Iceland that heavy industries use 79% of all electricity, thereof aluminium 70%!
Renewable energy consumption (total)	222,6	2015	PJ	Hydro 19%, geothermal 66,3%, oil 13,1%, coal 1,6% (majority of oil in transportation, geothermal in heating and electricity production and coal in industrial processes)
Public investment in renewables	122%	2000-2010	% increase over decade	Nearly all addition during the past decades is renewable. Puclic investment is very different between years, large hydro power plants, geothermal plants and geothermal heating grids are very expensive
Share of energy sector	1500 / 0.9%	2016	At work / %of total	Only data available for Iceland as a whole. At work in main job by economic activity, sex and region "D - Electricity, gas, steam and air conditioning supply"
Cost of energy	2 / 11,97	2015	c€/kWh	2 c€/kWh for heating by distict heating (geothermal) and 11,97 c€/kWh for electricity
Energy grids				Extensive electricity grid and district heating in most areas. There is one major grid (see link) and several smaller local grids connectec to this main grid. There are weak links in the main grid, however not so much in E-Iceland
Energy security				In general high energy security in most areas. In some (mainly rural) regions there are still some old overhead lines where severe icing can cause energy disturbances. Also there are in few places weak links in the main grid.
Energy poverty				Does not seem to be common (see energy prices above). There are some "cold" areas where due to geological conditions there is not geothermal heating and thus more expensive.
Social perceptions of renewable energy				Most of energy in Iceland has for a long time been of renewable sources (special conditions) and is in fact what people take for granted (see article from UN in link)
				Due to environmental concerns (protection of pristine nature), there are debates on how extensive harnessing of the rivers, waterfalls and geothermal areas should be
				and whether to install wind turbines, even if there are still many opportunities to further exploit the energy sources (see linked article from National Geographic)...