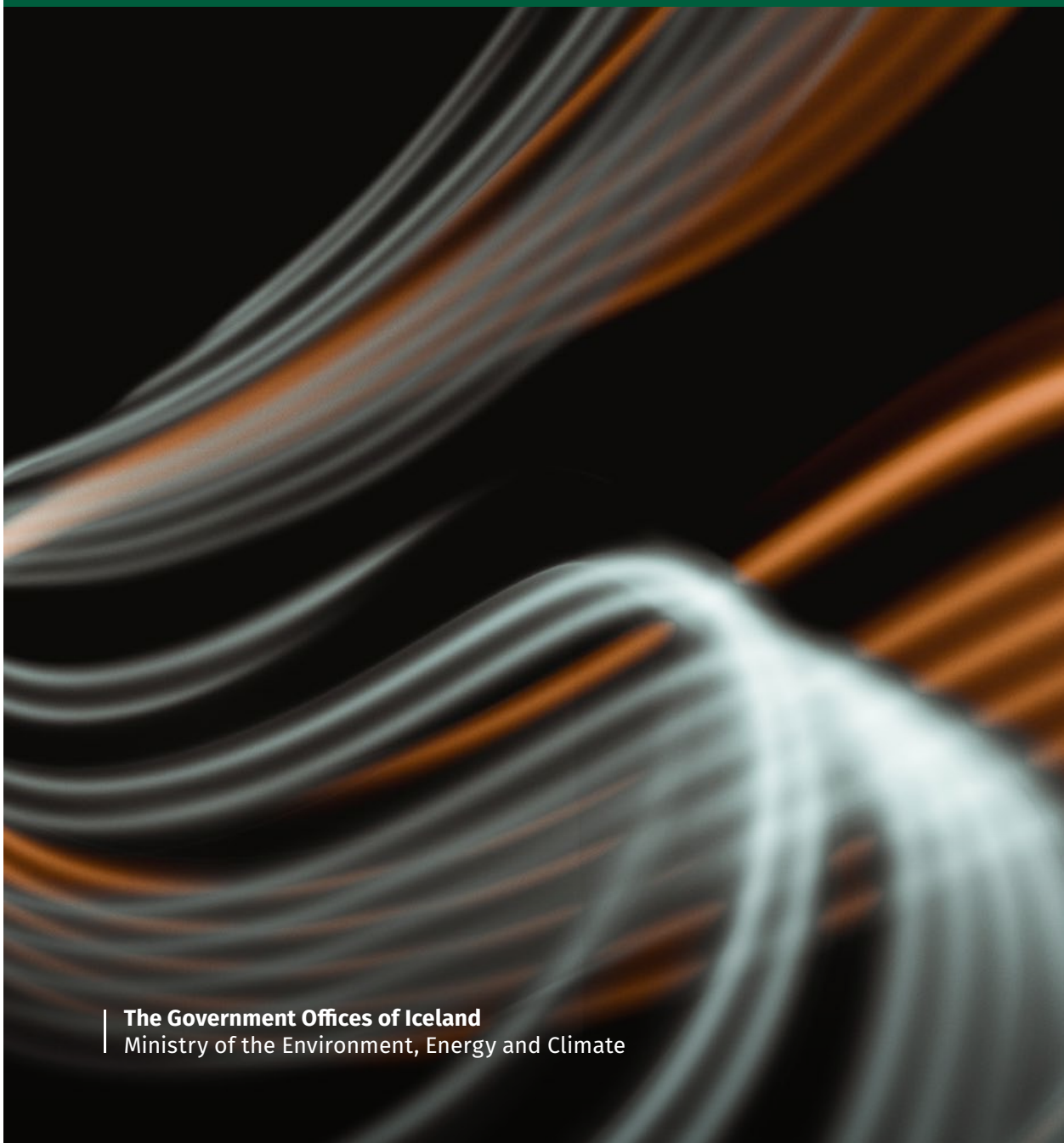
March 2022

The State and Challenges of Energy Affairs

with reference to the goverment's climate action targets and emphases



The Government Offices of Iceland
Ministry of the Environment, Energy and Climate

The State and Challenges of Energy Affairs

Assembled by a working group on the state and challenges of energy issues in Iceland

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Summary

- Iceland's energy transition goals need to be better aligned with energy production and energy transmission goals, which are the basis for the implementation of an energy transition in our society. The implementation of an energy transition will add to the energy demand to support further industrial growth.
- Energy security requires greater electricity production and a more robust transmission and distribution network, which in turn calls for a comprehensive planning of the energy network and the integration of working procedures.
- The assessment of the country's need for electricity and heat energy for the next two to four decades is set out in the form of numerical energy forecasts which need to be reviewed regularly. Six scenarios are set out in the report, four of which factor in Iceland's climate goals, ranging from little to no addition to Iceland's electricity output, up to more than doubling it to a 124% increase by 2040.
- Energy production aiming to reach, by stages, a full, sustainable energy transition also entails improved energy efficiency; increased energy savings, including through technological advances; increasing the power output of existing power plants; and adding more power plants.

- Efforts must be made to attain maximum social accord on the protection and use of geographical areas and the natural resources found there.
- Investments in energy development have hitherto not been made with a view to adhering to climate goals. A sufficient assessment of what those goals entail has not been made, and no decisions have been reached as to appropriate response. The opinion has been raised that the complexity of the regulatory framework and the time-consuming permission process have delayed developments within the energy network and are factors in opportunities for industrial development having not been implemented. There is an appeal for more energy and more energy security from all regions of the country.
- Considering the developments in recent years and for the future, the possible buyers of energy in this country include diverse industries, e.g. metalworks, data centres, the biotechnology industry, food producers, aquaculture companies and producers of E-fuels.
- Climate measures to reach carbon neutrality have set off a green industrial revolution all over the world. Iceland must be able to approach this mission by choosing methods that can range from being active participants in this revolution through continuing economic growth and improved standards of living, to slowing down, looking inward, decreasing economic activities with a high energy demand and looking towards other values.
- If the first road is to be taken alongside reaching the climate goals, energy production in Iceland must be increased by upwards of 100 MW per year for the next 20 to 30 years and a clear message be sent. This would entail an effort to increase exports, as well as a full energy transition. Additionally, the efficiency of the preparatory and permission processes must be increased, and the institutions involved must be given support to reach the investment and protection goals involved.
- It is important to fortify the Icelandic Energy Fund, increase research into local energy opportunities and seek wide collaboration with foreign institutions and companies to develop and implement energy solutions.
- It is important to ensure that energy and climate measures lead to real reductions within the country and do not cause increased emissions elsewhere.

Scenarios involving Iceland's increased energy demand with reference to the climate goals

Scenario	Main criteria	The additional energy demand until 2040/2050	Change from 2020
Scenario 1 The National Energy Authority – Basic forecast	• The basic public energy demand • Minimal energy transition	1,717 GWst by 2040 2,519 GWst by 2050	+9% +13%
Scenario 2 The National Energy Authority – "Green Future"	• Basic public energy demand • Partial energy transition, climate goals not fully achieved • No growth in industries with a high energy demand / energy-intensive users	2,688 GWh by 2040 3,980 GWh by 2050	+14% +21%
Scenario 3 Hydrogen Roadmap (Roland Berger)	• Complete energy transition on land, at sea and in air • The energy demand of the public market and energy-intensive users is not taken into consideration • Direct electricity supply to vehicles, ships and aircraft not included in the numbers	13,000–24,000 GWh by 2050	+68–125%
Scenario 4 Samorka – New climate goals	• Complete energy transition on land, at sea and in air • The energy demand of the public market and energy-intensive users is not taken into consideration	15,648 GWh by 2040	+82%
Scenario 5 Samorka – New climate goals and energy-intensive users	• Basic public energy demand according to the National Energy Authority's forecast • Complete energy transition on land, at sea and in air • Including intensive users of electricity according to the National Energy Authority's forecast, industries with a high energy demand (export pillar)	23,694 GWh by 2040	+124%
Scenario 6 The Icelandic Environment Association The Iceland Nature Conservation Association – No economic growth	• Energy transition without an increase in electricity production • GDP per person remains unchanged (no economic growth) • The 4 biggest users utilise waste energy to produce electricity or for the closing of the aluminium smelter in Straumsvik before 2035	Not specified	Not specified

Figure 1. The Energy Demand Scenarios.

	Energy transition (full in certain categories)					Government climate goals	Energy demand of the general market	Export growth	Energy demand of scenario
Party	Passenger cars	Heavy vehicles	Domestic flights	International flights	Ocean	Full energy transition, carbon neutrality	Society and general use		GWh by 2040 (% increase)
The National Energy Authority's basic forecast	●	●	●	●	●	●	●	●	9%
The National Energy Authority's "Green Future"	●	●	●	●	●	●	●	●	14%
Hydrogen Roadmap	●	●	●	●	●	●	●	●	68–125% (2050)
Samorka I	●	●	●	●	●	●	●	●	82%
Samorka II	●	●	●	●	●	●	●	●	124%
The Icelandic Environment Association /The Iceland Nature Conservation Association*	●	●	●	●	●	●	●	●	Not specified

**no economic growth is assumed in the bottom scenario*

Figure 2. The Criteria for Scenarios.

1. Introduction

1.1 Analysis and Key Issues

On 11 January 2022, the Minister for the Environment, Energy and Climate appointed a working group which, according to the letter of commission, was tasked with preparing a report on Iceland's position and challenges in energy issues. The objective and purpose of the report should be to present facts on the basis of professional considerations and information on key aspects of energy issues in an accessible format for the information of the government, stakeholders and the general public.[1]

The task force's analysis was divided into the following components:

- Evaluating the current position, i.e. analysis of the information available and evaluation of the information they provide.
- Assessment of whether and what information is lacking in order to be able to assess the situation objectively, e.g. in terms of energy needs with regards to energy transition.
- Assessment of possible weaknesses or obstacles (to government policy formulation) that emerge following analysis and position-taking.

The report of the task force should also contain the following key issues:

- Energy demand should be explained with reference to the emphasis and goals of the government on climate issues. Scenarios should be set up for energy demand to complete the energy transition. Different scenarios depending on which methods will be used in energy transition and which technology will prevail. The discussion of energy demand should also look at the position of district heating companies in meeting the demand for geothermal heat in parallel with population development.
- The situation in the electricity transmission system shall be explained, i.a. based on the parliamentary resolution on the government's policy on the development of the electricity transmission system. Are there any obstacles that prevent the system from being used in an optimal way and making full

[1] For further details, see letter of commission dated 11 January 2022 in Annex.

use of the energy that is put into the system? Assess the most urgent needs for improvement and their reasons.

- The state of the energy market in Iceland shall be reported with regard to the government's climate goals through energy transmission. Furthermore, the market's ability to ensure public energy security, whether government intervention is needed to ensure electricity security and available ways to do so should also be stated. I.a. based on a report on energy security in the wholesale electricity market.

- State the current state of affairs regarding the supply and demand of electricity as well as how it is anticipated that these matters will be able to develop in the coming months and years. Who are the likely buyers of energy based on current developments and in the future?

1.2 The Task Force and Consultation

The working group was composed as follows:

Vilhjálmur Egilsson, Economist, Chairman

Ari Trausti Guðmundsson, Geophysicist

Sigríður Mogensen, Division Manager at the Federation of Icelandic Industries

Erla Sigríður Gestsdóttir, Senior Advisor, and Magnús Dige Baldursson, Legal Advisor from the Ministry of the Environment, Energy and Climate worked with the working group

1.3 Consultation and Information Acquisition

According to the letter of commission, the working group was to consult regularly with a special consultation group of the Ministry and institutions, composed of the following parties:

Halla Sigrún Sigurðardóttir, Director General, Ministry of the Environment, Energy and Climate

Steinunn Fjóla Sigurðardóttir, Director General, Ministry of the Environment, Energy and Climate

Jón Geir Pétursson, Chairman of the project management team of the plan for the protection and energy utilisation of land areas

Halla Hrund Logadóttir, Director General, National Energy Authority (NEA)

Sigrún Ágústsdóttir, Director General, The Environment Agency of Iceland

In addition to consultation with the consultation group, the working group sought information from stakeholders in order to present as clear a picture as possible of the facts regarding Iceland's state of and challenges in energy issues. The following stakeholders assisted the working group in gathering and compiling information of various kinds:

Blami

EM Orka

Fallorka

Fjordungssamband Vestfirdinga (Westfjords Regional Development Office)

Graenvangur

Hafthorsstadir vindorka

HS Orka

Icewind

ÍSOR

Landsnet

Landsvirkjun (National Power Company of Iceland)

Landvernd

Iceland Nature Conservation Association

Nordurorka

Orka heimilanna

Orkubu Vestfjarda

Orkusalan

Orkuveita Reykjavikur (Reykjavik Energy)

Qair

RARIK

Icelandic Association of Local Authorities

Association of Municipalities in East Iceland

Association of Municipalities in the Southern Peninsula

- Samorka
- Federation of Icelandic Industries
- Association of Southern Municipalities
- Association of municipalities in the Greater Reykjavik Area
- Association of municipalities in North-East Iceland
- Association of municipalities in North-West Iceland
- Association of Municipalities in West Iceland
- The Icelandic National Planning Agency
- Straumlind
- Zephyr Iceland

The above-mentioned parties provided a great deal of information that forms the basis of this report. These include responses to a detailed questionnaire sent by the working group to the above-mentioned stakeholders and others.

The working group met regularly with the consultation group, which assisted in the preparation of the report. The working group also met with stakeholders.

The report is also based on public information and government policies regarding, or related to, energy and climate issues. These include the Energy Policy, the Energy Policy Action Plan, the Climate Action Plan, the National planning strategy, the Systems Plan and the parliamentary resolution on the government's policy on the development of the electricity transmission system and the report on energy security in the wholesale market.

1.4 Structure and Content of the Report

The object of this report is to present facts on the basis of professional considerations and information on key aspects of energy issues in an accessible format for the information of the government, stakeholders and the general public. The presentation of the report takes into account the presentation and structure of the Energy Policy. At the beginning of each section, a summary and an overview are compiled based on the working group's comments.

1.5 The Unique Position of Iceland and Matters of Dispute

In many respects, Iceland is in a unique position in matters of energy efficiency and energy transition. As an island far from mainland Europe and North America, Iceland has an isolated electricity system. The country has powerful energy resources in its diverse, and in many ways unique, natural environment with rich conservation value. The government has set an Energy Policy until 2050 with sustainability as a guiding principle and a Climate Policy that takes into account the Paris Agreement 2030, carbon neutrality by 2040 and the goal of a fossil fuel free Iceland in 2050, which has now been accelerated to 2040. Opinions are divided on public actions, actions of others and on Action Plans that should lead to energy transition. The matters of dispute concern, i.a. the different assessments of how much electricity is needed for energy transition for transportation and for a full energy transition, in which regions this electricity should be generated and how it should be distributed and finally, with what production methods the electricity should be generated. Furthermore, opinions are divided on increasing energy production for a variety of new business and export activities that are being worked on around the country. Energy-intensive industry generates about a quarter of Iceland's export revenue and has played a major role in building Iceland's electricity system and living standards in Iceland.

Iceland is ahead of other nations in the field of energy transition. The clean energy transition of electricity and heat is almost complete in Iceland, which is unique in the world, in addition to which Iceland is in a good position to become one of the first countries, or even the first, to completely stop using fossil fuels. This provides Iceland the opportunity to serve as an example in the international climate context.[2] Climate goals call for action in energy issues, and energy affairs call for increased energy acquisition. Climate goals have not been accompanied by a sufficiently comprehensive and continuous assessment of energy demand and measures regarding energy acquisition and the strengthening of the transmission system. There is a growing demand for renewable energy and a call to action for increased electricity supply in all parts of the country due to energy transition and various opportunities in new business and export activities. A new Ministry of the Environment, Energy and Climate was established recently. Energy issues now fall under the auspices of that Ministry, while planning has been transferred to the Ministry of Infrastructure. This change is intended to integrate and seek a balance between the perspectives of environmental and climate protection on the one hand and energy acquisition and the energy industry on the other, both of which are fundamental preconditions for future prosperity and economic growth in Iceland and around the world.[3]

[2] https://www.althingi.is/altext/152/s/0169.html
[3] https://www.althingi.is/altext/152/s/0169.html

The Masterplan (for Nature Protection and Energy Utilization) seeks to harmonise the perspectives of energy acquisition and nature conservation under its auspices. It therefore assumes the involvement of many external experts, the executive branch and, ultimately, Parliament. A Masterplan (for Nature Protection and Energy Utilization) has not been approved by Parliament since 2015. The goals for energy transition and a fossil-fuel-free Iceland in relation to climate goals and the guiding principles of the Energy Policy for a sustainable energy future call for an increase in energy supply and a strengthening of the electricity transmission system, as there have been a number of obstacles on the road.

This report seeks to present a variety of facts, presenting the relationship between energy acquisition and energy transmission with society and nature, as well as institutions' and stakeholders' assessments of energy demand, energy supply and energy consumption, i.e. forecasts and scenarios. Matters of dispute have also been raised, which calls for further analysis and decision-making. All of this could explain the evolution of energy issues and the rapid development of energy transition as it appears in the multifaceted dissemination of information in society, discussions and in further policy-making and decisions.

2. Energy Policy and Goals for Climate and Energy Affairs

2.1 Summary

- The government has adopted an Energy Policy that aims to protect the interests of current and future generations. The Energy Policy includes a vision of a country of clean energy.
- The Energy Policy is accompanied by an Action Plan with defined actions and tasks that are intended to implement the policy and support it.
- At the beginning of the recent electoral term, the government set itself the goal of eliminating the use of fossil fuel in Iceland by 2050. With the agreement of the current government, that goal was accelerated to 2040.
- Iceland and Norway are participating in a common goal with the European Union to reduce emissions by 40% by 2030 compared to 1990.
- According to the government agreement, an independent national target of a 55% reduction in emissions from Iceland's direct responsibility will be set for the same period.
- Rules on energy trade are part of the Agreement on the European Economic Area (EEA Agreement).
- EEA legislation covers i.a. the internal energy market, requirements for energy efficiency, eco-design and energy labelling and relates in particular to consumer perspectives, environmental protection, efficiency in the operation of energy companies, corporate separation of exclusive licensing and competitive factors, equal access and market economy in electricity and natural gas trade.
- A comprehensive review of EU energy legislation entitled "Clean Energy for All Europeans" is now available and is intended to better promote energy transition and fulfill the obligations of the Paris Agreement to reduce greenhouse gas emissions.

2.2 A Sustainable Energy Future

2.2.1 The Energy Policy for 2050 Submitted to Parliament

An Energy Policy titled “A Sustainable Energy Future” was submitted to Parliament at the 151st Legislative Assembly 2020–2021, in February 2021. The Energy Policy was prepared by a cross-party parliamentary committee in extensive co-operation with the government, institutions and stakeholders. The policy attains to the period up to and including 2050 and is the first long-term Energy Policy for Iceland that is prepared in this manner.

The Energy Policy aims to protect the interests of current and future generations. Sustainable development is a guiding principle that reflects the balance between economic, social and environmental factors.

The Energy Policy includes a vision for a country of clean energy.

Iceland is a land of clean energy where all energy production is of a renewable origin. Renewable energy production plays a fundamental role in the fight against climate change. The energy is used in a sustainable way for the benefit of society and the public. All energy demands are met safely in the long and short term. The country is a leader in sustainable energy production, energy transition, energy efficiency and efficient multi-use of energy sources. There is commitment to the protection of nature and the utilisation of energy resources, as the environmental impact is minimal.

The societal benefits of energy resources are maximised and the nation benefits. Energy is the driving force behind a variety of economic activities where there is equal access nationwide to energy at competitive prices. The nation possesses excellent knowledge and progressive thinking in relation to energy issues, which results in thriving value creation and innovation.

Figure 3. A Vision of a Sustainable Energy Future from the Energy Policy.

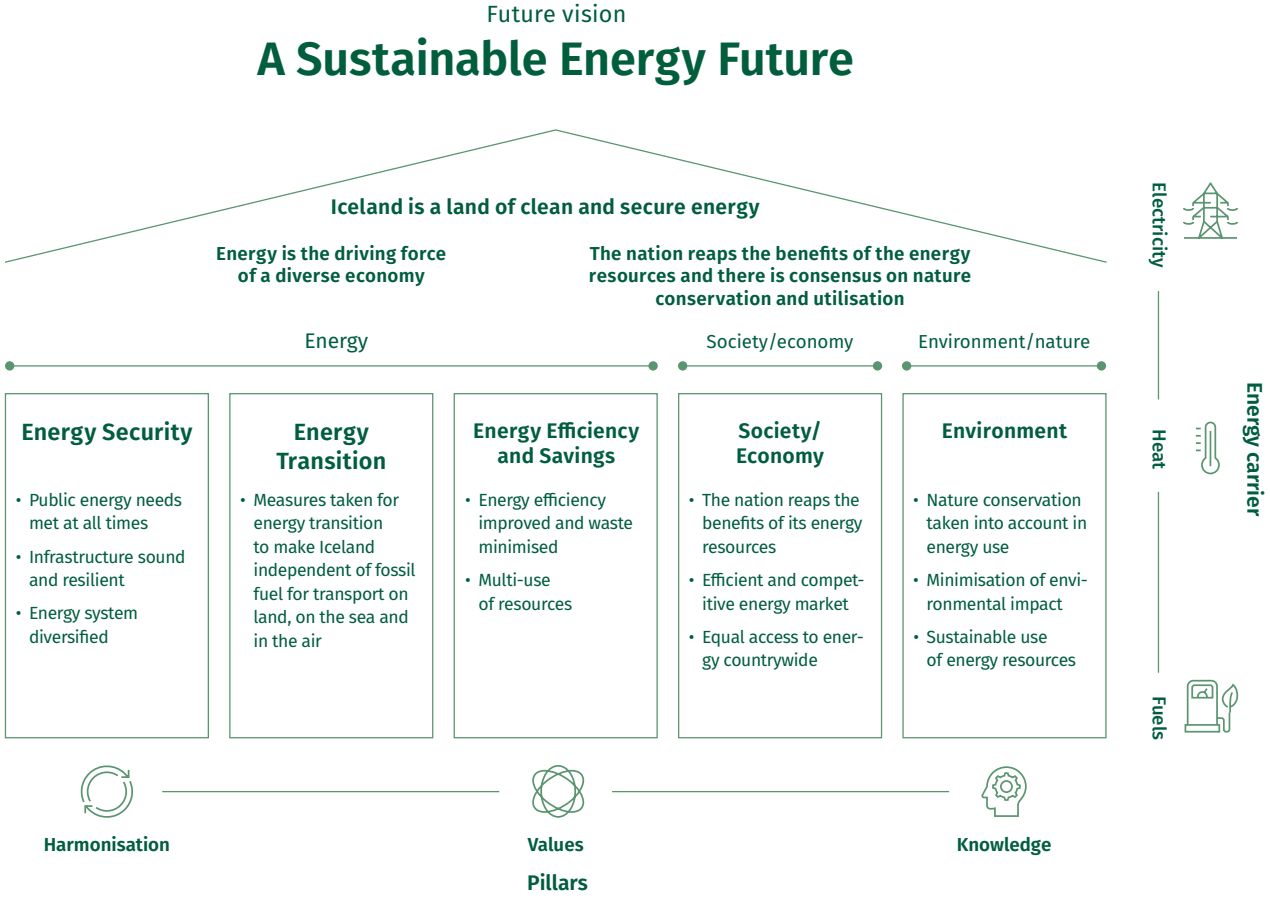


Figure 4. The Energy Policy Platform.[4]

The Energy Policy has five guiding principles, and this report follows the same structure.

Energy Security

Energy Transition

Energy Efficiency and Savings

Society and Economy

Environment and Nature

[4] www.orkustefna.is

2.2.2 Key Targets of Iceland's Energy Policy

The key targets of the energy policy are:

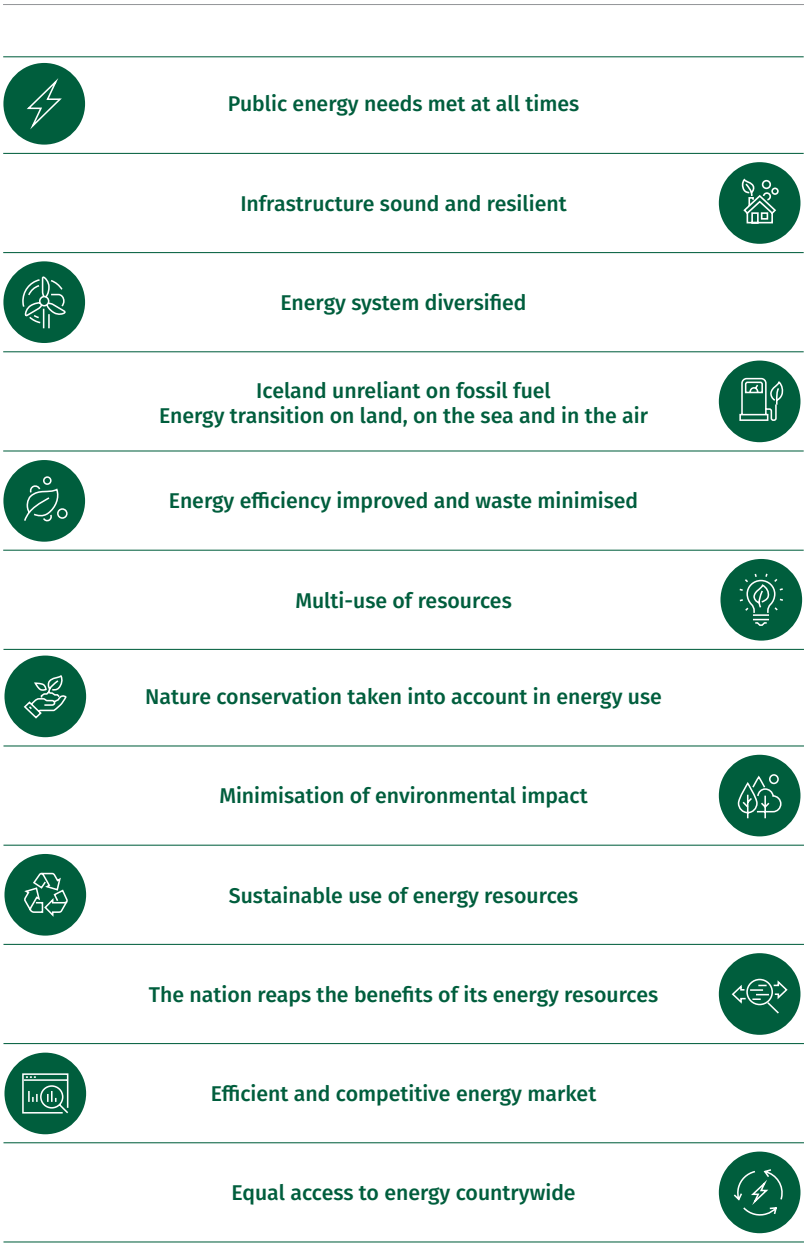
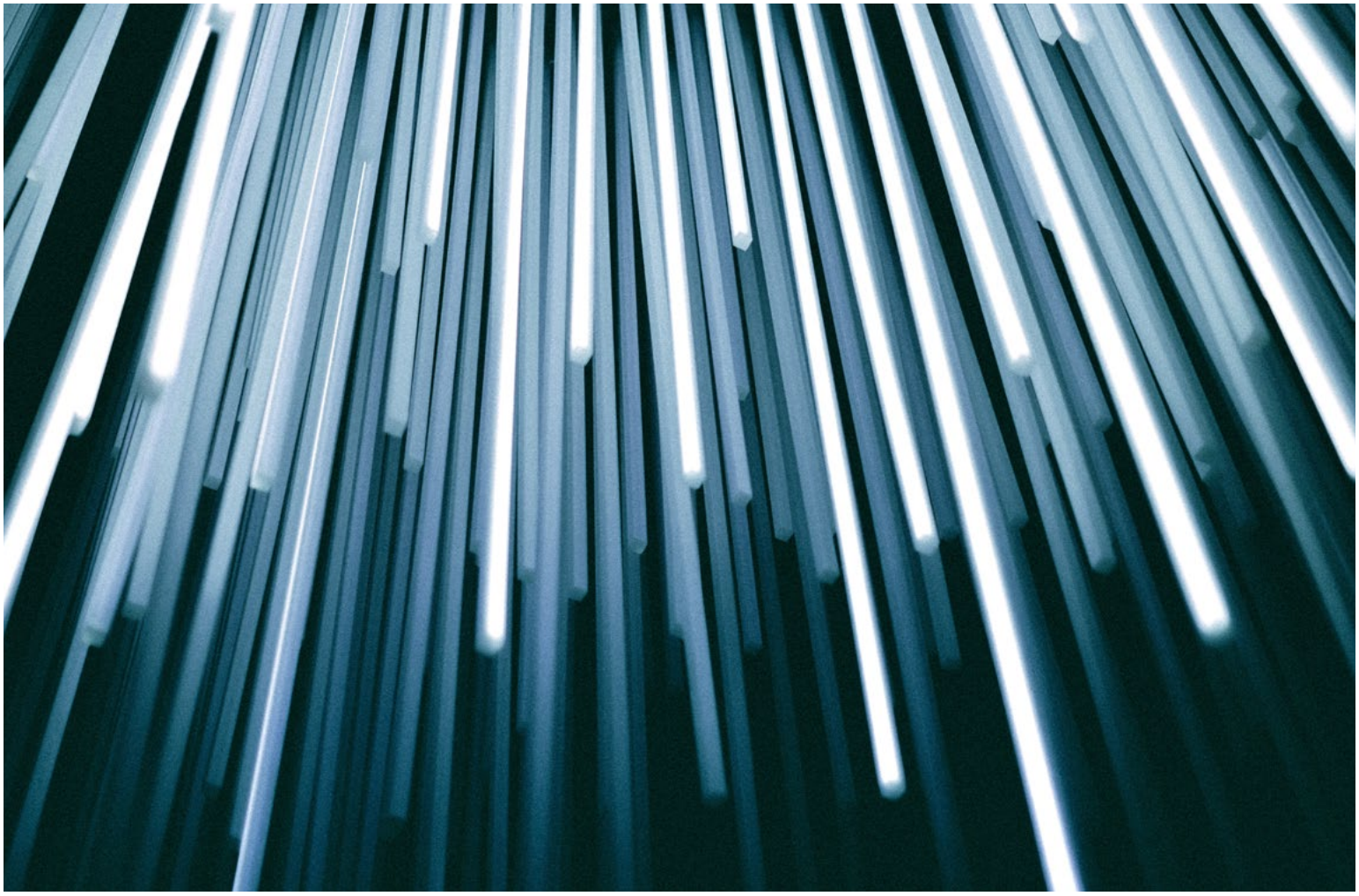


Figure 5. Objectives of the Energy Policy.



The Energy Policy is accompanied by an Action Plan with defined actions and tasks that are intended to implement the policy and support it.[5]

2.3 Energy and Climate Targets

2.3.1 Three Principal Goals

Three main climate goals have been set. At the beginning of the recent electoral term, the government set out the main targets below, aiming for the end of use of fossil fuels by 2050. During the current electoral term, the timeframe has been accelerated to 2040. In addition to the main targets, objectives are also set for the share of renewable energy in transport and marine-related activities.

[5] https://www.stjornarradid.is/library/01--Frettatengt---myndir-og-skrar/ANR/Orkustefna/200327%20Atvinnuvega-raduneytid%20Orkustefna%20lodrett%20185x248mm%20Vidauki%20II%20V6.pdf

- The Paris Agreement:
  - Joint target with the EU and Norway of a 55% total reduction in emissions by 2030 compared to 1990 (to implement the goals of the Paris Agreement).
  - What the target on Iceland's direct responsibility will be within the common goal is not clear, but it will increase significantly from the previous target of a 29% reduction.
  - An independent national target of a 55% reduction in emissions by 2030 compared to 2005 on Iceland's direct responsibility.
- 40% share of renewable energy in transport by 2030.
- 10% share of renewable energy in marine-related activities by 2030.
- Iceland will be carbon-neutral by 2040
- Iceland will achieve full energy transition and will be independent of fossil fuels by 2040–2050.[6]

2.4 Energy Commitments on the Basis of the EEA Agreement

Rules on energy trade have been part of the Agreement on the European Economic Area (EEA Agreement) since its entry into force in 1994. Energy is defined as a product and therefore falls under the free movement of goods, which is part of the four freedoms, on which both the European Union's (EU) internal market and the European Economic Area are based. The rules of the EEA Agreement on energy issues fall under IV. Annex to the EEA Agreement. The Annex covers e.g. the internal energy market, requirements for energy efficiency, eco-design and energy labelling. The Annex thus covers trade in both electricity and natural gas, fuel and electrical appliances. The European Union's acts on energy, which have been incorporated into the EEA Agreement, concern in particular consumer perspectives, environmental protection, efficiency in the operation of energy companies, business separation of exclusive licence and competition factors, equal access and a market economy in electricity and natural gas trade.[7]

[6] Energy policy and scenarios in the latest forecast of the National Energy Forecast Committee (NEFC), DNV report and Hydrogen Roadmap are based on the year 2050 for independence from fossil fuels. The government agreement is based on the year 2040.

[7] https://www.althingi.is/altext/149/s/1315.html

A comprehensive review of EU energy legislation titled “Clean Energy for All Europeans” is now available. The review began with proposals from the European Commission at the end of 2016 and the approval of the Council of Europe of four acts in May and December 2018 and the last four on 22 May 2019. The acts in question are directives and regulations on the energy efficiency of buildings, renewable energy, energy efficiency, monitoring and governance systems and four acts on electricity market issues. The EU launched the review of the legislation to better promote the energy transition and fulfill the obligations of the Paris Agreement to reduce greenhouse gas emissions. Among its main items are provisions for increased production of green energy and improved energy efficiency. Faster energy transition through innovation, improved energy efficiency and a more efficient transmission system are encouraged. Emphasis is placed on favouring green energy producers, both existing producers and general consumers, e.g. with wind or solar energy, either for own use or into the electricity system. Consumers’ equal access to efficient energy for space heating and cooling and house electricity should also be ensured.

As before, the guiding principle of the regulatory framework is to improve the interests of consumers and the environment as well as to strengthen the economy. The Ministry of the Environment, Energy and Climate has already begun working in accordance with the provisions of the new regulation on monitoring and governance systems concerning climate obligations.

Implementation in Iceland is subject to reservations and exceptions that may arise after the work of the consultation group. The government discusses the acts through the agency of the Minister of the affairs. Finally, the government’s parliamentary resolution is submitted to Parliament.

2.5 Iceland’s Climate Commitments

2.5.1 The Paris Agreement

In 2015, the Paris Agreement on Climate Change was adopted. Iceland ratified the agreement in September 2016, and it entered into force on 4 November 2016. According to the Paris Agreement, the member states themselves must set targets for reducing greenhouse gas emissions, the so-called nationally determined contributions (NDCs), and Iceland submitted its first NDC in September 2016, stating that Iceland intends to participate in the EU’s joint target of reducing emissions by 40% by 2030, compared to 1990. In February 2021, Iceland submitted an updated NDC stating that Iceland will participate in the EU’s new target of a 55% reduction in emissions (in co-operation with the EU member states and Norway) instead of the previous 40%.[8]

[8] https://himinnoghaf.is/loftslagsmal/article/skuldbindingar-islands/

2.5.2 The Agreement with the EU and Norway to Enforce the Paris Agreement

According to an agreement with the European Union, Iceland and Norway are participating in a joint target of a 40% reduction in greenhouse gas emissions in the period 2021–2030. Within the 40% target, the share of Iceland's direct responsibility was 29%, i.e. emissions falling outside the European Union's Emissions Trading System (ETS). Targets of the direct responsibility of states are set according to pre-determined criteria and algorithms where, e.g. the national income per capita and the cost-effectiveness of operations are considered.

The joint overall target has been tightened from 40% to 55%, but it has not been confirmed what the target of Iceland's direct responsibility will be within the new 55% overall target, but it is expected that it will increase considerably. The government has also set an independent national target of a 55% reduction in emissions falling outside the ETS system by 2030 compared to 2005.

With this arrangement, Iceland, Norway and the EU Member States have one joint contribution to the Paris Agreement, but the internal rules of the states determine the share and obligations of each state. The common goal is implemented in such a way that part of the reduction that is to take place in emissions is divided among the states and forms their direct obligations. This emission is therefore the direct responsibility of the states (ESR – Effort Sharing Regulation). Part of the reduction falls on an emissions trading system, the ETS system. Numerical targets for both of

these factors are based on 2005. Third, there are special rules regarding land use (LULUCF – Land Use, Land-Use Change, and Forestry).

Iceland's ESR obligations cover emissions from energy (including transport and fisheries), industrial processes and chemical/product use, agriculture and waste, but not emissions falling under the EU ETS or emissions and greenhouse gas sequestration from LULUCF.

Member States shall ensure that the annual greenhouse gas emissions covered by ESR in the years 2021–2029 do not exceed defined limits that are linear from 2020, based on average emissions in the years 2016–2018, and end in 2030 on the target of each member state. The EU Regulation on Effort Sharing (ESR – No. 2018/842) specifies the minimum percentage by which each Member State shall reduce its greenhouse gas emissions falling within its scope in the period 2021–2030, compared to 2005 emissions. According to an agreement from 2019, that percentage was 29%. In accordance with the obligation, the annual emission allocation has been calculated and the Iceland emission allocation can be seen in the decision of the EFTA Surveillance Authority (ESA) published in July 2021.[9]

In addition to having a defined annual emission allocation, it provides for various possibilities for flexibility in states' efforts to meet their obligations. States can borrow up to 10% of the allocated emission allowance for the coming year in the period 2021–2025 and up to 5% in the years 2026–2029. In instances where the state's emissions for a given year are less than the amount of allocated emission allowances, the excess allowances may therefore be used to meet later obligations, until the year 2030. States may transfer up to 5% of their annual emissions allocation for the period of 2021–2025 to other Member States that can use the allowances and up to 10% for the period of 2026–2030. States that are not on the right track, based on their obligations, can use this allocation to negotiate transfers from states that are better off than their obligations require.

States are authorised to use forestry and land-use allowances to a certain extent, and certain states are authorised to transfer emission allowances from the ETS system in order to meet their obligations under the Regulation. The level of that allowance for individual states varies. As far as Iceland is concerned, the aforementioned allowance amounts to 200.000 tonnes of CO_2 equivalents during the period and corresponds to 4% of Iceland's ETS emissions in 2005.

In 2027 and 2032, a detailed assessment will be carried out as to whether states have met their obligations in terms of annual emissions for each year within each five-year period (2021–2025 and 2026–2030), including utilising the flexibility provisions.

[9] https://www.eftasurv.int/cms/sites/default/files/documents/gopro/College%20Decision%20204%2021%20COL%20-%20Determination%20of%20the%20Annual%20Emissions%20Allocations.pdf

If a state does not meet its obligations, the excess of that year's emissions in CO_2 equivalents will be multiplied by a coefficient of 1.08 and added to next year's emissions, and the state will not be allowed to use flexibility provisions regarding transfers of allowances to other states until it meets its obligations.

2.5.3 Joint Overall Target Updated from 40% to 55%

In drafting this report (February/March 2022), the European Commission (EC) has submitted a proposal for the reduction of emissions under direct responsibility of the Member States and has published in part the allocation and calculation rules behind it. The proposal is still under review in both the European Parliament and the European Council, and therefore, the allocation and calculation rules behind it cannot be considered final. The proposals assume a maximum reduction target for individual states of 50% and a minimum of 10%. The basis for that calculation is a defined criteria designed to ensure fairness, economy and that adjustments are made in respect of the particular circumstances of the states concerned, e.g. the proportion of emissions in industries which are technically difficult to reduce, such as agriculture and the fisheries sector.

As a proposal for a target for the Member States has not been approved, the targets of Iceland and Norway have not been assessed and will not be formally available until a decision has been made on the targets of the EU Member States.

Based on the presented assumptions and taking into account the composition of emissions from Iceland in comparison with other states and the cost analysis of reduction measures and taking into account the specific adaptation of the regulatory framework, due to the circumstances in Iceland, including the high proportion of renewable energy, it is firmly assumed that the reduction target for direct responsibility of Iceland will increase significantly within the new target. In this context, it is worth reiterating that there is no formal decision regarding the assumptions, calculation rules or possible adjustments due to the specific circumstances of individual states, and therefore this figure may change.

According to the government agreement, an independent national target of a 55% reduction in emissions from Iceland's direct responsibility will be set for the same period.

The government agreement states that in consultation with municipalities and the business community, the intention is to set phased emission targets for each industry.

It is clear that Iceland's target of a 55% reduction in greenhouse gas emissions on Iceland's direct responsibility by 2030, carbon neutrality no later than 2040 and that Iceland will be the first nation to be independent of fossil fuels by 2040 is one of the more ambitious national targets. However, the 2050 target is considered more realistic for independence from fossil fuels if technological developments are taken into account.

The Environment Agency of Iceland submits reports and information to the European Union on policies and measures aimed at reducing greenhouse gas emissions. It is worth mentioning that the assessment of the reduction in the action plan and the assessment of the reduction according to the calculations of the Environment Agency are not entirely based on the same assumptions or methodologies and are therefore not fully comparable.

The Environment Agency's projections take into account measures that have already been implemented or are at least timed and financed. According to them, the reduction in greenhouse gas emissions under Iceland's direct responsibility will amount to:

28% in 2030 compared to 2005

46% in 2040 compared to 2005

According to the Action Plan as it was presented when these calculations were made, Iceland is unlikely to achieve the Paris targets of 2030, despite some flexibility with the use of the ETS, because the EU has raised its total emissions targets to 55%, which affects Iceland's share.

It is also unlikely to achieve the independent target of a 55% reduction in emissions by 2030 as set out in the 2021 government agreement without significantly adding to measures.

The Environment Agency estimates that emissions from the energy sector (which includes geothermal power plants and fuel consumption) will decrease by 31% in 2030 compared to 2005. The Environment Agency's calculations are based on i.a. the fuel forecast issued in September 2021, which does not assess all the actions of the Climate Action Plan.

3. Energy Security

3.1 Summary

- Six scenarios are set out in the report, of which four take Iceland's climate goals into account, ranging from little to no addition to Iceland's electricity output, up to more than doubling it up to a 125% increase by 2040.
- There has been limited construction of hydroelectric and geothermal plants in later years, considering the demand. Preparations have been underway for some construction which is permitted with the current utilisation category. No new plants over 10 MW have received a utilisation permit for the past 5 years, but there have been utilisation permits for increasing the utilisation of hydroelectric and geothermal plants, as well as a permit for few smaller plants. The third phase of The Masterplan (for Nature Protection and Energy Utilization) is awaiting processing by parliament. The fourth phase is underway and has not been delivered to the minister.
- The year 2021 had poor water supply which, along with energy demand outstripping supply, has lead to Landsvirkjun utilising permits to curtail electricity delivery to those parties with curtailable electricity contracts, those parties being fish meal plants, large-scale users and district heating plants.
- Transmission limitations are currently in place between regions.
- Several construction projects focused on the transmission systems have been delayed considerably.
- A multi-factor initiative will be implemented to strengthen the distribution and transmission system following the storm of December 2019.
- The strengthening of three-phase electricity has been supported in the distribution system and work is underway on increased proportion of underground cables to improve the population's access to electricity and a more powerful distribution system.
- Several wind energy projects are being reviewed, but no work has begun on those projects. Opinions on zoning issues and permits have been divided.
- There is an increased energy need if the country is to be able to meet the demands of the energy transition in the decades to come, if the intention is to

utilise domestic energy resources according to the Energy Policy. E-fuel can be produced domestically or imported. The energy transition is thought to require between 4–24 TWh, depending on how much domestic E-fuel can be produced. The highest end of the range assumes that a full energy transition will take place.

- There is an energy demand from dozens of companies of varying sizes, including possible large-scale consum domestically and abroad.
- The first criteria with the year 2050 as a reference point for a fossil fuel free Iceland is more realistic than the year 2040 given the current state of energy and technological development.
- Seller of last resort in a wholesale marketplace is not defined according to electricity legislation.[10]
- The energy forecast of the NEA does not factor in future development in industry, i.e. plans for growth and the investments of large-scale electricity consum.

3.2 Energy Supply and Development

The Energy Policy: **The Energy System is More Diverse**

3.2.1 Supply of Electricity and Geothermal Energy

Energy security is dependent on a few key factors: the supply of electricity, the demand for electricity and geothermal energy, the transmission and distribution network and the legal framework for energy issues. At present, primary energy use, which is obtained from four energy categories, is essentially the same as shown in a graph from the NEA.

[10] See page 34 in the report of the working group. https://www.stjornarradid.is/library/01--Frettatengt---myndir-og-skrar/ANR/ThKRG/Sk%C3%BDrsla%20starfsh%C3%B3ps%20um%20orku%C3%B6ryggi_LOKAEINTAK.pdf

Primary Energy Consumption in Iceland 1940–2020

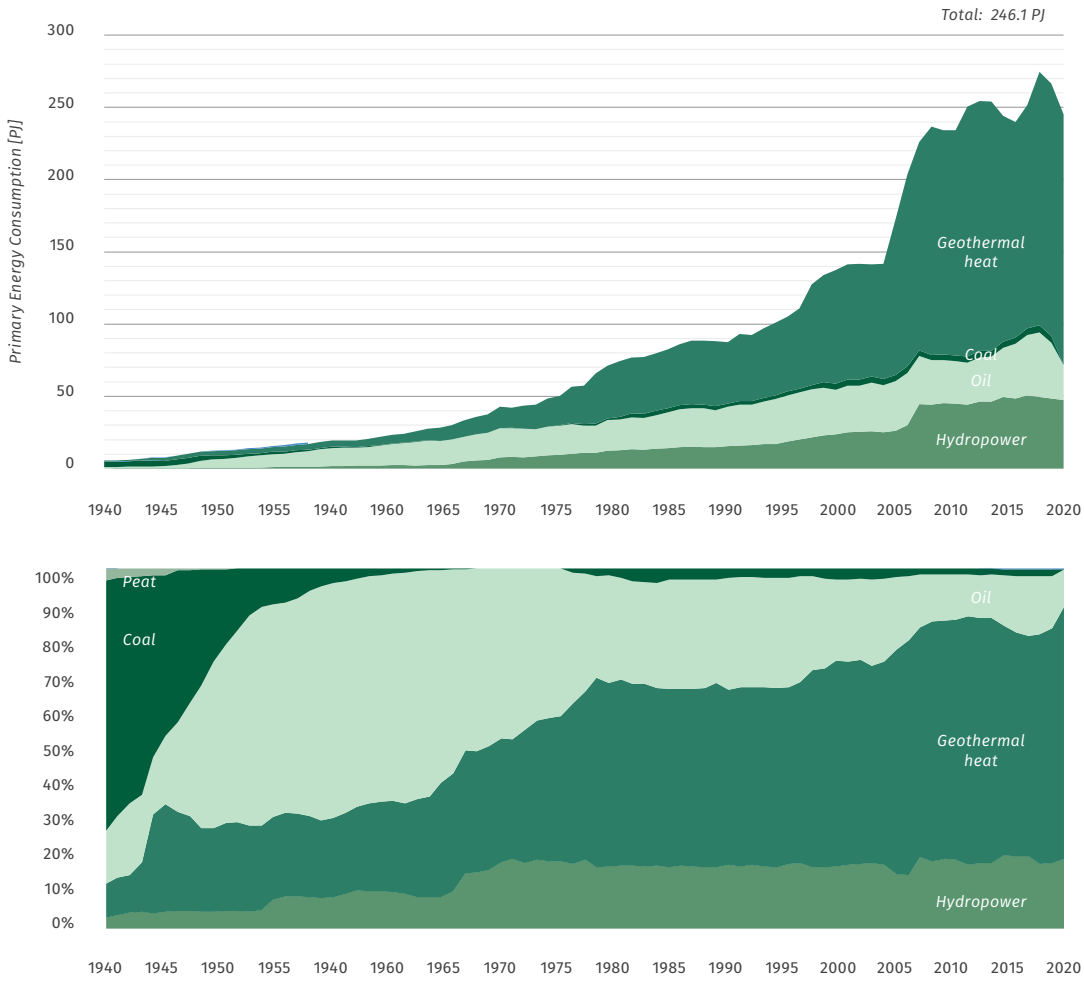


Figure 6. Primary Energy Consumption. *Source: Orkustofnun (National Energy Authority).*

Hydropower and geothermal energy are the main primary energy categories behind electricity production in 2021. In the year 2022, the burning of oil needs to be increased due to electricity curtailment to fishmeal factories, heavy industry and electric district heating. Data centres will in some cases have backup power (diesel stations), but smelters or silicon processing plants will not. In 2021, most of the installed electric power was in the hands of several electricity producers, cf. the following table.[11]

[11] This table is missing Bru, HS Orku's plant in the column "Installed Electrical Capacity – Hydropower: 9,900kW". Small wind power plants, 600kW, are wind turbines in Þykkvabaer that have been demolished. Installed power – fuel is in part as a reserve power source.

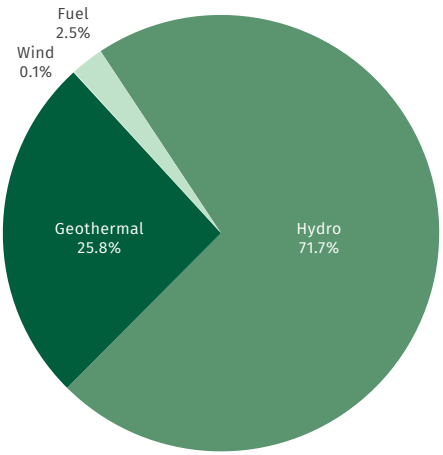
Producer *Producer*	Installed Electrical Capacity – Hydropower [KW] *Installed electrical capacity – Hydro [kW]*	Installed Electrical Capacity – Geothermal Heat [KW] *Installed electrical capacity – Geothermal [kW]*	Installed Electrical Capacity – Wind Power [KW] *Installed electrical capacity – Wind [kW]*	Installed Electrical Capacity – Fuel [KW] *Installed electrical capacity – Fuel [kW]*	Total [kW] *Total[kW]*
Landsvirkjun	1,991,300	153,200	1,800	-	2,146,300
Orka Natturunnar	8,200	423,000	-	-	431,200
HS Orka	-	176,400	-	-	176,400
Orkusalan	37,780	-	-	-	37,780
Orkubu Vestfjarda	17,322	-	-	17,328	34,650
RARIK	-	-	-	33,889	33,889
Small-scale plants	34,575	600	600	-	35,775
Landsnet	-	-	-	10,800	10,800
HS Veitur	-	-	-	7,194	7,194
Nordurorka	-	-	-	2,760	2,760
Fallorka	6,407	-	-	-	6,407
Rafveita Reydarfjardar*	240	-	-	-	240
Orkuveita Husavikur	-	-	-	-	-
Total	**2,095,824**	**753,200**	**2,400**	**71,971**	**2,923,395**

** In 2020, RARIK acquired the substations and distribution system of Rafveita Reydarfjardar*

Figure 7. Electricity Producers.

Source: Orkustofnun (National Energy Authority).

Installed power by origin 2019



Total Installed Power Capacity: 2,923 MW
Statistical material from the National Energy Authority (Orkustofnun): OS-2021-T012-01

Figure 8. Installed Power. *Source: Orkustofnun (The National Energy Authority)* [12]

3.2.2 Masterplan and Power Production Capabilities Within Its Utilisation Category

The government's Masterplan (for Nature Protection and Energy Utilization) prepares the Parliament's decision on the ranking of power development options into the protection, utilisation or standby categories according to a statutory process. Various power development options are in the utilisation category of the Masterplan (for Nature Protection and Energy Utilization), both in the current utilisation category and in phase three, which is currently being processed by the Parliament. In addition, many power development options are being discussed by the project management (phases four and five), both new power development options and options from the standby category.

The Parliament has twice approved parliamentary resolutions on the ranking of power development options on the basis of the Masterplan (for Nature Protection and Energy Utilization), in 2013 and 2015. In the utilisation category for the current Masterplan (for Nature Protection and Energy Utilization), the energy options found in Table 1 were approved. In total they amounted to approximately 1,151 MW of installed power. The annual energy capacity is approximately 9.2 TWh. Hydropower is approximately 156 MW, and geothermal heat is approximately 995 MW.

[12] If we look at production figures for the year 2020, the production of petrol stations was 6.66 GWh, or about 0.035% of the country's electricity generation, see Appendix 1 in the Electricity Forecast 2021–2060. This figure gives a completely different overview, as it shows installed power.

Table 1. Power generating options in the utilisation category of the current Masterplan (for Nature Protection and Energy Utilization) approved by the Parliament in 2013 and 2015.

Type of Energy	Water Catchment Area High-Temperature Geothermal Area	Power Development Options	MW	GWh/year	Econom. Cat.
Hydropower	Ofeigsfjordur	The Hvalarvirkjun Power Plant	35	259	5
Hydropower	Blanda	The Blonduveita Power Plant	28	180	4
Hydropower	Þjorsa	The Hvammsvirkjun Power Plant*	93	720	4
Geothermal power	The Reykjanes Area	Reykjanes	80	568	2.5
Geothermal power	The Reykjanes Area	Stora-Sandvik	50	410	2.5
Geothermal power	The Svartsengi Area	Eldvorp	50	410	3
Geothermal power	The Krysuvik Area	Sandfell	50	410	3
Geothermal power	The Krysuvik Area	Sveifluhals	50	410	2
Geothermal power	The Hengill Area	Meitillinn	45	369	3
Geothermal power	The Hengill Area	Grauhnukar**	45	369	3
Geothermal power	The Hengill Area	Hverahlid**	90	738	3
Geothermal power	The Namafjall Area	Bjarnarflag	90	738	2
Geothermal power	The Krafla Area	Krafla I, Expansion	40	320	2
Geothermal power	The Krafla Area	Krafla II, Phase I	45	369	2
Geothermal power	The Krafla Area	Krafla II, Phase II	90	738	2
Geothermal power	The Þeistareykir Area	Þeistareykir**	180	1476	2
Geothermal power	The Þeistareykir Area	Þeistareykir**, western region	90	738	2

** Approved by the Parliament in 2015*

*** NEA has issued a utilisation permit*

A proposal for the classification of power development options on the basis of Phase 3 of the Masterplan (for Nature Protection and Energy Utilization) is now before the Parliament. There are proposals for eight new power development options in the development category, which are added to those that already exist. These eight power development options have a total of about 657 MW of installed capacity. The annual energy capacity is approximately 4.6 TWh. Hydropower is approximately 227 MW, geothermal heat is approximately 288 MW and wind power approximately 100 MW.

Table 2. Power generating options in the utilisation category of a proposal for the third phase of the Masterplan (for Nature Protection and Energy Utilization) currently pending before Althingi. If approved, they will be added to the current Masterplan.

Power Development Options	Type of Energy Production	MW	GWh/year	Econom. Cat.
Skrokkolduvirkjun	Hydropower	45	345	3
Holtavirkjun	Hydropower	57	450	4
Urridafossvirkjun	Hydropower	140	1037	2
Austurgilsvirkjun	Hydropower	35	175	5
Austurengjar	Geothermal Power	100	820	3
Hverahlid II	Geothermal Power	90	738	4
Þverardalur	Geothermal Power	90	738	4
Blondulundur	Wind power	100	350	X

In addition to the aforementioned power development options, which the project management and its teams of experts have completed an assessment of, in accordance with statutory procedures, an assessment is now underway for various power development options that the National Energy Authority has defined and requested to be considered. The project management of the fourth phase received 46 power development options for evaluation and drafted a classification of 13 of them. In addition, there are about 40 options in the standby categories of the first phase. The appointment period of the fourth phase project management expired in 2021, when the fifth phase project management took over the work.

To understand the context in these variables, it should be noted that in 2020, the electricity production was 19,127 GWh and the highest energy peak of the system was 2,408 MW.

If we look at the power development options that are in the approved utilisation category of the Masterplan (for Nature Protection and Energy Utilization) and excluding the power development options for which the National Energy Authority has already issued a utilisation permit, there are a total of 764 MW of estimated power in ten power development options, both geothermal and hydropower.

In addition, there are about 657 MW in eight power development options in the proposal in the utilisation category of the third phase, which is now before the Parliament for consideration, both geothermal, hydropower and wind power. Parliament's approval of the third phase, as submitted, would mean a total of 1,421 MW in utilisation category in 18 potential power development options.

It is also worth noting that an additional 80 power development options are in the process of the project management of the Masterplan (for Nature Protection and Energy Utilization) that need to be evaluated and proposals prepared for classification into utilisation, standby or protection. It is clear that an addition to the utilisation category can be expected there.

According to information from Landsvirkjun, the status of its power development options is as follows: In the second phase of the Masterplan (for Nature Protection and Energy Utilization), there are two hydropower development options, one in project design and the other in an invitation to tender. The phase also includes three geothermal development options, one of which is in a project design phase and the project design phase of another has just begun. Landsvirkjun has submitted to the Masterplan (for Nature Protection and Energy Utilization) another five power development options, of which two have wind power and three have hydropower at different design stages. According to information from HS Orka, it has four geothermal development plant options in the utilisation category of the second phase of the Masterplan (for Nature Protection and Energy Utilization) and one in the standby category. In addition, one hydropower option where the initial design and environmental impact assessment is completed. The company also plans to expand its power plants and improve efficiency. The plans are at different stages, from initial design to construction.

3.2.3 Overview of Wind Power Projects at Various Stages

For several years, projects in wind power have been submitted to municipal authorities or reported on in various media. Those that are currently at some stage of development from idea to processing by municipal authorities and/or institutions are as follows:

Table 3. Overview of wind power options according to current planning, announced organisational plans and environmental assessment of works, 23.02.2022.

Municipality	Power plant / location / developer *(specified maximum size according to planning and environmental impact assessment)*	Planning	Environmental impact assessment of construction
Hvalfjardarsveit	Brekka, Zephyr Iceland 50 MW.	Not provided for in the current planning. A proposal for a new Municpal Plan that is being prepared states that no position will be taken on individual wind power plants unless there is a definition of an area in the utilisation category of the Master Plan.	Pre-consultation meeting according to Article 8 of the Act on Environmental Assessment of Projects and Plans January 2022.
Borgarbyggd	Grjothals, Owners of Hafthors- and Sigmundarstadir 400 ha area (in Municpal Plan). 30 MW (in environmental impact assessment).	Municipal authorities presented a prospectus for amendments to the Municpal Plan in 2021.	Decision of the National Planning Agency on the assessment plan 17.9.2020.
Borgarbyggd	Muli in Hvammur, Qair Iceland 95 MW.	Not provided for in planning.	Qair Iceland assessment plan presented in January 2022. The Planning Agency's opinion on the assessment plan is not available.
Snaefellsbaer	By Gufuskalar 8.1 MW, 75-metre-high wind turbines.	Provided for in Municpal Plan.	Not conducted.
Snaefellsbaer	Northeast of Gufuskalar 3 MW, 75-metre-high wind turbines.	Provided for in Municipal Plan	Not conducted.
Dalabyggd	Hrodnyjarstadir, Storm orka 130 MW.	Provided for in the Municipal Plan amendment approved by the municipal authorities; the Minister of Infrastructure is included for approval. Also included in proposal for a new Municipal Plan that is being prepared.	Decision of the National Planning Agency on the assessment plan 28.7.2020.
Dalabyggd	Solheimar, Qair Iceland 150 MW (in Municipal Plan). 115 MW (in environmental impact assessment).	Provided for in the Municipal Plan amendment approved by the municipal authorities; the Minister of Infrastructure is included for approval. Also included in proposal for a new Municipal Plan that is being prepared.	Decision of the National Planning Agency on the assessment plan 17.9.2020.
Reykholahreppur	Garpsdalur, EM Orka 89 MW (in Municipal Plan). 130 MW (in environmental impact assessment).	Provided for in the Municipal Plan amendment approved by the municipal authorities; the Minister of Infrastructure is included for approval. Also included in proposal for a new Municipal Plan, approved by the municipal authorities for advertising.	Decision of the National Planning Agency on the assessment plan 28.7.2020.

Municipality	**Power plant / location / developer** *(specified maximum size according to planning and environmental impact assessment)*	Planning	Environmental impact assessment of construction
Nordurthing	Hnotasteinn, Qair Iceland 35 windmills, 200 m high (in Municipal Plan). 200 MW (in environmental impact assessment).	Municipal authorities presented a prospectus for amendments to the Municipal Plan in 2020.	Decision of the National Planning Agency on the assessment plan 2.7.2021.
Mulathing	Lagarfoss 10 MW, 2 wind turbines.	Municipal authorities presented a prospectus for the preparation of the Municipal Plan in 2019.	Not conducted.
Mulathing	Klaustursel, Zephyr Iceland 250 MW.	Not provided for in planning.	Pre-consultation meeting according to Article 8 of the Act on Environmental Assessment of Projects and Plans January 2022.
Skaftarhreppur	Grimsstadir, Qair Iceland 171 MW.	Not provided for in the current planning. The proposal for a new Municipal Plan that is being prepared contains general provisions on wind energy but not local provisions on wind power plants.	Decision of the National Planning Agency on the assessment plan 29.9.2021.
Rangarthing ytra	Habaer, Þykkvabaer 1,9 MW, 2 wind turbines.	Provided for in Municipal and Local Plan.	Not subject to the then-applicable law.
Rangarthing ytra	Vindaborg in Þykkvabaer, Biokraft 45 MW.	Not provided for in planning.	Decision of the National Planning Agency on the assessment plan 17.4.2017.
Rangarthing ytra and Skeida- and Gnupverjahr.	Burfellslundur, Landsvirkjun 200 MW.	Not provided for in planning.	National Planning Agency's opinion on Environmental Impact Assessment 21.12.2016.
Skeida- and Gnupverjahreppur	Hafid, Landsvirkjun 1.8 MW, 2 wind turbines.	Provided for in Municipal and Local plan.	Not subject to the then-applicable law and is a pilot project.
Skeida- and Gnupverjahr.	Hrutmulavirkjun (Skaldabudir) 85 MW.	Municipal authorities presented a prospectus for amendments to the Municipal Plan in 2020.	Not conducted.
Grimsnes- and Grafn.hr. & Ölfus Municipality	Mosfellsheidi, Zephyr Iceland 100 MW (in GoG Municipal Plan). 200 MW (in environmental impact assessment).	The municipal authorities of Grimsnes and Grafningshreppur approved a proposal for a new Municipal Plan for advertising, which provides for the wind power plant, in February 2022. Not provided for in the Municipal Plan of the Municipality of Ölfus or in a proposal for a new Municipal Plan approved by the town council in November 2021.	Decision of the National Planning Agency on the assessment plan 9.3.2021.

Source: The Icelandic National Planning Agency

In addition, the Municipal Plans of several municipalities provide scope for the development of small, single wind turbines outside urban areas. Often based on 10–30-metre-high wind turbines, 0.5–1 MW. Akureyri municipality has also presented a prospectus for making amendments to the Municipal Plan for six 12-metre-high wind turbines, each 6 kW, in Grimsey.

3.2.4 Expansion of Current Power Production Facilities

Increased flow of glacial lakes due to glacial shrinkage and other watercourses due to changes in precipitation can improve the production capacity of hydropower plants. This then takes into consideration, i.a. technical modifications to power engines or additions to power plant power engines. Additional power from geothermal power plants can be obtained through better utilisation of wastewater heat and the generation of other, so-called industrial waste.

The NEA has processed four utilisation permits, which can be considered as booster actions for existing power plants from 2017 to 2021, and all of these measures have already been put into operation. The booster totals 12.85 MW in installed capacity. No application for such an action is awaiting processing by the NEA in January 2022, according to its information.

3.2.5 Factory Waste Heat

Furthermore, it is possible to utilise heat emanating from high-energy industries (often referred to as waste heat), e.g. metallurgical plants to produce electricity and geothermal heat. These are options that have not been fully evaluated.

3.2.6 Small Power Plants (<10 MW)

Most of the utilisation permits that have been issued in the last 5 years have been for small power plants, i.e. power plants under 10 MW of installed capacity, or a total of 21.8 MW in hydropower in 9 small power plants and 4.5 MW in geothermal energy (3 small power plants). These power plants are all operational. The NEA now has two applications for hydropower utilisation permits and one application for wind power utilisation permits, a total of 16.85 MW. Varmaorka produces electricity from geothermal areas in low-temperature areas in Fludir/Kopsvatn, Reykholt and at Krauma by Deildartunga, a total of almost 1 MW.

It should be noted that the NEA's analysis of small power plant options reveals that they are numerous and with a combined capacity of around and over 2,500 MW, with the reservations stated in the reports.

3.2.7 Tidal Power Plants

The National Energy Authority has issued an exploration permit for plans for up to a 30 MW tidal power plant in Gilsfjordur in Reykholahreppur. An older power plant is being examined in Hvammsfjordur, Dalabyggd. The exploration permit authorises research and measurements in a specified area.

3.2.8 Digital Infrastructure Security

Delivery security and management security depend on secure digital systems for both power plants and the transmission and distribution system. Landvirkjun and Landsnet own and operate their own telecommunications company, Orkufjarskipti hf., which was established in December 2011. The company operates a powerful telecommunications system that is intended to meet the electricity system's requirements for a stable and reliable telecommunications network. This is a fiber-optic network that maintains communication routes to the power stations and substations of the electricity system (information from Landsvirkjun).

Landsnet has implemented a management system for information security, and it is certified according to ISO/IEC 27001:2013. It includes documented operational procedures, technical cybersecurity safeguards of various kinds, and awareness training for staff. Regular security tests of information systems are carried out by external parties. Efforts are being made to examine and assess the risks involved in the operation of digital substations, as well as to implement appropriate mitigation measures (information from Landsnet).

3.3 Community Development, Energy Forecasts and Energy Transition

The Energy Policy: **Public energy need met at all times**

3.3.1 Criteria for Evaluating Energy Requirements and Energy Demand

Since 1996, the National Energy Forecasting Committee (NEFC) of the NEA has prepared an energy forecast, most recently updated for 2021–2060, together with an annual document on the criteria of the energy forecast.[13] Special forecasts are made for electricity, fuel and heat.

The main criteria are: Economic growth, population and housing development, number of foreign tourists, homes and leisure centres, agriculture, fisheries, aquaculture, various industries and development of production there, services, utilities, goods and people transport within and outside the country, manpower and accommodation. Electricity forecasts include energy-intensive consum, but do not assume growth in use beyond what is stipulated in agreements. This is because predictability is not considered sufficient and energy sales to those parties are subject to special agreements. Recently, predictable energy transition has been assessed and included in the forecast. The energy forecast provides a basis for energy demand and its development for decades. It must be borne in mind, however, that there are a number of uncertainties, and updates such as the one prepared for the 2020 forecast must be considered. The actual energy consumption of each year is summarised in the next calendar year, at which time it's revealed how successful the assessments and the forecast were.

The criteria of other energy forecasts are in addition to this, e.g. either energy transition in land transport and in the fishing fleet or full energy transition. This refers to the energy transition of all vessels and ships, in international flights and all kinds of machinery and equipment that use fossil fuels.

3.3.2 Electricity Consumption for 2020 and Predicted Consumption for 2021 and 2022 acc. to the National Energy Authority

A comparison from the NEA on electricity consumption in 2020, together with electricity forecasts for 2021 and 2022 by user category, indicates the direction of general electricity consumption in the country's electricity system. Priority load and load curtailable in the general system are also reported.

[13] https://orkustofnun.is/orkustofnun/rad-og-nefndir/orkusparnefnd/nefndin/almennar-forsendur/

Table 4. Electricity consumption for 2020 and electricity forecast.

Source: Orkustofnun (The National Energy Authority) [14]

Large-scale use	Actual Figures 2020 *Energy GWh*	Proportion %	Electricity Forecast 2021 *Energy GWh*	Electricity Forecast 2022 *Energy GWh*
Large-scale-use metal-lurgic operations	14,003	73%	14,583	14,972
Large-scale-use data centres	828	4%	956	1,127
Large-scale total	**14,831**	**78%**	**15,540**	**16,099**
General use				
Households	879	5%	887	907
Agriculture	230	1%	246	240
Industry	735	4%	797	804
Services	1,040	5%	1,215	1,288
Utilities	317	2%	286	284
Fisheries	85	0%	88	90
General use total	**3,287**	**17%**	**3,519**	**3,612**
Other				
Transmission losses	359	2%	398	416
Distribution losses	181	1%	169	174
Withdrawals from processing companies	470	2%	480	490
Losses and withdrawals from processing companies total	**1,010**	**5%**	**1,047**	**1,080**
Energy consumption and losses total	**19,127**	**100%**	**20,105**	**20,792**

[14] Losses in the distribution system in the year 2020 were 187 GWh, and according to the table, that is 1% of all electricity production in the year 2020. Distribution losses in the distributers' system as a proportion of the energy acquisition of DSOs were 5.4% in 2020.

Table 5. Priority load and curtailable load by consum in the general category.

Source: Orkustofnun (National Energy Authority).

General use 2020	Priority load *GWh*	Curtailable load *GWh*
Households	879	-
Agriculture	230	-
Industry	480	255
Services	1,036	4
Utilities	144	174
Fisheries	85	-
General use total	**2,854**	**433**

According to the electricity forecast, the load of general consum and energy-intensive consum 2022–2026 will increase by 105 MW. The increase of new electricity production during the same period is estimated at a total of 37 MW. It amounts to about 35% of the load increase. What is lacking can be obtained within operatingpower plants, but then with the result that the maximum load in the electricity system approaches the installed total power of the power plants. This is unacceptable i.a. because part of the usable electricity is lost in the transmission system and part of it must always be available for temporary problems in the energy production of some power plants, in addition to which there must be scope to respond to different annual run-offs (prepared from the report Power and Energy Balance 2022–2026. Efla for Landsnet, 2021). It should be noted that since the water supply at hydropower plants varies and regular maintenance must be assumed, it cannot be assumed that installed power is a measure of energy supply.

3.3.3 Scenarios for Energy Requirements and Energy Demand

The following information is from the National Energy Authority's electricity forecast (National Energy Forecasting Committee). It should be noted that the electricity forecast primarily assesses the general public's use in Iceland. There is no forecast of a change in the use of electricity-intensive industries by energy-intensive consum (consumption over 80 GWh per year; power demand 8–10 MW), and therefore, a new energy-intensive consum can have a considerable effect on the forecast presented below. Examples of energy-intensive consum include data centres, onshore aquaculture, greenhouse operations and the metallurgy or silicon industry.

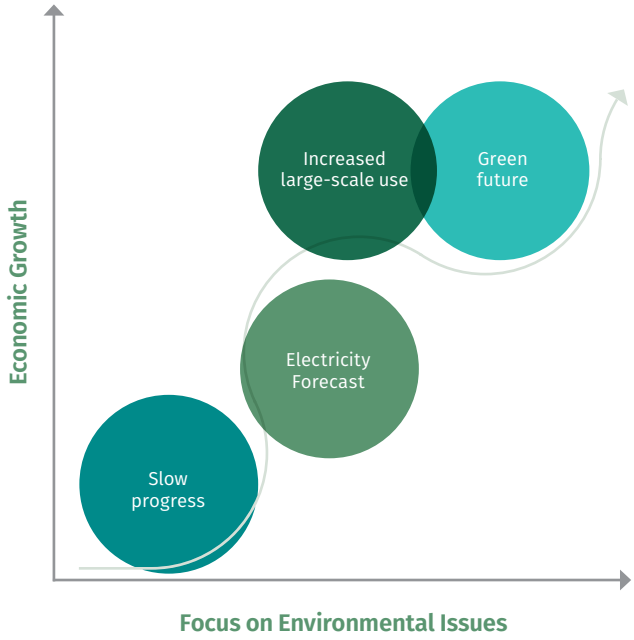


Figure 9. From the Energy Forecast *Source: Orkustofnun (National Energy Authority).*

Base Scenario of the 2021 Electricity Forecast

2020: Energy consumption was a total of 19,127 GWh and power requirements 2,408 MW

2025: Estimated use 21,371 GWh and power requirements 2,696 MW

2030: Estimated use 21,903 GWh and power requirements 2,783 MW

2040: Estimated use 22,824 GWh and power requirements 2,930 MW

2050: Estimated use 23,677 GWh and power requirements 3,063 MW

Ority electricity forecast – additional energy consumption in the general market

In the latest version of the NEA's electricity forecast, the additional electricity demand of the general market (households and companies other than energy-intensive consum of electricity) are assessed thusly compared to 2021:

374 GWh by 2025	**844 GWh by 2030**
1,717 GWh by 2040	**2,519 GWh by 2050**

The ority forecast does not take into account Iceland's climate goals and does not take or insignificantly takes into account the electricity that will be needed to produce E-fuel for hydrogen engines in vehicles and machinery, in fishing vessels and for international flights.

The "Green Future" Scenario

The revised electricity forecast 2021 states: The Green Future scenario assumes more economic growth than the electricity forecast. The criteria are changed in such a way that the main goals of the government when it comes to climate issues are achieved. These include an action plan on energy transition, an action plan on climate change until 2030, a legislative bill on carbon neutrality in 2040 and an Energy Policy for Iceland until 2050. The most important goal is for Iceland to become independent of fossil fuels by 2050. Energy transition takes place much faster in the Green Future scenario than in the electricity forecast, and the annual growth in general electricity consumption in this scenario is around 2.4%. General consumption will increase by 160% and will be around 8,900 GWh in 2060. According to this scenario, the additional energy demand of the general market (households and companies other than energy-intensive consum of electricity) are estimated thusly compared to 2021:

- 534 GWh by 2025
- 1,355 GWh by 2030
- 2,688 GWh by 2040
- 3,980 GWh by 2050
- 8,900 Gwh by 2060

It must be addressed here that this scenario does not take or insignificantly takes into account the electricity that will be needed for the production of E-fuel for hydrogen engines in vehicles and machinery, in fishing vessels and for international flights. The scenario also assumes a relative contraction in high-energy industry and thus Iceland's export earnings. Nevertheless, the scenario assumes increased economic growth.

Other Scenarios

Energy transition in heavy vehicles and machinery on land and due to engines in ships and new aircrafts will require E-fuel. Its production requires significant electricity.

In 2021, the consulting company Roland Berger prepared a draft to a hydrogen and fuel roadmap for what was the Ministry of Industry and Innovation. The company's analysis takes into account the government's climate goals and proposes e.g. an estimate of how much electricity may be needed for the production of E-fuel for the aforementioned energy transition on land, sea and air. The company estimates that the electricity demand, which is in addition to other energy demand, could amount to:

- 1–2 TWh by 2030 (1,000–2,000 GWhs)
- 6–10 TWh by 2040 (1,000–2,000 GWhs)
- 13–24 TWh by 2050 (1,000–2,000 GWhs)

The largest increase amounts to just over the total production of electricity today, which is close to 20,000 GWh or 20 TWh – a power efficiency of about 2,500 MW. The company's analysis is marked by the government's previous goal, a fossil fuel independent Iceland by 2050, i.e. full energy transition. That goal was accelerated to 2040 in the current government agreement. Amended criteria from 2040 to 2050 call for an analysis of what the change will entail in terms of electricity acquisition and its timeline. Furthermore, in terms of decisions about the high-energy E-fuel industry or the import of E-fuel. As the state of energy issues stands now, as well as the technical status of electric fuels and machinery – given a full energy transition – the 2040 targets are unlikely to be achieved by 2050.

For example, a 9,000 GWh addition to the current electricity consumption until the year 2030 due to energy transition in Samorka's forecast and up to 23,000 GWh until 2040 (according to Roland Berger), i.e. the doubling of electricity production; it is clear that the steps are big. This applies even if much lower electricity consumption is forecast. An increase of around or over 2,500 MW over 18 years instead of 28

years shows that the new criteria of the government need further examination. To shed light on the difference, each year's energy increase would be 138 MW based on the strongest estimate of the energy demands of a full energy transition in 2040, but 89 MW/year compared to 2050. For comparison, the Sigalda plant is 150 MW.

Samorka – an Updated Scenario for New Climate Goals

Samorka has assessed energy demand until 2040 due to society's basic energy demand as well as domestic energy transition and energy transition in international transport based on the government's climate goals. Samorka's analysis is based on the electricity forecast 2021–2060 as well as analyses that Samorka has carried out on energy demands due to energy transition in accordance with the government's new goals for full energy transition by 2040. This is not a forecast, according to Samorka, but a calculation. In collaboration with Efla Engineering, looking at what lies ahead based on official forecasts and the government's targets. The accompanying figure presents society's total energy demand according to Samorka's analysis and the National Energy Authority's electricity forecast for society's basic energy demand. The reason why energy-intensive consum of electricity are included in society's basic energy demand is that they have supported a large part of Iceland's export earnings and are expected to continue to grow in export industries that use green energy.

Calculation of society's total energy demand in 2040 based on government targets

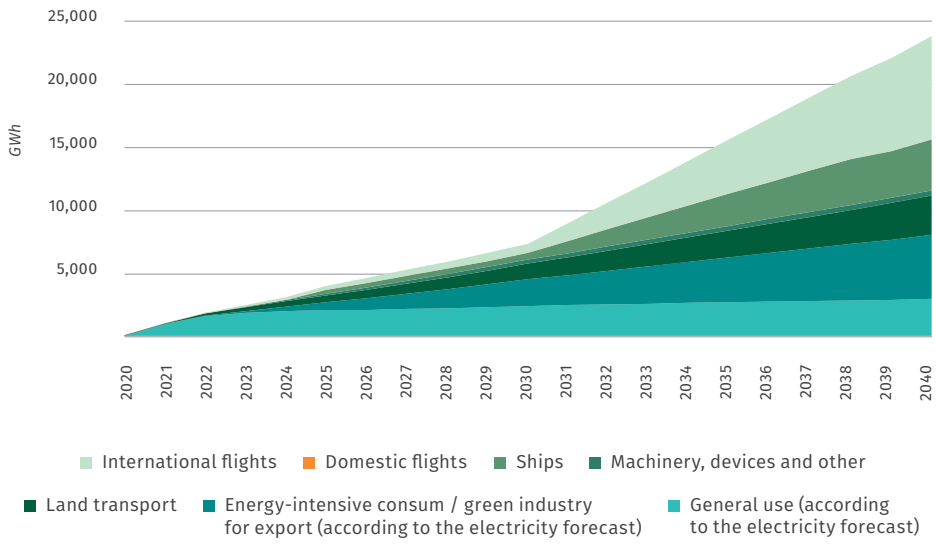


Figure 10. Samorka's Scenario. *Source: Samorka.*

- 7,255 GWh by 2030
- 15,557 GWh by 2035
- 23,694 GWh by 2040

Landvernd / Nature Conservation Association – Common Vision[15]

- Energy transition without a considerable increase in electricity production.
- Population growth based on Statistics Iceland's population forecast (central forecast) (like the National Energy Authority's electricity forecast).
- GDP per person will remain unchanged.
- The 4 biggest users to use 50% of waste energy to produce electricity or for the aluminium smelter in Straumsvik to close before 2035.
- The increase in commercial vehicles (and equipment) will be in line with population growth, but the frequency of travel in private cars will not increase.
- All private cars to run on electricity by 2035. Imports of cars with internal combustion engines to be banned in 2025 or 2030.
- Commercial vehicles will evolve into electric cars from 2025 to 2040.
- In the years 2025–2040, the fishing fleet will evolve to use direct hydrogen or electric fuel. Small boats on electricity.
- In the years 2025–2035, electricity will be used in domestic flights.

Landvernd and the Iceland Nature Conservation Association note that the Climate Council reiterates the following:

"... it has been reiterated that the criteria for the forecasts due to the energy transition will need to be updated and those must be in accordance with the government's goals. The Climate Council has e.g. repeatedly emphasised the following: "... Forecasts, i.e. fuel forecast, need to be updated regularly and Iceland's climate accounting needs to be updated faster. The Council considers it timely to present, in

[15] Based on joint responses by Landvernd and the Icelandic Nature Conservation Association to the committee's report in January 2022.

parallel with the energy forecast, a realistic plan for how the phasing out of fossil fuels will be achieved. Uncertainties regarding the assessment of expected results need to be explained."[16]

3.3.4 Power and Energy Balance

Landsnet regularly compiles a report for the purpose of assessing the expected balance between energy production capacity and energy consumption over the next five years, as well as calculating the loss of load (LOLP) probability. The report was published in 2019 and launched a great discussion about the state of energy issues in Iceland, possible energy shortfall and who is responsible for the energy security of household in the country. A new report was issued in January 2022.

A report on power and energy balance was published in 2022 and was valid for the period 2022-2026. The 2019 report that the loss of load probability (LOLP) would increase over the forecast period. In 2022 LOLP would be over two hours and thus exceed the acceptable threshold. The probability would be even higher in 2023, or over 5 hours per year, more than five times higher than Landsnet's benchmark. The results of repeated calculations with new criteria published in the report from 2022, on the other hand, assume that the loss of load probability is below Landsnet's benchmark this year but will exceed the benchmark next year, 2023. In 2024, it will fall slightly below the benchmark, but after that, the probability will grow rapidly above the benchmark by one hour a year and end at about three hours a year at the end of the 2026 forecast period.

The loss of load probability is the interplay between the power demand of electricity users, installed power in power plants and the failure of production units or other equipment in a power station. The power demand varies within the year and is to some extent unpredictable. Landsnet has had the guideline that loss of load in the electricity system should be less than one hour a year. This corresponds to the loss of load probability being less than approx. 1 in 10,000.

When looking at the loss of load probability during the period, the results are as follows:

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[16] https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Loftslagsr%c3%a1%c3%b0%20-%20R%c3%bdni%20%c3%a1%20a%c3%b0ger%c3%b0a%c3%a1%c3%a6tlun%20%c3%ad%20loftslagsm%c3%a1lum%202020.pdf

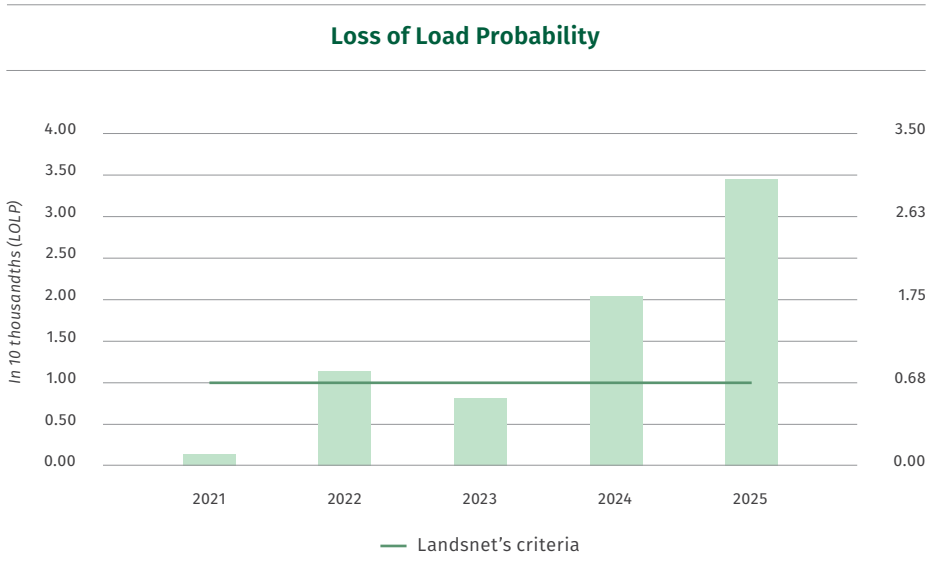


Figure 11. Loss of Load Probability (LOLP). *Source: Landsnet.*

As the figure shows, the probability is relatively low in 2022 but will increase sharply in 2023; by 2024, it is estimated that there will be a 30 MW expansion in operations at Reykjanesvirkjun, and therefore the probability falls back below Landsnet's benchmark. The loss of load probability increases greatly when withdrawals from the transmission system approach the installed power, as shown in Figure 11, and then not much can go wrong that would cause customers to experience loss of load or that reserve power has to be run to meet demand. If the loss of load probability is to be kept below Landsnet's benchmark, more production units will have to be put into operation during the period than is assumed here, or the load curtailed.

3.3.5 Curtailable Load 2021 and 2022

Shortly before the writing of this report, Landsvirkjun announced foreseeable electricity curtailment for energy-intensive consumers with curtailable electricity contracts, applicable to metal works, data centres, district heating utilities and fishmeal factories. Curtailment of electricity from January or February to April 2022, amounts to e.g. 2.5% for major industry and 100% for district heating utilities and fishmeal factories, a total of about 160 MW (3% of Landsvirkjun's electricity production). Curtailable load is up to 250 GWh for energy-intensive users and district heating utilities in addition to 200 GWh reduced for fishmeal factories. In total, upwards of 450 GWh. It is considered very likely that similar curtailments

may occur in the coming years. There has been no curtailment in electricity for the past six years.

Three main reasons are given. Landsvirkjun mentions curtailed water reserves in the reservoirs of the main hydropower plants, especially Þorisvatn, and that electricity utilisation is now approaching the installed capacity of power plants, which makes it difficult to smooth out fluctuations in electricity production. Landsnet agrees with the latter and also mentions that the Regional Transmission Line between the northeastern part of the country and the power plant cluster in the South does not meet the growing need for transmission. It should also be noted that with the enactment of the Electricity Act, Landsvirkjun's obligation to ensure the supply of electricity to the public was abolished.

Finally, it should be noted that restrictions on the transmission system mean that it is not possible to transfer sufficient electricity between regions when the water budget varies from region to region. The European Union's benchmark is to have a 15% transfer capacity of installed capacity between countries. In Iceland, the transmission capacity between regions is less than 5%.

Curtailable load in Landsvirkjun's agreements was as follows:

Landsvirkjun's electricity sales of curtailed load in GWh

Contract types	Industry	2017	2018	2019	2020	2021	Total	Percentage of total sales to industry
Curtailable load in long-term contracts	Aluminum smelters	901	850	466	462	398	3,077	3.2%
	Silicon smelters and other	73	86	36	56	93	344	4.1%
Other curtailable load	Smelting and fish drying plants	195	239	150	180	178	942	100%
	District heating utilities	219	240	174	170	149	952	100%
	Total	**1,388**	**1,415**	**826**	**868**	**818**	**5,315**	

Table 6. Curtailable load 2017–2021. *Source: Landsvirkjun.*

The table below gives an overview of electricity that has been sold as curtailable load over the past five years. The information is based on data obtained from

energy companies. Figures on energy sales of district heating utilities and fishmeal factories appear both at Landsvirkjun as a wholesaler of electricity and at other energy companies as a seller of electricity. All figures are in GWh.[17]

Table 7. Sales of curtailable load by energy company. *Source: Parliament.*

	2017	2018	2019	2020	2021	Total
Landsvirkjun						
Aluminium smelters	901	850	466	462	398	**3,077**
Silicon smelters and other	73	86	36	56	93	**344**
Smelting and fish drying plants (wholesale)	195	239	150	180	178	**942**
District heating utilities (wholesale)	219	240	174	170	149	**952**
Total	**1,388**	**1,415**	**826**	**868**	**818**	**5,315**
Orka Natturunnar						
Fishmeal factories	108	128	54	54	53	**397**
Aluminium industry	198	172	157	142	145	**814**
Liver melting	9	1.5	-	-	-	**10.5**
Chemical industry	25	25	29	29	31	**139**
Total	**340**	**326.5**	**240**	**225**	229	**1360.5**
Orkusalan						
Fish freezing	0.4	0.5	0.2	5	6	**12**
District heating utilities	43	45	46	47	19	**200**
Saltfish and stockfish processing	15	15	16	16	13	**75**
Schools	1	0.9	0.9	0.8	0.6	**4**
Swimming pools and sports centres	2	2	2	2	3	**11**
Total	**61.4**	**63.4**	**65.1**	**70.8**	**41.6**	**302**

[17] https://www.althingi.is/altext/152/s/0518.html

	2017	2018	2019	2020	2021	Total
Orkubu Vestfjarda						
District heating utilities	83	84	84	85	83	**419**
Swimming pools and sports centres	4	3	3	3	3	**16**
Total	**86**	**87**	**87**	**88**	**86**	**435**
HS Orka						
Fishmeal factories	80	80	16	12	22	**210**
District heating utilities	62	78	29	53	52	**274**
Aluminium smelters	63	63	66	66	62	**320**
Total	**205**	**221**	**111**	**131**	**136**	**804**
IOM/N1 rafmagn						
Fishmeal factories	0	10	78	75	67	**230**
Total	**0**	**10**	**78**	**75**	**67**	**230**
Total (excl. wholesale)	**1667.4**	**1643.9**	**1083.1**	**1107.8**	**1050.6**	**6551.5**

Electricity sales to data centres 2017–2021 amounted to 3,915 GWh.[18] According to the new electricity forecast of the NEA, the power demand of data centres in 2022 will be around 150 MW and the energy demand around 1,260 GWh. Short-term contracts cover about a quarter of energy sales to data centres.

Concession companies that have chosen to negotiate for curtailable electricity are RARIK, Orkubu Vestfjarda, HS Veitur and Hitaveita Fjardabyggdar. On average, this is a total of 15 GWh of curtailable electricity in February and March, 12 GWh in April and 10 GWh in May, for the years 2020, 2021 and 2022 (from Orkubu Vestfjarda).

3.3.6 The Response of Landsvirkjun and Landsnet 2022

In light of this situation, Landsvirkjun has presented a vision for possible additions to the company's electricity production based on the next five to eight years, and taking into account the three published scenarios on electricity demand. There, the lowest total number of additions is 480 MW, based on 2030, the median is 600 MW (full energy transition of transport) and the highest 1,200 MW based on full energy transition by 2040 (Mbl. 28.01.22).

Landsvirkjun proposes six power development options that its board could decide on in 2022 to start further work on (arrangement is without priority). The first two energy options are in the utilisation category of the approved phase of the Masterplan (for Nature Protection and Energy Utilization). The other four options are either dependent on the Parliament's approval of the third phase of the Masterplan or an amendment to the law that allows an increase in the generation of power of existing power plants over 10 MW outside the Masterplan:

- Hvammsvirkjun in Þjorsa (95 MW).
- Expansion of the geothermal power plant at Þeistareykir (at least 45 MW).
- Three hydropower plants in Blonduveita (total 30 MW).
- Wind farm west of Hofsjokull (Blondulundur 100 MW).
- Wind farm above Burfell (Burfellslundur 120 MW).
- Increase in the power generation of the Tungnaar power plants (100 MW).

For reference, it should be mentioned that the installed capacity of the power plants is a total of 495 MW, which is similar to the scenario of energy demand with the lowest power figure of 480 MW above.

[18] https://www.althingi.is/altext/152/s/0518.html

According to information from Landsvirkjun, long-term work is ongoing on 5–15 MW additions (top pressure power plants) at Þeistareykir, 50 MW Bjarnarflagsvirkjun by Lake Myvatn (in the utilisation category of the Masterplan (for Nature Protection and Energy Utilization)) and the expansion of the Krafla power plant (50–150 MW) which is in the utilisation category of the Masterplan. Finally, the Skrokkalda power plant and two power plants in Nedri-Þjorsa could be considered if they are in the approved utilisation category after the Parliament's approval of its third phase during the electoral term.

Landsnet's responses are set out in the report Power and Energy Balance 2022–2026 (Jan. 2022). It states that the calculated load lof loss probability is below Landsnet's 2022 benchmark, but will be above it in 2023. In 2024, the probability decreases slightly below the benchmark, but after that the probability grows rapidly above the benchmark until 2026.

In response to this situation, Landsnet considers it necessary to add power engines or power plants to electricity production, increase energy savings, improve the utilisation of existing power plants by developing the transmission system or systematically reduce electricity consumption in the system.

According to information from Landsnet, it is estimated that the aforementioned system development will take place by enlarging the area within the bottlenecks in the transmission system between Blondu lina 1 (Blanda Power Station) and Fljotsdalslina 2 (Fljotsdalur Power Station). These include Blanda Power Station, Krafla Power Station, Þeistareykir Power Station, Laxa Power Station and Fljotsdalur Power Station, as well as smaller power plants in the area. By connecting the Hryggstekkur transformer station in Skriddalur to 220 kV smelter lines, fishmeal factories and other general uses between Vopnafjordur and Faskrudsfjordur will fall within the area. The project is on schedule in 2025. The laying of an overhead line between Blanda and Holtavorduheidi (Hrutatunga) is planned for 2027 but will be accelerated. Northwest Iceland and the Westfjords will thus be added to this area. The utilisation of power plants within the area will increase and there will be less need for energy transmission out of it.

3.3.7 The State of Electric Heating Utilities

Electric heating utilities with alternative oil heating (E/O utilities) are managed by Orkubu Vestfjarda. The heating utilities are in Patreksfjordur, Flateyri, Sudureyri, Ísafjordur and Bolungarvik. In order to ensure their operation and stop oil heating when needed, there are two ways available: Utilising hydropower (20–30 MW) to have enough electricity and providing geothermal water where possible (from Orkubu Vestfjarda).

RARIK operates an E/O utility in Seydisfjordur. In Seydisfjordur, the E/O utility is coming to an end and if the result is direct electric heating, the local system will need to be repaired. At Hofn, geothermal water has been found and utilised for a large part of Hofn and Nes, and it is probably possible to obtain more water to complete heat implementation.

HS Orka operates both E/O utilities and district heating utilities, which use sea temperature with a heat pump, in the Westman Islands. As geothermal water is not available in the Islands, there are two ways available: To strengthen electricity transmission to the Westman Islands and increase the power of the heat pump system (from HS Orka).

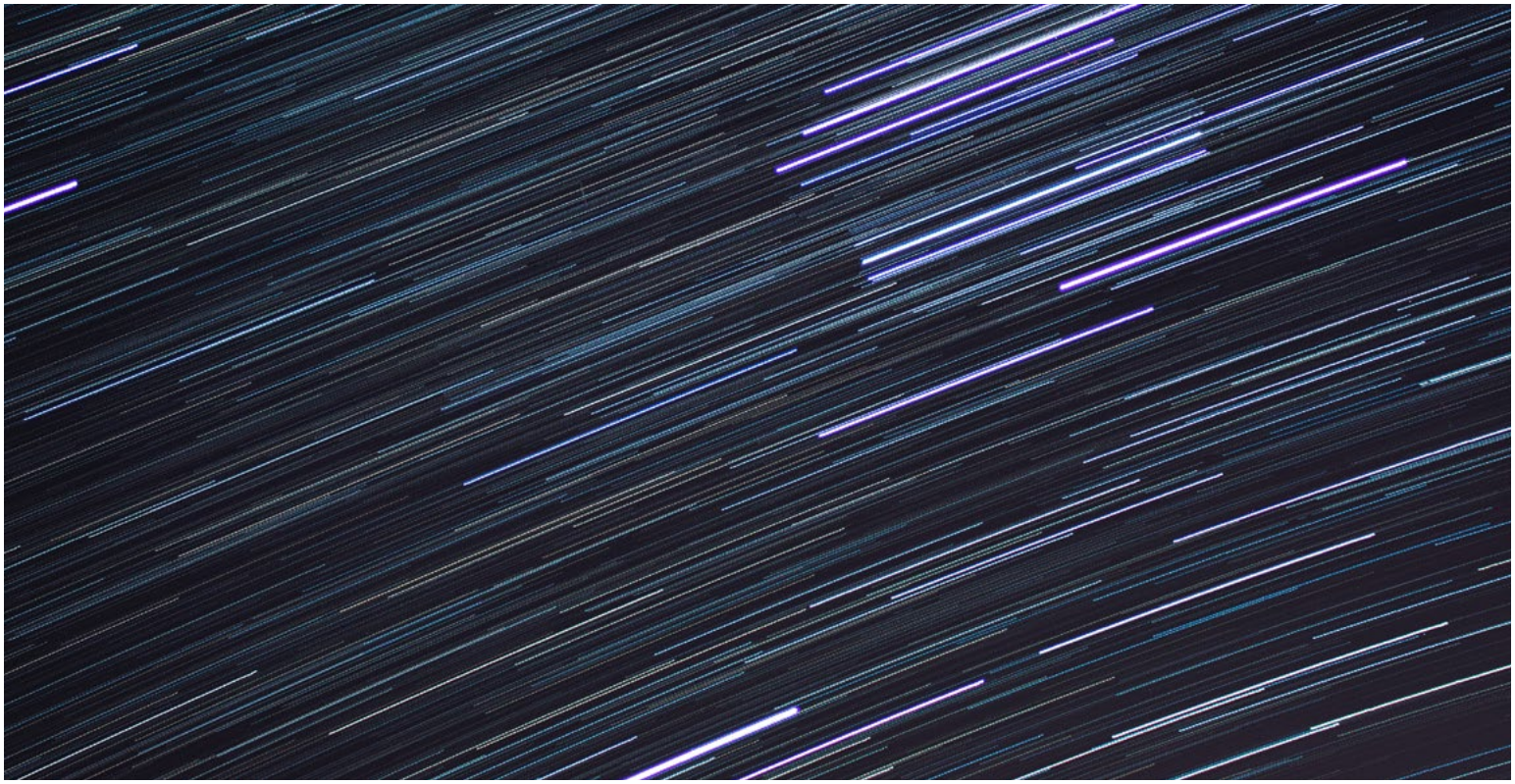
Knowledge of geothermal energy must be increased in low-temperature areas, in so-called cold areas, in high-temperature areas and in areas within the eruption zone that are not obvious high-temperature areas. This requires e.g. reviewing the organisation and funding of geothermal research as a whole and re-evaluating the supervisory role of the National Energy Authority and the role of ISOR as an independent researcher and independent reviewer (from ISOR).

3.3.8 The State of Geothermal Heat Utilities

It is clear that the demand for district heating water is increasing in line with increased economic activity and population growth. In low-temperature areas, new production areas will be sought, and in cold areas. Increased processing of already utilised areas will be explored and heat pumps will be relied on to an increasing extent. In high-temperature areas, new areas will be visited within already utilised high-temperature areas, and it will be ensured that the approved utilisation area in the Masterplan (for Nature Protection and Energy Utilization) will be used for both electricity and geothermal heat production, where possible due to the distance from settlements. If the utilisation of deep boreholes (cf. the IDDP project) the processing capacity of high-temperature areas can change greatly.

Demand for geothermal heat is expected to grow most in the southwestern part of the country. According to Orkuveita Reykjavikur's estimate, the thermal power demand of district heating utilities in the capital area could increase from 1050 MW (t) to 1520 MW (t) in 2040. Six other smaller district heating companies in the towns between Borgarnes and Hvolsvollur are not included as well as a few even smaller district heating utilities. It can be assumed that the energy capacity of most operating district heating utilities in other regions needs to be increased in a similar proportion based on population growth and increased economic activity.

In the capital area, Veitur expects some increase from the Hengill area (Hellisheidi and Nesjavellir power plant) and possibly with the construction of new heating



stations in Hengill. Geothermal exploration is also being carried out in possible low-temperature areas in the vicinity of the capital area, and finally the Krysuvik area is being considered as a key resource for meeting future demand for heat in the capital area as well as in the Southern Peninsula.

It has been discussed whether it should not be investigated to what extent electricity can be used to sharpen the temperature of borehole water in low-temperature areas. The importance of reserving geothermal areas near population centres for district heating utilities in plans and programmes has been pointed out. Sooner or later, it may turn out that geothermal energy does not meet the needs of district heating utilities in some places. Among the solutions, consideration has been given to using electric heating of outlet water in a dual heating system, e.g. by Nordurorka.

3.3.9 Public Electricity Security

With the Electricity Act, No. 65/2003, Landsvirkjun's obligation to provide users in the country with an adequate supply of electricity was abolished and the supply of electricity was to be determined by market laws instead. The current legislation thus does not prescribe the responsibility or obligation of any party to handle the open market, but it is clear that the demand for electricity in the open market has grown in recent years. In this connection, it may be pointed out that a working group on energy security in the wholesale market[19] for electricity pointed out the possibility of prescribing universal service in law in accordance with the EU Electricity Directive No. 2009/72, which states that households shall have the right to receive electricity of a certain quality. The Minister has instructed a working group to follow up on the proposals of the above-mentioned working group with proposals for changes to the regulations with the aim of ensuring the energy security of the public.

[19] https://www.stjornarradid.is/library/01--Frettatengt---myndir-og-skrar/ANR/ThKRG/Sk%C3%BDrsla%20starfsh%C3%B3ps%20um%20orku%C3%B6ryggi_LOKAEINTAK.pdf

3.4 Transmission System

The Energy Policy: **Infrastructure is sound and resilient**

3.4.1 Electricity Transmission System

The provisions of the Electricity Act on a Grid Development Plan that pertains to its structure and is presented to stakeholders, the general public, municipalities, etc., apply to the electricity transmission system. The Grid Development Plan is reviewed regularly by the National Energy Authority, which also seeks comments on it. The implementation of the Grid Development Plan involves thorough preparation, e.g. with the presentation of transmission options. The Grid Development Plan has a strong position in relation to the planning of municipalities, as they are intended to adapt their planning to the approved plan. Landsnet operates the transmission system. The numerical information that follows is processed from content from Landsnet.

Transmission restrictions in the system are defined on the basis of so-called formats, which are determined by two or more transmission lines that together form a bottleneck into or out of a specific area or region. The main purpose of defining the formats is to ensure that the power transmission through the format is not so great that a simple disturbance causes instability in the system or a system crash. Transmission within these so-called stability limits of the formats ensures that the system operation remains stable in the event of a simple interruption and that there is no need to reduce electricity to users. Transmission restrictions through formats are usually based on the transmission capacity of the line that has the least transmission capacity of the lines that the format intersects. These bottlenecks or formats affect how the installed capacity of the power plants can be fully utilised, and fluctuations in the water budget of reservoirs between years can affect the supply of electricity, as transmission formats can limit the possibility of transferring electricity between regions. For years, transmission restrictions and instability have been problems in the operation of the regional transmission line and reductions in energy supply have increased year by year and it is foreseeable that these reductions will continue to increase (From Power and Energy Balance 2022–2026. Efla for Landsnet, 2022).

Transmission loss is the electricity lost due to resistance in power lines and voltages in the transmission system. About 2% of the electricity received by the system does not reach users. This corresponds to about 400 GWh per year or all of Krafla Power Plant's production.

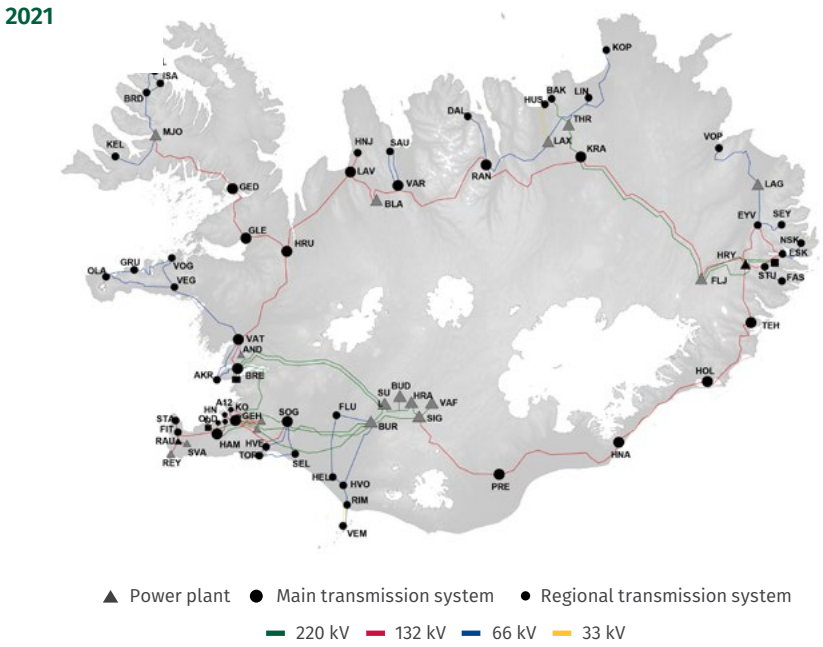


Figure 12. The Transmission System. *Source: Landsnet.*

3.4.2 Frequency, Voltage Quality and Transmission Security

Landsnet monitors frequency and voltage quality in the entire transmission system throughout the year in the company's energy management system where frequency values are recorded automatically every ten seconds. In 2020 and 2021, the average system frequency met the quality requirements of the current regulation. Monthly internal frequency targets were also met. In 2020, voltage quality was met at all sampling sites. Furthermore, Landsnet's goals of interrupted loads met the average length of curtailable load and the duration of serious individual disruptions according to the company's information.

3.4.3 Age of the Transmission System

The average age of substations/switchgear equipment at Landsnet is 24 years, while the average age of transmission lines (per km) is 44 years. However, the defined service life of a line is 50 years and 40 years for substations. After three years, more than 25% of the power line system will be over 50 years old. The regional transmission line that runs from Sigalda and around the country to Hvalfjordur (about 900 km) was built in the years 1972–1984 and the oldest part of it is 48 years old.

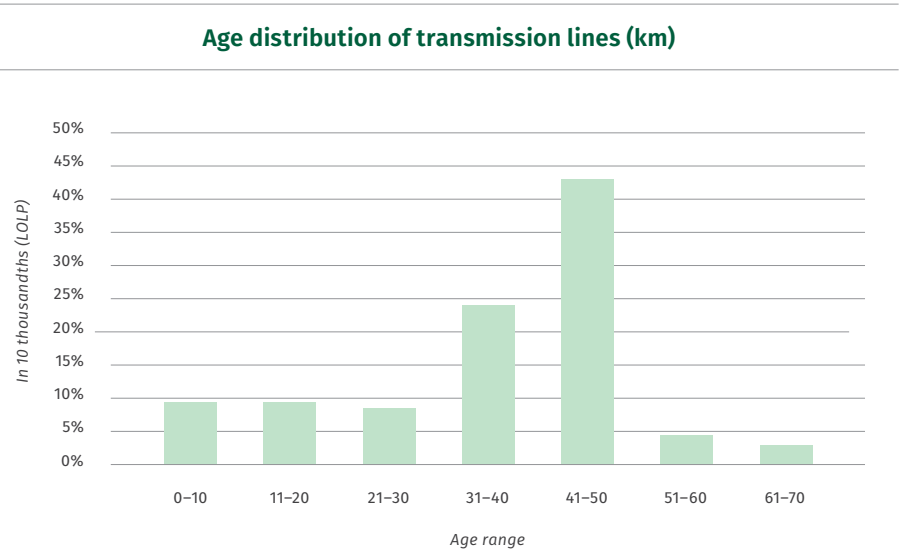


Figure 13. The Age Distribution of Transmission Lines. *Source: Landsnet.*

The age distribution of substations is more even than the age distribution of transmission lines as shown in the attached figure. About a quarter of substations have been built or renovated in the last 10 years. 17% of substations, on the other hand, have exceeded the defined service life.

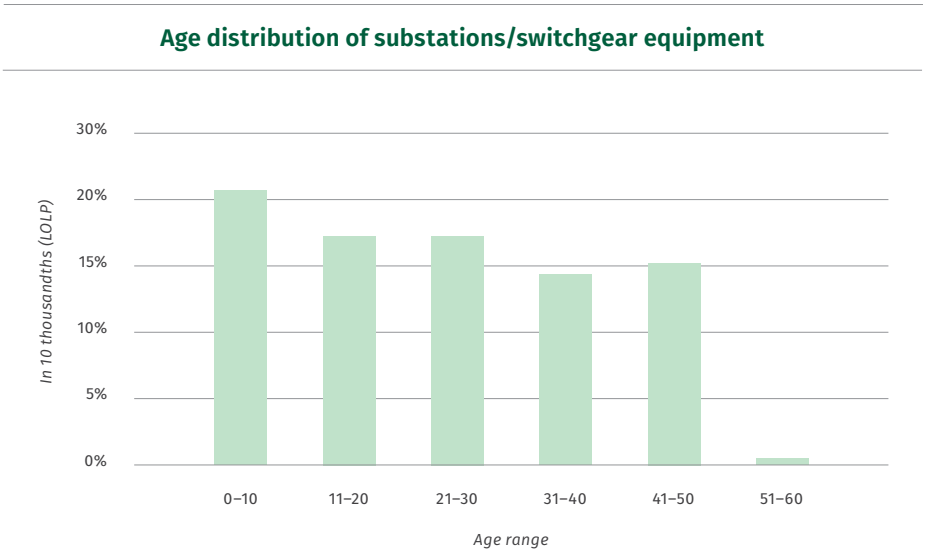


Figure 14. The Age Distribution of Substations. *Source: Landsnet.*

3.4.4 Infrastructure Development Over the Past 5 Years

Over the past five years, Landsnet has invested around ISK 40 billion, or ISK 8 billion a year. Of this, just over ISK 17 billion is due to investments in transmission structures. Landsnet's estimates assume that the company's investments in 2022 will amount to just over ISK 6 billion. Of this, ISK 1.3 billion in the regional systems and ISK 3.9 billion in the main transmission system. Portable backup power stations, a total of 12 MW, were purchased in 10 units. Five units are already in use and the others are expected to be operational in the first quarter of 2022.

A smart network is an electricity network that combines in a smart, equal, digital way the functions and capabilities of everyone who is connected to it so there is sustainable, economical and secure energy supply. Landsnet has already taken smart networks into its service in at least six places or areas.

Over the next five years, ISK 56 billion is expected to be invested in the implementation plan, of which 42 in the main transmission system. Of these, 13 projects will be completed during these years and two projects are on a long-term schedule. Almost ISK 10 billion goes to the regional transmission systems (at least 9 projects). Investments in other structures and improvements are expected to be in the range of ISK 600–800 million per year. For example, Landsnet has increased transmission capacity with the new Krafla Line 3 line, between Fljotsdalsvirkjun and Krafla

Power Plant, the construction of Holasandslina 3 between Holasandur (Krafla) and Akureyri is well advanced and the fully designed Blondulina 3, between Blonduvirkjun and Akureyri, is in the process of environmental assessment.

3.4.5 Strengthening of Transmission System Between Regions

Emphasis has long been placed on improving the interconnection of the country's main power development areas, i.e. power plants in Middle East Iceland (750 MW), Northeast Iceland and at Blanda (400 MW), in the Hengill area and Southern Peninsula (450 MW) and finally in the river basin areas of Tungnaa, Koldukvislar and Þjorsa (1200 MW, see map).

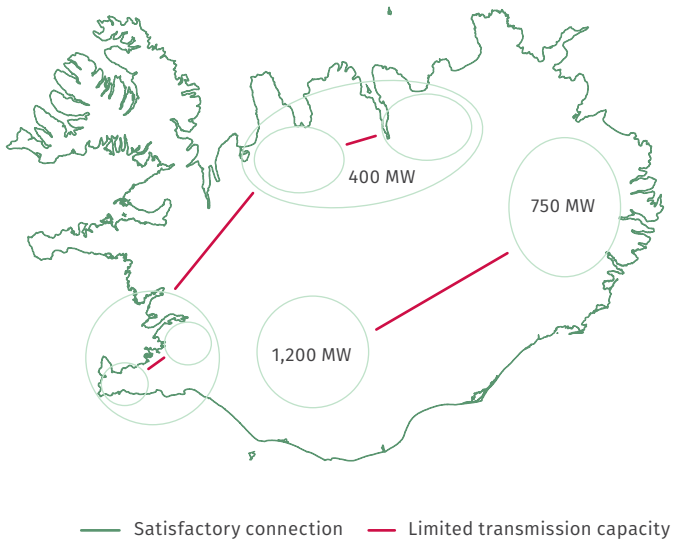


Figure 15. The Transmission Capacity Between Regions. *Source: Landsnet.*

The government focuses on improving the connection of key areas and three areas are mentioned as priority areas: The Westfjords, Eyjafjordur area and Southern Peninsula. According to Landsnet, a strong connection has been established with the industrial area at Bakki by Husavik. Voltage has been increased in East Iceland's transmission system, which improves interconnections. An improved connection to the main transmission system is achieved with the connection of the East Iceland system to 220 kV lines at Hryggstekkur in Skriddalur, which is on the 2025 action plan. The Southern Peninsula's double connection is on the action

plan but has been delayed due to licensing issues. Improvements in North Iceland are twofold. The first connection, between Holasandur and the Eyjafjordur area, will be ready in the summer of 2022. Construction on the connection from there to the Blanda Power Plant is expected to begin in 2023. The strengthening of the main transmission system in the Westfjords is on the long-term plan of the Grid Development Plan. The option of strengthening takes into account the development of power plants within the Westfjords. A new connection to the eastern part of the transmission system in South Iceland is in the final stages of construction (via Laekjartun).

Improvements to the western part of the South Iceland system are currently being prepared and will be part of Landsnet's next action plan.

3.4.6 Double Connections (N-1)

It is important that users do not experience electricity disturbances even if the connection to the power plant at one end of the transmission line is lost. Energy then arrives uninterrupted from another direction, i.e. from the transmission system. Such a double connection (N-1) is active in many places, but not everywhere.[20]

According to Landsnet, double connections have been completed at the following locations: Saudarkrokur, Neskaupstadur, Þorlakshofn, Ólafsvik, Grundarfjordur, Bolungarvik.

The following double connections are in the action plan: The Southern Peninsula, Dalvik, Talknafjordur, Bildudalur, Rimakot. Double connections in the next 4 to 8 years: Mjolka, Snaefellsnes, Vestmannaeyjar, Faskrudsfjordur, Husavik, Breididalur (Ísafjordur and Bolungarvik).

Double connections after that will be implemented in the following places: Seydisfjordur, Vopnafjordur and Kopasker (no deadline must be completed before 2040 according to government policy).

It should be borne in mind, however, that all areas rely on a strong main transmission system, a regional transmission line, and it is therefore necessary to consider strengthening it first.

3.4.7 Landsnet Emergency Committee

Landsnet operates an active Emergency Committee that meets in the event of a serious disaster or when there is a risk of a disaster in the electricity system.

[20] N-1 is a kind of criteria or objective in the operation of the system, so that the system should withstand interference even if they cause the line to fail, they do not cause a system breakdown or reduction. Within 15 minutes, the system should be able to withstand other interference, even though this line is not necessarily operational. By announcing N-1 in this way, it sounds like it only applies to dual connections, but transmission networks are very non-linear systems, which means that interference in one place can cause failure in a completely different place. Therefore, N-1 is relevant in this context but also in a broader context.

The Emergency Committee consists of Landsnet's senior management as well as key employees in the operation of the electricity system. The Emergency Committee is in constant communication about everything related to security and operational security in a common electronic project area. In addition, the Emergency Committee regularly meets formally and, if necessary, both for training and for discussions and planning on operational safety issues. The Emergency Committee sets the standards that the company takes into account to prevent accidents and mishaps and to reduce the consequences of incidents. In addition, two training exercises are held by the Emergency Committee each year, varying in size and more often than not the members of the Emergency Co-operation of the Electricity System NSR, are invited to participate. Landsnet's Emergency Committee and the Emergency Committees of other electricity companies are to respond to more serious disasters in the electricity system and strengthen communication and co-operation between responders in the electricity sector. The priority of the Emergency Committee is to prevent loss of life, property damage to structures and the environment and a reduction in energy supply.

3.4.8 Emergency Co-operation of the Electricity System (NSR)[21]

Electricity is a natural and important part of modern society. Neither households, businesses nor society can be without electricity. In the event of a serious shortage of electricity or power outages to users for hours or days, there is a great danger ahead. Society can be paralysed and the impact on the national economy can be significant. It is therefore necessary to clearly define the entire response process as well as to ensure the continuous operation of the electricity system, both for the producers of electricity and for those who transport or distribute it, as well as for energy intensive electricity consum. If such a definition is available, it is easier to respond to serious crises.

3.4.9 Cybersecurity

Delivery security and management security depend on secure digital systems for both power plants and the transmission and distribution system. Landvirkjun and Landsnet own and operate their own telecommunications company, Orkufjarskipti hf. which was established in December 2011. The company operates a powerful telecommunications system that is intended to meet the electricity system's requirements for a stable and reliable telecommunications network. This is a fiber-optic network that maintains communication routes to the power stations and substations of the electricity system (information from Landsvirkjun).

[21] Emergency Co-operation of the Electricity System: "A co-operation forum for processing plants, transmission companies, distribution utilities, energy-intensive users and public entities in Iceland due to a disaster that threatens the production, transmission or distribution of electricity and/or energy-intensive users." Definition from the Electricity Act No. 65/2003.

Landsnet has implemented a management system for information security and it is certified according to ISO/IEC 27001:2013. It includes documented operational procedures, technical cybersecurity safeguards of various kinds, and awareness training for staff. Regular security tests of information systems are carried out by external parties. Efforts are being made to examine and assess the risks involved in the operation of digital substations, as well as to implement appropriate mitigation measures (information from Landsnet).

With the Security, Networks and Information Systems of Important Infrastructure Act, No. 78/2019, different administrative institutions were entrusted with the supervisory role of the security organisation of network and information systems of important infrastructure, each in its own field. It will be in the hands of The Electronic Communications Office of Iceland, the National Energy Authority, the Financial Supervisory Authority, the Directorate of Health, the Environment Agency and the Icelandic Transport Authority. Their role will be to ensure compliance with the provisions on minimum requirements for risk management and preparedness and the obligation to report incidents.

3.4.10 Development of Infrastructure

In December 2019, the government agreed to appoint a working group of five ministries tasked with evaluating measures to strengthen the infrastructure in the transmission and distribution network of electricity and telecommunications, transport, regional affairs and the RÚV distribution network to ensure that such basic infrastructure is as well equipped as possible to handle storms or other natural disasters. An action plan was approved by the government at the end of February 2020. It contains 287 measures for infrastructure development.

Work on over 60% of short-term measures was fully completed by the end of 2021. Work also began on 95% of long-term measures. It is well underway on 30% of measures. Repairs to the electricity system in North Iceland by speeding up the installation of underground cables were completed with ten operations. Work on more than 100 measures has been delayed, i.a. due to the pandemic. The measures include, i.a. improving backup power, increasing the reliability of electricity and telecommunications systems, defining the role and staffing of companies and institutions, coordinating infrastructure planning, strengthening the civil protection system, education and information dissemination to the public and strengthening research and monitoring of natural disasters.

3.5 Distribution Network

Energy Policy: **Infrastructure for electricity and district heating utilities needs to be developed and grow in line with the needs of society**

3.5.1 The Distribution Network

The electricity distribution network is connected to the transmission network through distribution system operators and the vast majority of it is operated at a lower voltage than the transmission network. Through overhead lines and underground cables, electricity is distributed to sales companies that serve the public, institutions and businesses other than energy-intensive consum.

3.5.2 Distribution System Operatos (DSOs)

DSO's have exclusive license for the distribution of electricity in a defined area.

Their role is to manage the distribution of electricity and system management in their DSOs area. DSOs utilities are subject to the supervision of the NEA. Five DSOs operate in Iceland.

HS Veitur distributes electricity on the Reykjanes peninsula, in Hafnarfjordur, in Álftanes and the southern part of Gardabaer, in Árborg and in the Westman Islands.

Nordurorka distributes electricity in Akureyri.

Orkubu Vestfjarda distributes electricity in the Westfjords.

Veitur distributes electricity in Reykjavik, Seltjarnarnes, Kopavogur, Gardabaer to the north, Mosfellsbaer, Kjalarnes and Akranes.

RARIK distributes electricity throughout the country, with the exception of the Westfjords, the southwestern corner, parts of Árborg, the Westman Islands and Akureyri.

The main tasks in the national distribution network are its continued underground cable installation and three-phasing, safer power supply and improvements to substations and conveying stations. Not all regions of the country can be covered at this time, but examples are taken from the work of RARIK and Orkubu Vestfjarda.

3.5.3 Underground Cable Installation, Three-phase Distribution and RARIK Smart Metre Installation

Renewal with underground cables with RARIK has been ongoing since 1995. In the last five years, RARIK has, according to the company's information, laid 1,766 km of 11–33 kV cables in the ground instead of the older lines. At the same time, 1082 km of overhead lines have been taken down. Regular renewal of switchgear equipment has taken place and work is underway to move the outdoor switchgear equipment of conveying stations to houses and transformers are being expanded. RARIK aims to ensure that all farms in the RARIK energy supply area have access to three-phase electricity within eight years, and that by 2035 all RARIK customers will have such access. Two initiatives are currently being carried out by the government with the payment of an accelerated contribution: The acceleration of the three-phase implementation in Myrar, which will end next year, and the acceleration of the three-phase implementation to larger consum who operate farms before the end of 2025. RARIK currently operates the largest electricity distribution network in Iceland as well as operating heating and district heating utilities in five locations in the country. The distribution network is constantly being renewed and over the next 5 years, energy meters in RARIK's distribution network throughout the country, both electricity meters and heat energy meters, will be replaced by smart meters. 84% of thermometers and 22% of electricity meters have already been replaced by smart meters.

3.5.4 The Distribution Network Operated by Orkubu Vestfjarda (OV)

OV's largest project according to the company's information was a collaboration on the circular connection of fiber optics in the Westfjords and the renewal of distribution lines as three-phase lines with a continuous project from Hrutafjardarbotn and into Ísafjardardjup. The length of the underground cable that is plowed and dug annually is determined by other projects in the distribution network, but has been in the range of 30–50 km per year in recent years. About 300 km await renewal and three-phasing, and it is expected to take up to ten years of work. In recent years, emphasis has been placed on the renovation of substations and also Landsnet's conveying stations, where the superstructure of the stations is a priority.

The available reserve power in the OV distribution area is just over 18 MW, of which 11 MW is in Landsnet's reserve power station in Bolungarvik, which is sufficient for priority electricity consum in most of the distribution area. The smart network automatically starts reserve power at the reserve power station in Bolungarvik, which is sufficient for the northern Westfjords, but it is assumed that Mjolkarvirkjun will be run in island operations and maintain power in the southern Westfjords. In recent years, OV has emphasised the renewal of reserve power in Patreksfjordur with a new 2 MW reserve power engine. 1.5 MW reserve power in Sudavik has been

renewed with automatic start-up. 1.2 MW of reserve power was added in Flateyri, which can be started automatically. Work continues on improvements in reserve power development in the Westfjords and with the most powerful distribution network connected in a secure way to an improved transmission network. Smart meter implementation has already begun, as well as adaptation to energy transition. All OV sales meters are smart meters.

3.6 Matters of Opinion and Decision-making Issues

Energy policy is in place. "Society's Energy Demand" is a broad concept that can be understood in several ways. The energy market should be open according to the Energy Policy and then presumably for new supply and new demand. It is necessary to create a common vision of what this means for decision-making regarding energy development.

A new proposal for a parliamentary resolution on the development of the electricity transmission system must be submitted in 2022. It needs to address a number of requests for increased transmission capacity, interconnection and better controls.

The status of wind farms must be set out in the Masterplan (for Nature Protection and Energy Utilization). The issue concerns, among other things, that the environmental impact of wind farms is of a different nature than that of hydropower and geothermal power plants. Also whether or how they are subject to the overall organisation of energy production and land use and thus the role of municipalities in the construction of wind farms. Should a Masterplan as such act as a control instrument in the overall structure of energy production in Iceland, which is primarily about where society wants to head in economic and employment matters, as well as environmental issues? In Article 1 of the Act on Conservation and Energy Utilisation Plan, No. 48/2011, it is assumed that each power development option is assessed on the basis of conservation value, efficiency, profitability and other values, different interests and sustainability.

District heating utilities and the development of utilisation of geothermal heat have not received as much attention as the production of electricity. Attention is drawn to the fact that it is not yet clear how the need for geothermal heat will be met in the foreseeable future. It is important to clarify the picture regarding the development of district heating utilities. It is also necessary to take a position on proposals for increased general research on geothermal energy in Iceland by ÍSOR.

Energy efficiency and energy saving play a role in a successful energy transition. Consideration needs to be given to allowing companies' authorisations to utilise resource flows, e.g. waste heat, for the production of electricity that can be sold into the electricity market or utilised in other ways, e.g. due to district heating.

The short-term market for electricity increases energy security and is high on the agenda of other European countries when it comes to energy policy and energy security. The short-term market plays a dual role in energy security: 1) Provides short-term security regarding balance in production and use. 2) Provides transparent price formation, as rising energy prices give clear indications of investment needs in the system. Such marketing activities in Iceland need to be examined.

The development of a new export business that uses significant energy is uncertain. Many projects are in preparation, e.g. in biotechnology, food production and the metal industry and have been part of the success of the education, research, innovation and employment policies that have been pursued in recent years. It is necessary that there is coherence between Industrial Policy and Energy Policy, and it must be assessed whether there is a natural context between them.

Different scenarios reflect different emphases in the development of society and the economy in the future. However, there are scenarios available based on achieving full energy transition in accordance with Iceland's climate goals. Based on the strictest assumptions, it is estimated that the current electricity production will need to be more than doubled, and new electricity generated on average 90–140 MW per year will be used annually for the next 18–28 years, depending on how fast the work is carried out.[22] The question remains whether various plans will be made for the development of new export activities that would significantly increase the demand for electricity. Furthermore, there have been grand plans put forward for electricity generation for the production of hydrogen and derivative products. It is necessary to make a decision in policy-making in these matters and send a clear message to the many parties who are each working in their field. Public Energy Policy cannot be based on an open market if it is effectively closed.

[22] It is important to keep in mind that power and energy are not the same. The energy production of hydropower plants and wind farms are completely different for the same installed capacity. Therefore, a larger increase in installed capacity would be needed if wind farms alone were to support increased electricity production due to energy transition than if hydropower plants were built instead.

The NEA has expressed its concern that there is no guarantee that an increased supply of electricity would be used in the energy transition.[23] The probability of this happening depends primarily on whether the supply of electricity can be increased in line with increased demand. The National Energy Authority has a role to play in this. The main issue is the question of whether the energy market is in fact open to sufficient supply or whether barriers to entry (formal or informal) call for a special dispensing system to decide who should receive electricity and who should not.

International co-operation on climate change suggests that one country does not solve the matter of achieving carbon neutrality by transferring its own tasks to other countries. This is apparent in e.g. the Climate Policy of our neighbours in Denmark, where one of their four main policies is that measures to reduce emissions should lead to a real reduction in domestic prices, but at the same time it must be ensured that Danish measures do not push emissions beyond the borders. There is reason to review whether the Icelandic government's actions on climate and energy issues do not meet this condition of a real domestic reduction and that emissions are not transferred to others.

The development of Landsnet's transmission network has become a step behind the transmission need. There are plans for improvements based on the current situation and the question is whether they should not be accelerated as much as possible. It is also important to assess whether Landsnet's transmission network plans can handle the energy transition in stages, and thus up to more than double the estimated electricity production over the next 18–28 years and even more electricity production if demand for additional energy transition is met.

The electricity distribution network has been under constant development, but nevertheless many projects are on the horizon and it would be necessary to assess whether implementation can be accelerated. Requests for increased transmission capacity and more secure interconnection as well as interaction with backup power in individual areas or locations need to be discussed. It must be ensured that the distribution companies have the investment capacity needed to carry out all normal tasks.

In the government agreement that took over in 2021, the goal of a fossil fuel-free Iceland was accelerated to 2040 from 2050. It is necessary to elaborate on the reasons for this acceleration and make it clear to all parties involved what it entails. If the goal is to be met, all electricity producers, public institutions and stakeholders involved in the licensing process must coordinate criteria and actions.

[23] The NEA has also pointed out the different negotiating positions of the general market and industry in this context.

4. Energy Transition

Energy Policy: **Energy Transition on Land, Sea and in Air**

4.1 Summary

- Iceland is in the unique position that almost no fossil fuels are used for electricity production and space heating. This means that a reduction must occur in road transport, fisheries and air transport. Thus, the country's energy transition options are fewer and narrower than in other countries, and energy transition in road transport needs to be rapid. Energy transition based on domestic energy sources are accompanied by increased energy security, less currency outflows and less harmful pollution.
- The target of a 10% share in energy transition in transport was achieved by 2020. Important milestones in land-based energy transition have been achieved through the addition of biofuels to conventional fossil fuels and the introduction of electric cars.
- Iceland is in second place globally after Norway in new registrations of electric and plug-in hybrid cars.
- Domestic production of electricity or biofuels is still small. Many parties are interested in the production of hydrogen and electric fuels but have not started production. Methanol production has stopped.
- Energy transition in ships and aircrafts is still barely noticeable. An approved parliamentary resolution proposal on energy transition in aviation is available.
- Through the Icelandic Energy Fund, the government has supported infrastructure development for electric cars and in the country's ports. There are plans to further support energy transition, e.g. in heavy transport, industry and E-fuel production.
- Iceland has a lower proportion blending mandate in fossil fuels than neighboring countries.
- E-fuels and hydrogen have not become competitive in price with fossil fuels.

- Manufacturers compete with other consum for electricity, e.g. various industries, data centres and more.
- The supply of vehicles for E-fuel and hydrogen, whether in heavy transport or aviation and ships, is still limited or in the development stage.
- About 80% of electric cars are charged in homes and workplaces.
- The 2021 government agreement set stricter climate goals. The Environment Agency believes that these goals will not be achieved based on current assumptions. Therefore, additional measures need to be considered, e.g. whether to accelerate the introduction of electric cars and, e.g. implement a domestic emission quota and trading system.
- It could also be borne in mind how funds through the international ETS system are spent in Iceland, e.g. in investing in climate-related projects.

4.2 Energy Transition on Land

Energy transition in land transport is well underway. The government's goal of a 10% share in energy transition on land, primarily through the introduction of electric cars, by the year 2020 was achieved and exceeded, cf. the graph.

Renewables in land transport

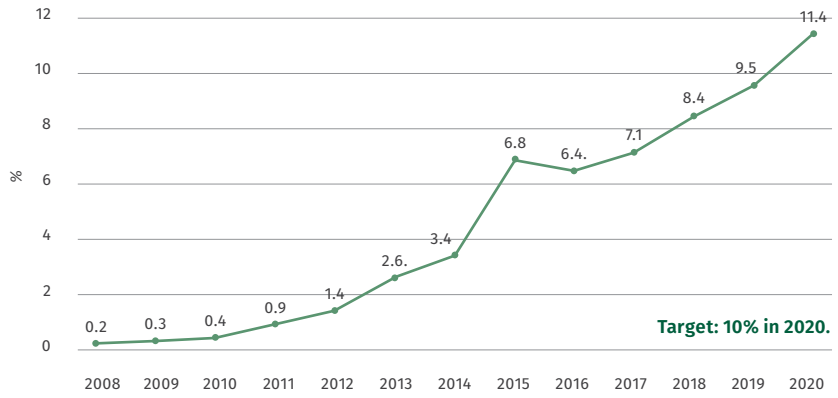


Figure 16. The Proportion of Energy from Renewable Sources.

Source: Orkustofnun (National Energy Authority).

For several years, Iceland has been in second place globally in terms of the speed of energy transition measured in new registrations of electric and plug-in hybrid cars (PHEV). The Nordic countries occupy the top three places, cf. figure below.

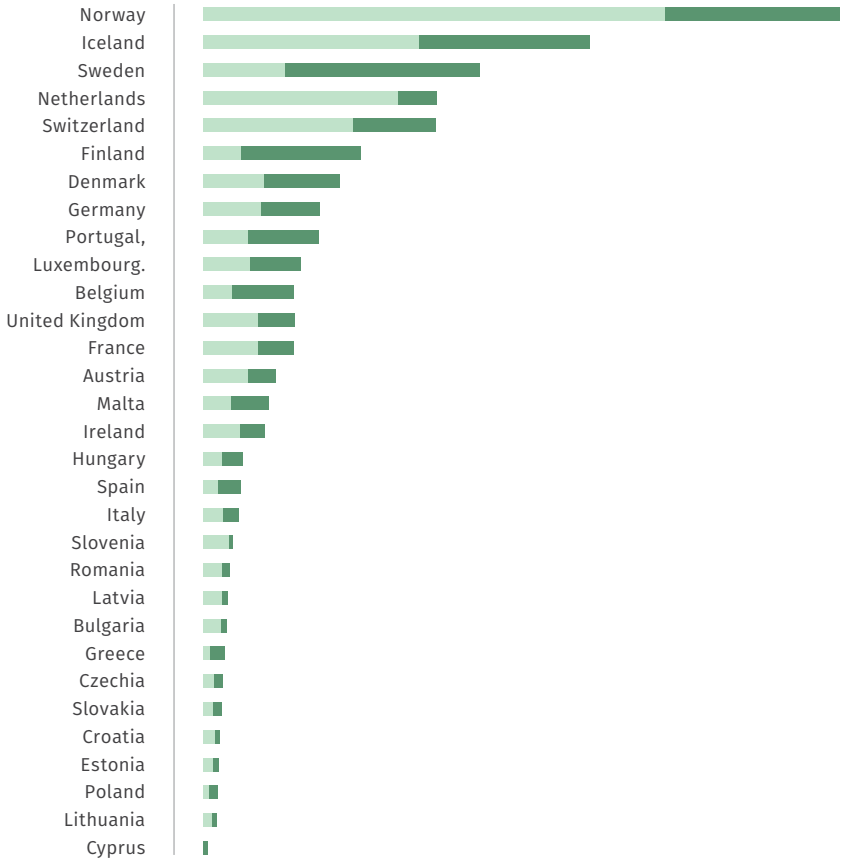
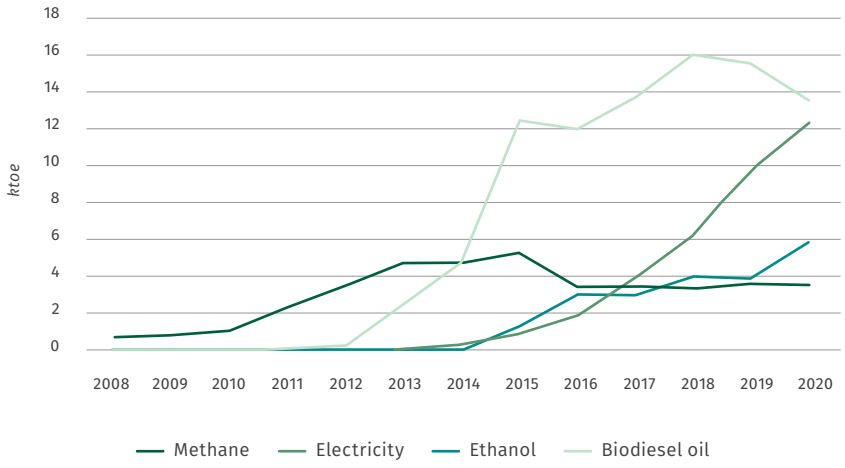


Figure 17. New Registrations of Electric and Plug-in Hybrid Vehicles (PHEV).[24]

Source: EAFO.

[24] https://www.eea.europa.eu/ims/new-registrations-of-electric-vehicles#:~:text=In%202020%2C%20the%20share%20of,and%20the%20Netherlands%20(28%25)

Growth of alternative fuels



Statistical Material from the National Energy Authority: OS-2021-T007-01

Figure 18. Trends in alternative fuel use by type. *Source: National Energy Authority.*

4.2.1 Government Actions

The introduction of concessions to facilitate the introduction of electric cars in the passenger car fleet has been crucial, most notably the abolition of VAT on environmentally friendly cars. In 2019, the period of validity of the VAT concessions according to Temporary Provision XXIV in the Value Added Tax Act for emission-free cars was extended until 31 December 2023. In addition, various other temporary measures were introduced to accelerate the energy transition, such as support for the purchase of bicycles, electric bicycles, eco-friendly motorcycles and light motorcycles, as well as coaches in public transport. Authorisation was also granted to reimburse the builders and owners of residential housing for VAT they have paid for work on the installation of charging stations in or near residential housing. Likewise, VAT on the purchase of home charging stations for electric cars is reimbursed. Exemption from VAT for renting environmentally friendly cars from car rentals and property or finance rental companies has been no less important because car rentals are the buyers of about 40% of newly registered cars each year.[25] In addition to the concessions set out in the action plan, there are now increased temporary concessions for car rentals to invest in environmentally friendly vehicles with the aim of accelerating energy transition. In the years 2021 and 2022, the emission (CO_2) of vehicles on which excise duty is calculated will be reduced by 30% before the imposition of excise duty in the case of vehicles intended for

[25] https://www.stjornarradid.is/library/01--Frettatengt---myndir-og-skrar/ANR/Orkustefna/LOK%20INE%202021%20Fl%c3%b6skuh%c3%a1lsar%20%c3%ad%20hle%c3%b0slukerfi%20landsins_Ni%c3%b0urst%c3%b6%c3%b0ur%20k%c3%b6nnunar%20%c3%a1%20me%c3%b0al%20rafb%c3%adlaeigenda.pdf

rental. However, the reduction can never amount to more than ISK 400,000 per vehicle. On the other hand, Ökutaekjaleigan undertakes to arrange its purchases so that environmentally friendly vehicles, which are covered by Temporary Provision XXIV in the Value Added Tax Act, will be 15% in 2021 and 25% in 2022 of total car purchases. It is worth mentioning that car rentals as well as other commercial companies were authorised during the period 1 January 2020 to 31 December 2023 to fully depreciate vehicles subject to registration in the year of purchase down to the scrap value of the property, provided that the vehicle is powered by methane, methanol, electricity or hydrogen and is wholly utilised in the taxable activities of a legal entity or self-employed person.

According to the Act on Renewable Fuels in Land Transport, No. 40/2013, a sales obligation is imposed for renewable fuels, incl. electricity. Fuel sellers must ensure that 5% of their fuel sales are from renewable sources. Sellers have met this by importing fuels with biofuel mixtures, but have not utilised methanol produced in Iceland. In neighbouring countries, this obligation has been increased and is e.g. 7.6% in Denmark, 20% in Finland, 10% in the UK and 17% in the Netherlands.[26]

Iceland is in the unique position that almost no fossil fuels are used for electricity production and space heating. There will therefore be a reduction in the use of fossil fuels in land transport, ocean-related activities and air transport. As a result, the country's energy transition options are fewer than in other countries. Energy transition in these sectors is more demanding as technological solutions and fuel supply are still evolving. Governments in neighbouring countries have focused less on energy transition elsewhere than on land. Actions under development at EU level target larger cargo ships but exclude the fishing fleets of the countries.[27] International requirements or harmonised actions are more suitable for sectors that are in international competition.

4.2.2 Transport

Transportation is classified as road transport, ferry/coastal transport, international shipping and domestic and international flights.

Of the 402 thousand vehicles that were in the country in 2021, about 27 thousand are electric or so-called plug-in hybrid cars (PHEV) (over 14.8%) and 25 hydrogen cars. The share of hydrogen cars and other E-fuel cars will also increase, especially large vehicles. According to figures from the Automotive Trades Association (25.12.2021), new registrations of passenger cars were these proportions of the whole: Electric cars 27.8% and PHEVs 26.0%.

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[26] https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Biofuel%20Mandates%20in%20the%20EU%20by%20Member%20State%20and%20United%20Kingdom%20-%202021_Berlin_European%20Union_06-06-2021.pdf

[27] https://ec.europa.eu/info/sites/default/files/fueleu_maritime_-_green_european_maritime_space.pdf

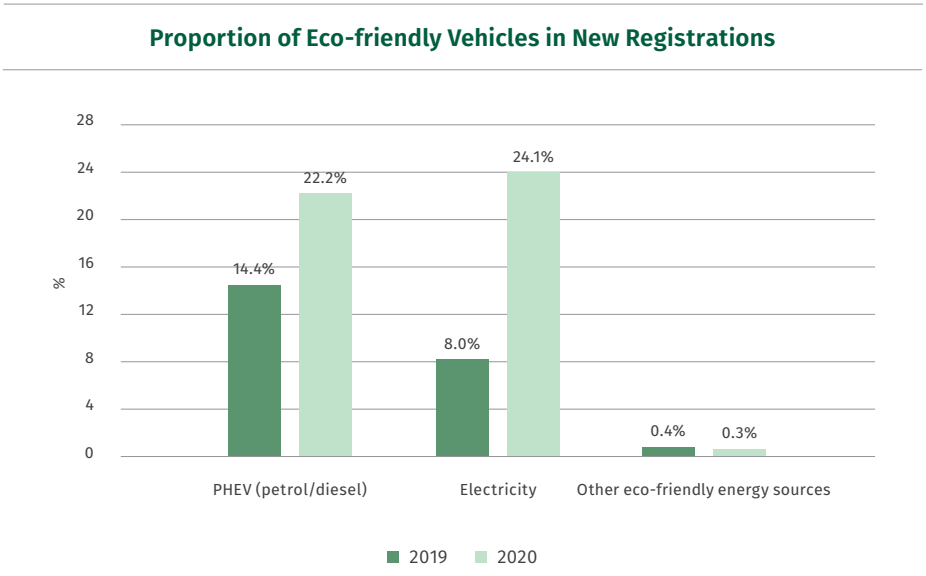

Figure 19. The Rate of Eco-friendly Vehicles in New Registrations. *Source: Samgongustofa.*

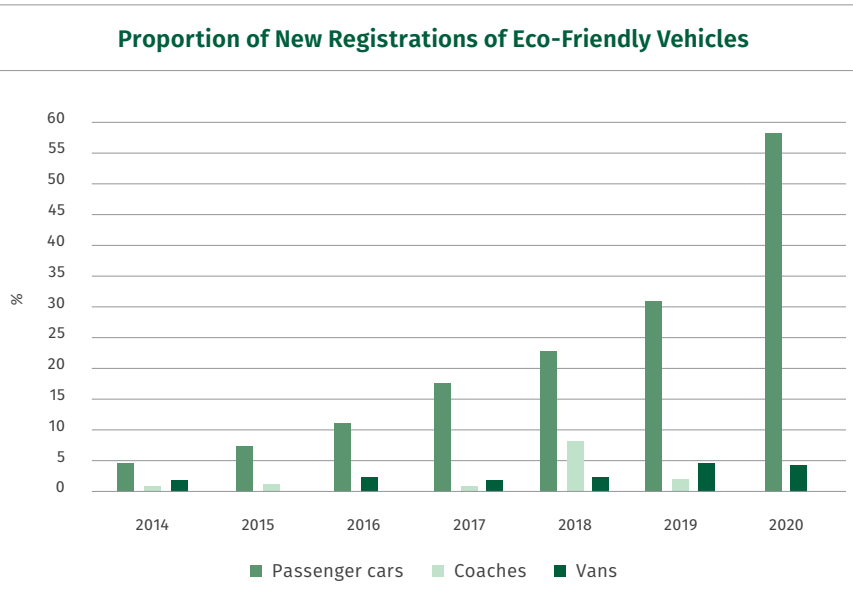

Figure 20. The Rate of New Registrations. *Source: Samgongustofa.*

Proportional distribution of energy sources in land transport

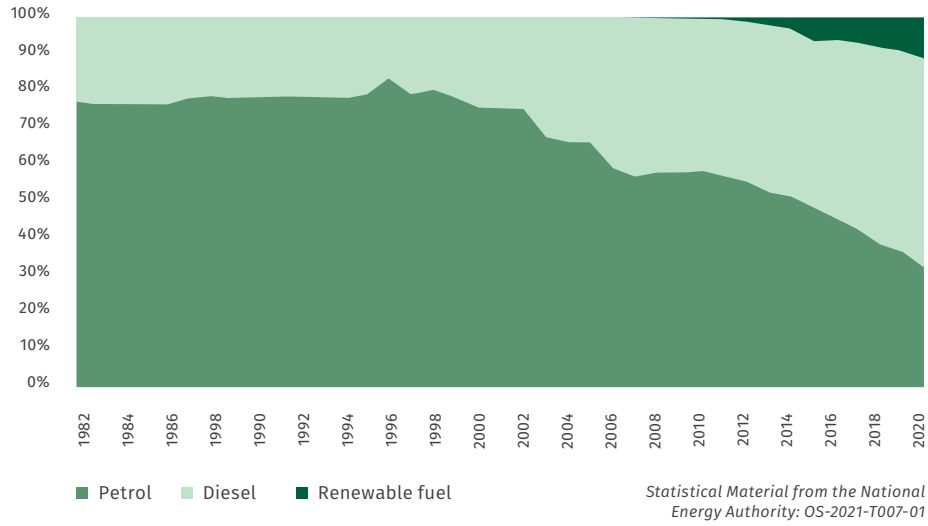

Figure 21. Proportional Distribution of Energy Sources. *Source: National Energy Authority.*

4.2.3 Agriculture

The majority of clean energy cars in agriculture are electric and PHEVs. Work equipment and large cars will potentially utilise hydrogen in the future, other electric or biodiesel, but such biofuels from rapeseed are already used domestically on agricultural machinery to a small extent. Farms are generally fully electrified. Energy transition is primarily related to all kinds of machinery and vehicles.

4.2.4 Tourism and Other Services

The main component of energy transition in tourism and most other service sectors is transport (see 3.1.1). Energy transition in service sectors takes place primarily there. Next in line is energy transition in recreation where internal combustion engines are now used.

4.2.5 Industry Outside the ETS system

Industry outside the ETS system: Companies already carry out energy transition in accordance with their industry policies. A big factor is transport and the use of machinery. The Energy Fund supported projects in connection with energy transition in industry with an allocation in 2021.

4.3 Domestic Fuel

Energy Policy: **Iceland unreliant on fossil fuels**

4.3.1 Electricity and E-fuel

Good results in energy transition in transport are primarily achieved with electric cars that run on electricity from batteries and with PHEVs that can be charged with electricity with an outlet. Of these cars, the vast majority are passenger cars and rather small commercial vehicles. Such direct use of electricity in energy transition falls under general use, as is currently the case with the general use of electricity and district heating by the public and companies. E-fuels and hydrogen are still used to a lesser extent in transport. Biofuels are used in transport as an additive with conventional fuels in the form of biodiesel and ethanol, but methane is also used in cars.

A proportion of passenger cars, larger cars, e.g. for the transport of goods, various vehicles, and machinery will be powered by E-fuels that require hydrogen in production. The use of E-fuel in vehicles is, in terms of technological development, less advanced than the use of batteries. A number of vehicle and machine manufacturers are working on the development of E-fuel engines in cars, from passenger cars to large passenger cars and commercial vehicles. Machinery for most ships and medium-sized and large passenger and cargo aircrafts will require a large amount of E-fuel.

Currently there are many matters of dispute about the price of E-fuels in comparison with fossil fuels, its efficiency and different types of fossil fuels, i.e. what is best suited as a power supply. It is unclear whether, and how much, of the fuel will be produced in Iceland and how much of it will be imported. The energy demand for this is evaluative and difficult to predict. Furthermore, it is not known how much fuel will be sold to ships and aircrafts calling at Iceland. Finally, it remains to be seen whether or not the E-fuel produced in Iceland will be exported for use abroad. It can be expected that, if E-fuel is produced here for a foreign market, the production will be for energy-intensive consum and not part of energy sales to general consum. Overall, however, it is clear that environmentally friendly, renewable electricity must be used to produce all E-fuels. No matter in which sector of transport or business the product is used, within the ETS system, within other related systems or outside the ETS system.

4.3.2 Hydrogen Produced at Filling Station

One hydrogen pumping station is in Reykjavik operated by Orkan by Vesturlandsvegur and another by Fitjar in Reykjanesbaer. The hydrogen is produced by Orka natturunnar at the Hellisheidi power plant and driven in a tanker to sales outlets. More hydrogen or electric filling stations will become part of the infrastructure as the number of electric vehicles increases.

4.3.3 Hydrogen Produced by Electrolysis in a Hydrogen Plant

In addition to ON's hydrogen production at the Hellisheidi power plant, two related projects have been in the pipeline. Landsvirkjun is examining hydrogen production at Ljosafossstod. The power requirement is 10 MW. Finnafjardarhofn's project envisages the production of hydrogen by electrolysis of water and possibly the production of more types of E-fuel. Ideas for hydrogen production also take into account activities by e.g. Þorlakshofn and in Husavik. There, Green Energy/Atome Energy intends to produce hydrogen and ammonia with a phased 30–100 MW power requirement.

4.3.4 Production of Biodiesel

Already, two companies produce biodiesel, as well as several farmers. The companies are Orkey (from waste cooking oil and animal fat) and Íslenska gamafelagid (from cooking oil). Sorpa and the company Ymir Technologies are working on a survey

and preparation for the production of biodiesel from slaughter and fish waste. In addition, there is a business plan for 5,000 tonnes of biodiesel production from 2017.[28] The base material is rapeseed and it is considered promising to utilise it much better and in more parts of the country.[29]

4.3.5 Production of Methanol

Carbon Recycling has operated methanol production in Svartsengi. Hydrogen is produced by electrolysis of water and reacted with carbon dioxide from volcanic gas that accompanies the energy production of HS Orka's geothermal power plant. The power requirement of the electrolysis is 6 MW. The annual production has been 4,000 tonnes and has been sold out of the country. CR works with Landsvirkjun, Elkem and Þrounarfelag Grundartanga to study the production of methanol in Jarnblendiverksmidjan with hydrogen from electrolysis and carbon dioxide from the production process. Projects for the production of E-fuel are listed in the table.

4.3.6 Production of Methane

Methane is produced in two places in the country. Sorpa's gas production plant produces 3 million Nm3 of methane annually. The methane is sufficient to supply 4–6,000 passenger cars or approximately 100 city buses. Nordurorka produces about 250 thousand Nm3 annually from the old landfill in Glerardalur, which powers about 8 city buses and a number of passenger cars. The production capacity of methane is about four times greater than that used by the country's methane-powered vehicles.

4.3.7 Overview of Several Companies in the Field of Hydrogen and E-fuel Production and Related Services

Vetnis

The company has focused on the energy transition of large vehicles from carbon fuel to green hydrogen. The company is also working on the development of infrastructure for the production and distribution of green hydrogen and the development of Iceland's first green transport fleet.

Qair Iceland

Qair Iceland is an independent producer of renewable energy with over 30 years of experience in the development, installation and operation of its own wind, solar, hydropower plants, as well as green hydrogen production. Qair operates in 16

[28] https://www.samgongustofa.is/media/siglingar/skyrslur/Lifdisill-vidskiptaaetlun-lokaeintak-2017-002-.pdf
[29] https://fiskifrettir.is/frettir/kanna-forsendur-lifdisils-fiskiskip/160826/
https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/Repjuol%C3%ADa_sk%C3%BDrsla_sept2021.pdf

countries and operates the subsidiary Qair Iceland. The company produces energy with hydropower through the subsidiary Arctic Hydro and aims to install about 900 MW of wind energy in the country.

Clara Artic Energy

The company was founded around the development of hydrogen and energy infrastructure solutions and has been active in consulting and business development in the fields of hydrogen storage, energy infrastructure, future energy markets and energy trading. The company's goal is to develop and invest in projects across the green hydrogen value chain.

Carbon Iceland

The company plans to reduce the amount of carbon dioxide in the atmosphere by several million tonnes per year. The company will purify the substance from the atmosphere in a special air purification plant and greenhouse gases from the pollution streams of large companies. It is planned to produce green carbon dioxide for food production and clean, green fuel for ships and other means of transport. The operations will be at Bakki by Husavik.

Green Fuel

The company Green Fuel plans to build an ammonia factory at Bakki in Husavik. Green Fuel is majority owned by Atome. The company aims for both export and serving the domestic market.

Atmonia

Atmonia's main goal is to significantly reduce greenhouse gas emissions with new technologies in the field of ammonia and nitrate production. Atmonia is an innovative company that is developing new technology for the production of ammonia from air, water and electricity without greenhouse gas emissions.

IdunnH2

IdunnH2 is an innovative company that works on the development of hydrogen production in Iceland. The company's goal is to produce competitive and environmentally certified green hydrogen with the aim of reducing greenhouse gas emissions both in Iceland and abroad.

4.4 Marine-Related Energy Transition

4.4.1 International Voyages

It is planned that the international vessels will mainly use E-fuel or biodiesel or biogas and the demand will increase gradually. Iceland's international voyages are dealt with at the International Maritime Organisation. Since 2018, however, large vessels moored in EU ports have been part of the ETS system in terms of emissions monitoring. As things stand today, there are no vessels on the Icelandic ship register that fall under the system.

4.4.2 Fishing Industry

Small fishing vessels: It is planned that coastal fishing boats and various fishing vessels on the mainland use electrical connections on land and are either electric boats and ships or plug-in hybrid vessels. There are still no such vessels in the country's fishing industry.

Medium and large fishing vessels: It is planned that such vessels use E-fuel or biodiesel of various kinds for fishing and processing on board. There are no such vessels in Iceland yet. See the discussion in DNV's report on energy transition of fishing vessels.[30]

Fish processing and landing: Various work equipment on land in the fisheries sector is powered by charging electricity, but the main factor in energy transition on land has been the implementation of electricity in fishmeal factories. All but two take advantage of it. In the 2016 VSÓ report for Landsnet, "Possible Energy Transition in Iceland", it is estimated that the total energy demand will be 62 GWh and the power demand 68 MW. It was actually 102 MW for factories in the east of the country in 2021.

4.4.3 Aquaculture

It has been decided that aquaculture barges in aquaculture will be electrified in Reydarfjordur and work is underway on the development of an electric wellboat at Blami, a collaborative project between Landsvirkjun, Orkubu Vestfjarda and Vestfjardastofa, in Bolungarvik. Such a development can be expected elsewhere in aquaculture areas in the sea and an increased electricity demand in the sector.

4.4.4 Electric Ships and Electric Boats

There is still very little energy transition in any kind of service sailing. Apart from Herjolfur IV and one of Nordursigling's boats (sailing ships that charge batteries under sails), there are no electric ships in operation.

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[30] https://samorka.is/wp-content/uploads/2021/12/Decarbonization-IMS_Final-Rev2.pdf

Among the reports that have been prepared are "The Energy Transition of Vessels" (Efla for the Ministry of the Environment and Natural Resources 2019) and DNV's report for Samorka, the Ministry of Environment, Energy and Climate, Faxafloa-hafnir and SFS. Samorka's disclosure of information now states that according to Samorka's estimate, the electricity demand for vessels could total 2,600 GWh in 2035 and up to 4,050 GWh in 2040, or the equivalent of close to 400 MW of power. The average increase in installed capacity per year could be 30–40 MW.

4.5 Energy Transition in Aviation

4.5.1 Electric and E-fuel Aircrafts

No energy transition has yet taken place in aviation in this country. The focus is mainly on electric aircrafts or aircrafts powered by E-fuels or a combination of renewable energy sources. An approved parliamentary resolution from 2021 on energy transition in aviation is available.[31]

It is planned that aircrafts in international flights run mainly on hydrogen, other E-fuels or a mix of renewable energy sources. No passenger aircrafts of this type are in use in Iceland. Icelandic airlines' flights between countries will be part of the CORSIA trading system, which is similar to the ETS system.

4.5.2 The Use of Electric Aircrafts

One single-engine, two-seater electric aircraft has been imported to Iceland. More such aircrafts can be expected for private and training flights. Icelandair Group has signed a letter of intent to explore the possibility of energy transition in domestic flights. On one hand, with Universal Hydrogen, which has designed energy transition equipment that could convert Dash-8s engines to hydrogen-powered engines. On the other, with Heart Aerospace, which is working on the development of electric passenger aircrafts. Play airline does not seem to have decided on the next steps in energy transition.

[31] https://www.althingi.is/thingstorf/thingmalalistar-eftir-thingum/ferill//?ltg=151&mnr=330

According to Samorka's assessment, the total energy requirement in aviation, mostly for international flights, could be around 4,316 GWh in 2035 and 8,196 GWh in 2040, or the equivalent of 1,040 MW in that case.

4.6 Infrastructure for Energy Transition

4.6.1 Development of Charging Stations

Public funding has also played an important role in energy transition, as it has provided funding for the development of infrastructure for electric cars through the Energy Fund since 2016.

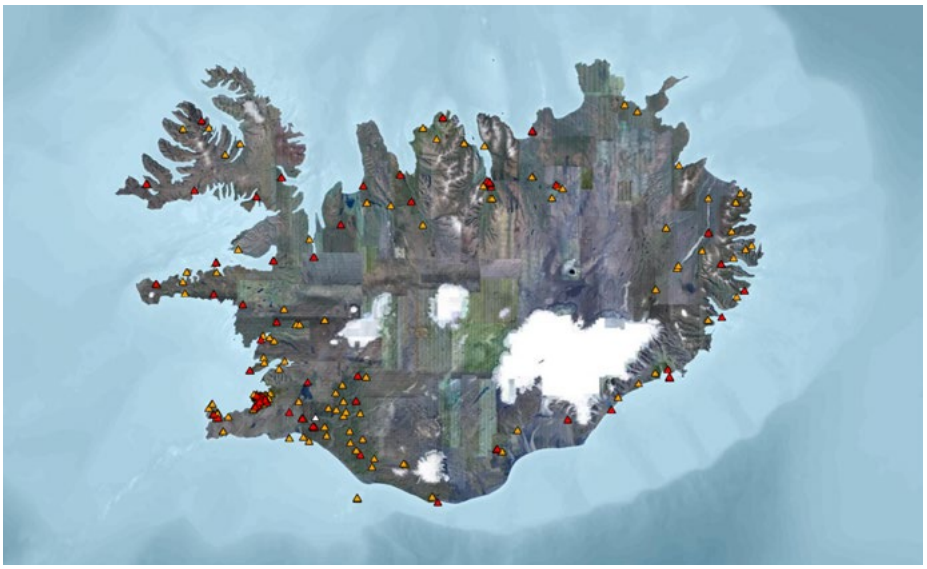

Figure 22. Fast Charging Stations for Electric Cars. *Source: National Energy Authority.*

The number of vehicles at each fast charging station is a certain standard for infrastructure supply. Despite the rapid increase in the number of electric cars, there has been a strong emphasis on supporting infrastructure development, which has led to the number of electric and plug-in hybrid cars at each charging station going from 82 cars in 2018 to 39 cars in 2020.

Number of Charging Stations.

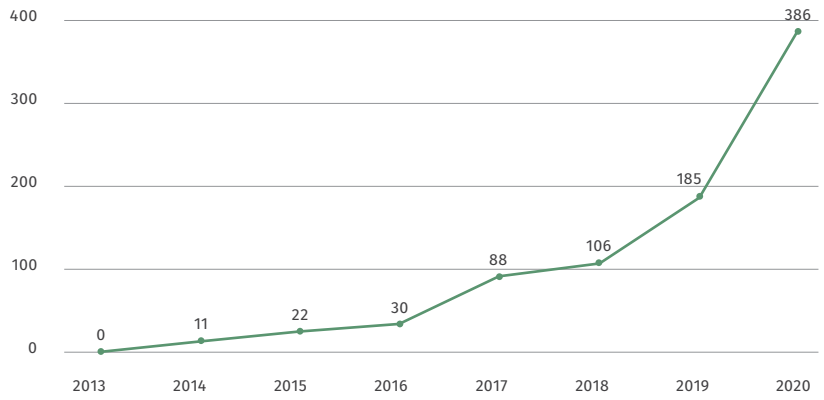

Figure 23. The Number of Charging Stations. *Source: EAFO.*

Number of Electric and Plug-in Hybrid Vehicles (PHEV) Per Charging Station.

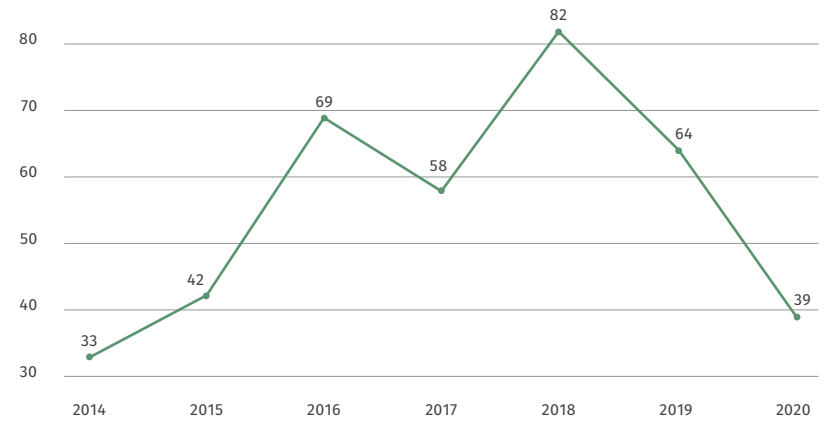

Figure 24. The Number of Electric and Plug-in Hybrid Vehicles Per Charging Station.

Source: EAFO.

The Energy Fund has developed into having the main goal of supporting energy transition. Grants for infrastructure for electric cars throughout the country have been an important part of promoting the energy transition on land. In recent years, the fund has also increasingly supported energy transition at sea, in industry and for the production of renewable fuels. The fund has been significantly bolstered with increased contributions from the Treasury.

Table 8. Energy Fund Grants for Charging Stations 2016–2021. *Source: The Energy Fund.*

2016	66,750,000	Infrastructure for electric cars all over the country, part 1.
2017	65,985,000	Infrastructure for electric cars all over the country, part 2.
2018	68,424,060	Infrastructure for electric cars all over the country, part 3.
2019	226,825,000	Fast charging stations for electric cars.
2019	30,319,869	Fast charging stations for electric cars – hotels and accommodation.
2020	108,964,500	Infrastructure grants for eco-friendly vehicles in public places.
2020	71,005,000	Infrastructure grants for eco-friendly vehicles.
2021	81,925,000	Purchase of eco-friendly work machines.
2021	106,409,000	Purchase of eco-friendly trucks or improved infrastructure.
2021	42,559,000	Charging stations at accommodation and popular tourist destinations.
Total	**869,166,429**	

According to a recent survey, most people charge their electric cars at home or over 80%.[32] This result is not surprising and confirms other studies on the charging behavior of electric car owners, both in Iceland and abroad, for example (Fleetcarma, 2020) and (Smart, 2015). Just over 9% said they mostly charge at the workplace, and only 1% of respondents mostly charged in a parking garage. It is perhaps surprising that nearly one in ten said they mostly charge the electric car at a charging station open to the public.

[32] https://www.stjornarradid.is/library/01--Frettatengt---myndir-og-skrar/ANR/Orkustefna/LOK%20INE%202021%20Fl%c3%b6skuh%c3%a1lsar%20%c3%ad%20hle%c3%b0slukerfi%20landsins_Ni%c3%b0urst%c3%b6%c3%b0ur%20k%c3%b6nnunar%20%c3%a1%20me%c3%b0al%20rafb%c3%adlaeigenda.pdf

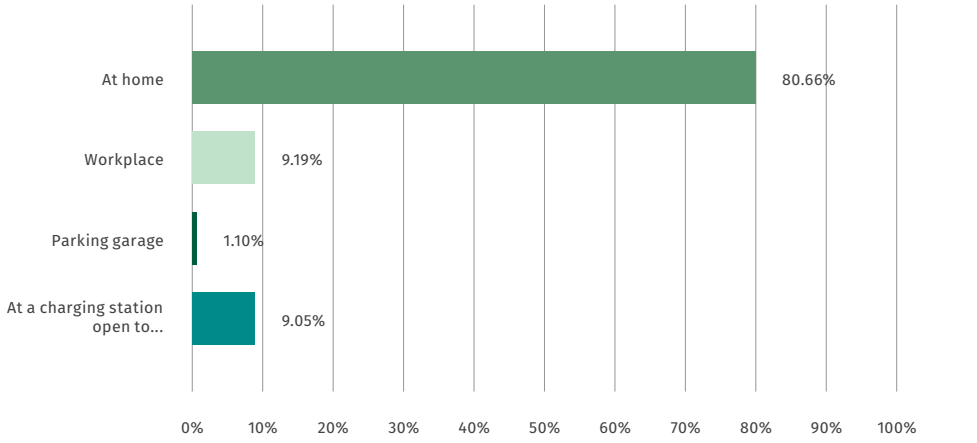

Figure 25. From Icelandic New Energy's 2021 Survey.

4.6.2 Ports

In many ports it is possible to connect ships to electricity sources and systematic work is being done to further modernise ports.[33] [34]

Ports that participated in the 2021 survey used 20 GWh of electricity. According to the VSÓ 2016 report, "Possible Energy Transition in Iceland", the total power requirement of ports could be around 16 MW and energy consumption around 58 GWh. That number has probably risen.

4.6.3 Batteries and E-fuel

Obstacles in energy transition can generally be divided into three: Technical challenges, cost challenges and infrastructure and energy challenges. It is estimated that direct electricity consumption with batteries could technically be utilised in up to 80% of road transport. However, battery technology is still evolving rapidly and will improve e.g. with new materials in batteries. The operating cost of battery vehicles is lower than that of conventional vehicles and the initial cost of each car decreases rapidly. The basic infrastructure is available but they need to respond to the demand in accordance with the rapid growth of the car fleet throughout the country. The electrical energy requirement of each vehicle is not high.

A large part of the fishing fleet, international flights and sea transport, as well as part of road freight transport, will probably depend on E-fuel. Technological devel-

[33] https://www.stjornarradid.is/verkefni/umhverfi-og-natturuvernd/loftslagsmal/adgerdaaaetlun-i-loftslagsmalum/adgerdirnar/loftslagsskyrsla-stok/?itemid=449f3305-b18c-11ea-8117-005056bc8c60

[34] https://www.stjornarradid.is/library/01--Frettatengt---myndir-og-skrar/ANR/Orkustefna/Rafv%c3%a6%c3%b0ing%20hafna%20%c3%a1%20%c3%8dslandi.pdf

opment in that field is rapid but many solutions are uncertain. The operating costs of vehicles, work machines, vessels and aircrafts with E-fuel are very high and their initial costs are high. Little to no infrastructure exists. The energy requirement for the production of E-fuel is evaluative, as it is uncertain what proportion of domestic fuel will be available. The production of E-fuel requires electricity and the energy efficiency of production and use is much lower than in the case of direct use with a battery.

4.7 Matters of Opinion and Decision-Making Issues

Along with the introduction of electric cars and general energy transition in land transport, fee collection/taxation of traffic need to be reconsidered. Fee collection is either based on investment in vehicles, maintenance or their use. We are faced with the need to expand the fee collection for usage as the number of electric cars increases. A position needs to be taken on increased incentives for electric car implementation, both with lower fee collection for investments and/or increased fee collection for investments and the use of vehicles with internal combustion engines.

A policy needs to be set on whether to increase the production of fuel in Iceland at least to the extent that corresponds to the demand for such fuel in the country when energy transition takes place. It is not yet clear enough what technology will prevail in individual aspects of transport and transportation, but in all cases hydrogen production is a key factor. Its feasibility needs to be examined and a position formulated on whether it is nationally economically viable to produce fuel for export from Iceland.

The future role of the Energy Fund needs to be decided and its scope examined in comparison with comparable funds in neighbouring countries. Iceland's goal of energy transition is based on Iceland being at the forefront of the energy transition wave in fishing and sea and air transport. This can be done through strong participation and investment in all kinds of development projects and leadership in the implementation of new technology. A strong Energy Fund can play a major role in financing projects in this field.

The ETS system is a relatively efficient system for achieving targets for reducing greenhouse gas emissions. There is reason to examine how it is ensured that the fees of Icelandic parties into the ETS go to innovation and development projects in industry in the field of energy and climate projects. There is also reason to examine whether it is realistic to implement a domestic quota and trading system in Iceland in order to achieve the goal of reducing emissions from general economic activity.

5. Energy Efficiency and Savings

Energy Policy: **Technological innovations inherent in smart technology need to be utilised**

5.1 Summary

- Increased energy efficiency in electricity production and consumption and increased savings in electricity in households as well as in the economy is important for future energy demand. Increased energy efficiency and greater savings facilitate energy transition.
- The Energy Fund, The Technology Development Fund and other funds support improved energy efficiency along with companies and organisations, e.g. in offshore and harbour activities.
- Smart meters are replacing older meters in the electricity system and in controlling it.
- There is increased public support for heat pump installation and emphasis is being placed on more environmentally friendly buildings that contribute to improved energy efficiency. Further concessions for the public and businesses are encouraged.
- Households have saved 10% on electricity with more energy-efficient household appliances.
- Stranded but usable energy, e.g. waste heat from heavy industry companies, is worth pursuing. Multi-use of energy flows, e.g. with resource parks is desirable.
- The capacity increase of existing power plants is already underway.
- Better connections in the transmission network between regions improve the utilisation of the electricity network.
- There are a variety of circular economy projects in power development areas where full utilisation of resources takes place.

5.2 Utilisation of Energy Resources Over the Years

It does not matter whether you look at apartments and other buildings or means of transport when assessing energy efficiency. Over the past century, there has been a revolution in these matters. This also applies to commercial activities. Concepts such as electrification, LED adoption, digital smart technology and eco-design tell that story in part. Utilisation of energy sources such as minerals, geothermal and nuclear energy, waterfalls, solar heat and wind has gradually been characterised by more and more methods of utilising each energy unit better than previously achieved. The reasons for this are evident.

Increased energy efficiency and maximum energy savings are of great importance for the future of mankind. Numerous parties rate it as ranging from 10% of carbon neutral actions to 25% (IRENA, International Renewable Energy Agency) or even 40% with multifaceted high technology.[35]

5.3 Technological development

5.3.1 Smart Energy System and Load Control

Digital technology, Internet adoption and the fourth Industrial Revolution relate to energy producers, energy carriers, the general public and business. Smart solutions strengthen the synergy of power stations and the transmission and distribution networks. They facilitate power control of the entire electricity system, i.e. bringing electricity with equality to all parts of the country, utilise all usable electricity and be able to respond to load fluctuations and increased load e.g. due to energy transition, innovation and industrial development.

Power control is thus carried out in order to optimise the annual production of electricity per installed power unit of each power plant.

5.3.2 Smart Network

A smart network is an electricity network that combines in a smart, equal, digital way the functions and capabilities of everyone who is connected to it, electricity producers, distributors and consumers, so there is sustainable, economical and secure energy/energy supply. Further information on smart networks can be found in Landsnet's presentation.[36]

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[35] https://www.iea.org/reports/energy-efficiency-2018

[36] https://www.landsnet.is/library/Skrar/Landsnet/Upplysingatorg/Kynningarmal/Vorfundur-Samorku/07%20Snjallnet%20-%20Vorfundur%20Samorku%20-%20Iris%20Baldursdottir.pdf

Nearly 13 items are listed that can be included in the concept smart network, from real-time monitoring of electrical equipment and electricity control in buildings to smart meters of energy consumption and automatic protection equipment in power plants or substations.[37]

5.3.3 Results of Smart Network Adaptation

Smart networks in East Iceland increase the utilisation of the transmission network and operational security in East Iceland, especially for power control to fishmeal factories. In Reykjanes, it increases operational security by facilitating power curtailments where possible, in the event of electricity disruptions. Smart and rapid reduction of power in the Þeistareykir power plant can increase the transmission capacity of the Byggdalina line between the Blanda and Fljotsdalur power plants. Smart networks in the Westfjords increase operational security and minimise power outages with the rapid entry of backup power and the automatic entry of priority users. The smart network of smelters minimises load on the Byggdalina line with fast load control and improves electricity quality during disruptions.

5.3.4 New Technology for Energy Savings

Energy savings is one of the key concepts in energy transition processes. Dissemination of information about its necessity and methods is i.a. handled by the Energy Agency within National Energy Authority. Energy efficiency/energy saving also concerns district heating and all space heating. Imporant to this are e.g. heat pumps, improved building insulation, improved indoor heat management and general consumer consideration. The development of technology and equipment is increasingly facilitating energy savings. Examples include LED lighting, more powerful and environmentally friendly vehicle batteries, more fuel-efficient electronics, as well as smart networks. Veitur ohf. is currently undergoing an overhaul with the introduction of smart meters. This is an example of the trends.

5.4 Support Environment

5.4.1 The Energy Fund

The Energy Fund under the auspices of the NEA supports a variety of projects within the energy sector, including for energy transition. From 2006 to 2010, the fund supported in total e.g. 63 projects, but from 2016 onwards the number of grants increased greatly, especially grants for energy transition. In 2016–2021, a total of 252 grants were allocated for energy transition and the total amount is ISK 1,258,362,000. Of these, 151 are grants for charging stations or infrastructure for electric cars.

[37] http://www.iec.ch/smartgrid/

5.4.2 Technology Development Fund

The Technology Development Fund under the auspices of RANNÍS supports technology development and innovation projects of various kinds every year. In 2021, 12 energy-related innovation projects were funded. Two are directly related to energy transition: Design of an electric catamaran (Icelandic New Energy ltd. and others) and energy transition of large vehicles into hydrogen (Vetnis). 12 educational and information projects also received grants, of which e.g. a presentation for 10- to 12-year-old primary school children on the use and importance of public transport (Straetoskalinn on behalf of Energy Agency) and dissemination of information to young people about climate issues and reduction of greenhouse gas emissions (information package on climate issues organised by The Icelandic Youth Environmentalist Association).

5.4.3 Icelandic New Energy (Islensk Nyorka)

Icelandic New Energy (founded in 1999) emphasises the acquisition and dissemination of knowledge on environmentally friendly energy carriers and currently carries out mainly research and consultancy projects in that field. The company participates in collaborative projects as a project manager, contractor and consultant with many domestic and foreign parties, e.g. in hydrogen projects.[38]

5.5 Economy in Energy Consumption

> *Energy Policy:* **Energy efficiency is improved and waste minimised**

5.5.1 Household Savings

The average electricity consumption of households has been declining for several years. This is due to increased LED lighting, more fuel-efficient electrical appliances, warming weather in areas of buildings heated with electricity and presumably with smarter use of electricity.[39] The need for recharging electricity in the operation of cars offsets and affects the overall picture in light of Samorka's analysis of the estimated energy demand for the passenger car fleet in 2040. It is estimated to be around 1,300 GWh or just over 6% of current electricity production. The estimated energy requirement of one electric car is about 2,800 kWh per year. That is about 70% of the energy consumption of the average household. Improved and

[38] https://newenergy.is/rannsoknir-og-throun

[39] https://www.stjornarradid.is/efst-a-baugi/frettir/stok-frett/?NewsId=28cb79af-e044-11e6-9c21-e4a47104df25

environmentally friendly public transport is taken into account in the plans for increased energy savings. Increased data and usage information can be used to tailor flexible tariffs to create incentives for energy savings and load distribution. This is partly in place today, but could be done much better with smart metering.

This development is also reflected in electricity savings in the operations of many companies. It can be assumed that with cost-effective savings for the public and companies, a 5–10% reduction in electricity consumption by households and companies can be expected, i.e. up to 350 GWh in two to three decades based on current electricity consumption. Equalisation of electricity prices was increased by an amendment in 2021 to Act No. 146/2020 amending the Act on Equalisation of Costs for the Distribution of Electricity, No. 98/2004. It can be considered that the changes affect the use of electricity for increased economy, but a comprehensive review is needed, cf. Deloitte's report, "Analysis of Regulations and Arrangements for the Transmission and Distribution of Electricity", to the Ministry of Industries and Innovation 2 February 2021.

5.5.2 Incentives for Companies and the General Public

Energy transition is encouraged through incentives for the public and companies, especially with regard to the purchase of eco-friendly cars. The VAT has been temporarily abolished on electric cars and PHEVs, but excise duties on vehicles will decrease in line with registered, declining CO_2 emissions. Automobile tax depends on the weight of the car and CO_2 emissions. The operation of an electric car saves fuel excise tax, which is included in the price of a litre of petrol and diesel and has e.g. been used for road construction. Therefore, i.a. discussed the introduction of driving charges on eco-friendly cars in order to ensure equality. Car rentals get a

special discount on public fees. These and other energy transition incentives are expected to change now and in the near future. Incentives for companies, institutions and innovation are first and foremost public grants or contributions to the budget and then agreements on investments by investors or companies. This can e.g. include charging stations for cars, district heating utilities where there are none, or where geothermal heat is found (single payments) and further electrification of ports. Horticulturalists have received a subsidy for electricity but now receive direct payments.

5.5.3 Energy Efficiency of Buildings

Progress has been made in the construction and operation of environmentally friendly buildings, as there are ample opportunities for improved energy efficiency and energy savings. It is based primarily on smart control of electrical and heating systems and technically improved insulation of buildings.

5.5.4 Grants for Heat Pumps

With amendments to the Act on Subsidies for Central Heating Costs, the state was allowed to participate with a one-off payment in the initial costs of environmentally friendly energy procurement, which reduces electric heating or oil heating. The state pays for part of the projected savings resulting from the project. They are based on usage of e.g. heat pumps, wood heating and other things that require less electricity consumption. VAT is also refunded on the purchase of heat pumps.

5.6 Improved Energy Efficiency

> *Energy Policy:* **Multi-use of resource streams**

5.6.1 Usable Energy Available

The term stranded energy could be used for the electrical and heat energy that is produced or can be produced but does not show up in usage for various reasons. The term underutilised energy could be used for energy released during industrial processes, unused heat in strata outside geothermal areas or in warm seas by Iceland. It is difficult to predict how much energy/power is there, but in total the power output runs at least a few hundred megawatts, largely heat energy.

5.6.2 Waste Heat From Industrial and Energy Processes

Some consideration has already been given to previously unused waste heat, which is now being utilised. These include runoff and steam from geothermal power plants and low-temperature utilities. Additions are possible here. Utilisation of heat from energy-intensive industrial processes, especially metalworks, is much less prominent. Treatment facilities and aeration systems are considered there. Such heat flows are better suited for direct use of water heating than for electricity production. It is estimated e.g. that 90,000 tonnes of alloy production could support 5 MW of electricity.

5.6.3 Utilisation of Natural Heat Reservoirs

Much progress has been made in harnessing geothermal power and in the search for low temperature geothermal reservois in areas that were previously considered cold or where no good drilling areas could be found. In the vicinity of geothermal areas or even far from them, there are known areas with hot but dry bedrock. It may be economical to extract heat from closed, shallow water systems by re-injecting adventive water. Thick sediments can store heat below a depth that the annual air temperature fluctuation does not reach and sea at 5–10 °C can suffice for heat pumps, cf. the district heating utility in the Westman Islands, which has reduced the town's power demand by more than half.

5.6.4 Better Utilisation of Older Power Plants and Multi-use

Electric power for electricity consumption in 2020 was 2,408 MW. Assuming that the new annual power demand is now in the range of 2,400–2,500 MW, the underutilised power is 300–400 MW. From this it can be considered that a large part can be utilised e.g. with an improved transmission system and smart power control, but a portion goes to transmission loss. Further utilisation of existing hydropower plants is about adding power engines and utilising unused water flow, or utilising increased but temporary runoff of glaciers, either with new power engines or technical changes to existing power engines. Existing geothermal power plants can be expanded by utilising heat energy flows (waste heat or so-called waste flows) with technical solutions or new power engines. Concurrently, it is possible to consider the 23 use categories of geothermal water and steam by temperature covered by the so-called Lindal processes.[40]

Landsvirkjun is considering the power increase of existing power plants over the next 5 years. Recent projects were completed in Bjarnarflag and Burfell and work was done on increased utilisation at Sultartangi power station, yielding 8 MW of increased power. The next projects that are being considered are the renewal of machinery in the Hrauneyjafoss power plant, which should yield 20 MW. Further-

[40] https://www.stjornarradid.is/media/atvinnuvegaraduneyti-media/media/acrobat/vidaukaskyrsla.pdf

more, the Sigalda power plant is being expanded by one machine with a capacity of 50 MW. It is worth mentioning that limited increased energy production capacity accompanies these projects. It is possible to expand hydropower plants in the Þjorsa area by one machine in Vatnsfellsvirkjun, Hrauneyjafossvirkjun and Burfellsvirkjun. All expansions over 10 MW must be processed in the Masterplan (for Nature Protection and Energy Utilization) according to current legislation (from Landsvirkjun).

HS Orka plans to expand Reykjanesvirkjun by 30 MW without new drilling, which will increase the power plant's efficiency by 30%. Renewal of machinery in Svartsengi will improve efficiency by 30–50%.

A proposal has been submitted to the consultation portal for an amendment to the law that allows the expansion of power plants with technical changes without this falling under the Masterplan. As before, the changes are subject to an environmental impact assessment of the project.

5.6.5 Energy Storage – Batteries and Heat Storage

It is necessary to be able to store electricity, e.g. to compensate for fluctuations in its use, to meet power outages and to take advantage of fluctuations in electricity production using different methods. Furthermore, powerful, large batteries are suitable for storing backup power. A rapid technological development of large batteries has taken place in recent years, but the development of heat storage is newer. Energy storage is feasible in Iceland. It should also be mentioned in this context that the reservoirs of the hydro-power plants are also energy storage facilities.

5.7 Current Projects 2022

5.7.1 ON Power Projects

The ON Resource Park is operated next to Orka natturunnar's geothermal power plant in Hellisheidi. In addition to carbon capture (Carbfix and Climeworks), there is a growing utilisation of the energy flows from the Hellisheidi Plant. VAXA is operating algea farming which generate protein and fatty acids and GeoSilica is processing silica rich water for nutritional supplements. ON is also exploring energy storage (the GeoSMART project) to improve the efficiency of geothermal energy utilisation.

5.7.2 HS Orka Projects

HS Orka Resource Park is next to the Svartsengi Plant and the Reykjanes Plant. In Reykjanes, Stolt Sea Farm does land-based fish farming and Samherji Fiskeldi foresees that this will yield up to 40 thousand tonnes of salmon each year. These two companies utilise and/or have agreed on the utilisation of up to 3,500 GWh of heat from warm waste water generated by the cooling of the HS Orka's generators. Two companies, Haustak and Laugafiskur, are working on fish drying in the Resource Park in Reykjanes and Haustak is also overseeing biotech solutions by utilising fish offal. These companies can process approximately 400 GWh of geothermal energy from the Reykjanes Power Plant. HS Orka's Resource Park by Svartengi houses: The Blue Lagoon (bathing resort) and the Blue Lagoon skincare and biotechnology company and the Carbon Recycling International (CRI) industrial plant which utilised, in addition to electric energy, carbon dioxide released from HS Orka's energy production to produce the E-fuel methanol (4,000 tonnes/year). The greenhouse and production facility ORF Liftaekni is located closer to Grindavik. The company produces cell growth factors (epidermal growth factors) from protein produced in genetically-modified barley. Several companies intend to produce E-fuel which would be located near the HS Orka plants. An example is Hydrogen Ventures (H2V), an international energy company that plans to produce large amounts of hydrogen and methanol in a similar way to CRI. In the first phase, it is estimated that H2V's capacity will amount to 30 MW of geothermal energy and that in the second phase, the company's production capacity will be increased.

5.7.3 Blami

Blami is a joint venture between Landsvirkjun, Orkubu Vestfjarda and Vestfjardastofa. The main objective is to support and promote innovation and development of energy transition projects by increasing the share of environmentally friendly fuels, hydrogen and E-fuels in transport and industry. The collaboration aims to promote energy- and climate-related innovation, bolster entrepreneurial efforts and create a robust environment for innovation in the Westfjords.

5.7.4 Eimur

Eimur is a joint venture of Landsvirkjun, Nordurorka, Orkuveita Husavikur and the Association of Municipalities and Business Development in the North-East to improve the utilisation of energy resources and promote innovation in energy matters in the North-East. The aim of this collaboration is for example to support the local economy and increase value generation with an emphasis on sustainability, green solutions, innovation and advanced technology. One of Blami's projects involves moving the wellboats in fish farming into electric vessels which will be based in Bolungarvik once the Artic Fish processing plant is operational.

5.7.5 Orkidea

Orkidea is a collaborative project on innovation in the South under the auspices of Landsvirkjun, the Association of Southern Municipalities, the Agricultural University of Iceland and the office of the Minister of Food, Agriculture and Fisheries.
The primary goal of this collaboration is to increase the generated value and clear the way for advanced food processing and biotechnology. The collaboration aims to strengthen innovation and research into the utilisation of green energy through collaboration with the academic community and the business community.

5.7.6 Grundartangi

The company Qair Iceland ltd. has signed a letter of intent at Faxafloahafnir to be granted land for the operation of a 280 MW hydrogen plant at Grundartangi. The company has also signed a letter of intent with three domestic electricity producers for the purchase of 85 MW of secure energy. It is estimated that the required electricity, 195 MW, will be generated by wind farms that Qair Iceland is developing. The production should help domestic energy transition and in light of that it has, for example, been working on an agreement with parties that focus on the development of aircraft E-fuel. It is estimated that waste heat will be used, e.g. for aquaculture or to pump into the district heating system of the capital area. A memorandum has also been signed with Nordural on co-operation on the capture of CO_2 for E-fuel production. Once domestic demand has been met, the remaining hydrogen will be converted into ammonia and exported to Europe. In light of that, a letter of intent has been signed with the carrier, in addition to which a letter of intent has been signed with the Port of Cuxhaven on the development of transhipment, storage and transport of the company's products. In connection with these agreements, Qair Iceland has become a founding member of the H2Cux project, which is a collaboration between companies, universities and institutions in the Cuxhaven area that focuses on the utilisation of hydrogen in various sectors of the economy. Production on Grundartangi is expected to begin in 2025, but the main uncertainty factor is whether a permit will be obtained to build a wind farm.

5.8 Matters of Opinion and Decision-Making Issues

Abroad, a large part of better energy efficiency in the future is linked to lower energy consumption in residential and commercial buildings. Decisions need to be made on the continuation of the support that has been given to heat pumps and the further spread of district heating utilities. There is a need to search more closely for geothermal energy in so-called cold regions and in the vicinity of low-temperature areas, and ensure that sufficient electricity is available for electric district heating when necessary. Furthermore, there is reason to review building standards with regard to energy efficiency such as with better insulation of houses.

Utilisation of waste heat in various types of industrial production is also an important factor in better energy efficiency. In Iceland, these issues are beginning to be considered in the large metalworks plants and the work is being accelerated successfully.

Great excess heat energy is released in thermal power plants. Various development projects are active in making better use of it than is already being done with good results. There is reason to be vigilant about how the progress of projects of this kind can be directly supported.

Hydropower plants are already working on harnessing more energy through technical changes and other power capacity increases. Energy increase projects and other planned changes to the hydropower plants largely revolve around increasing the flexibility of the electricity network. There is reason to encourage the acceleration of the work.

Many projects are on the agenda that will reduce electricity losses in production, distribution and transmission. These projects need to be given priority in the coming years, not least because it seems to be one of the fastest ways to increase the supply of electricity.

Further concessions for the public and businesses for energy transition are encouraged. There is every reason to reconsider existing concessions and other benefits in this regard.

6. Community and Economy

Energy Policy: **Energy is the driving force behind diverse Economic activities**

6.1 Summary

- It is clear that there will be a continuing increase in demand for electricity from energy-intensive consum and an high-energy industry will be more diverse in the future. There are various plans and projects in development and many projects have been rejected due to the state of energy issues and the lack of electricity and obstacles in the electricity transmission and distribution system.
- Many current energy-intensive consum are interested in increased investments and plans for growth, e.g. in smelters, data centres and in the biotechnology industry.
- Various government policies are linked to the promotion of green industries that use renewable energy, e.g. the Green Carpet, green industrial parks and Iceland's Export Policy.
- There is a call for an increased supply of electricity in all parts of the country, including new industrial projects and energy transition in transport.
- Competition in the electricity retail market has increased with the introduction of new entrants to the market. The lowest electricity price available to households has fallen by almost 20% at constant prices from the end of 2018 to 2021.
- Direct dividends from companies in energy production go to the owners of energy companies, e.g. the public through a holding in Landsvirkjun. Various values are created in society due to energy production and high-energy industry, among the public, institutions and the business community that buy and use energy.
- The electricity market is divided in two. Energy-intensive consum with long-term contracts and 78% of use and general consum (home and small businesses and industry) with the rest.

- A spot market does not exist.
- Iceland's economic benefit from the utilisation of geothermal energy instead of oil for space heating in 2020 was ISK 109.4 billion or 4.3% of GDP, according to figures from the National Energy Authority.
- There are indications of lost job opportunities in various parts of the country due to the state of energy supply or transmission. Reports have suggested that limited access to electricity slows down wage development, e.g. in the Westfjords.
- According to Statistics Iceland, export earnings from energy-related production are on average around 20–25% of Iceland's total export earnings. This does not include value creation due to the sale of electricity and services.

6.2 Organisation of Energy Issues in the Energy Market

6.2.1 Management System

According to presidential ruling no. 6/2022 on the division of political issues between ministries in the Government of Iceland, the Ministry of the Environment, Energy and Climate is in charge of energy affairs. This means that the Ministry handles issues concerning the security of the electricity network, the electricity market, equalisation of costs for central heating and distribution of electricity, energy savings, energy utilisation and energy transition, eco-design of products that use energy and energy labelling. The Ministry also handles various other tasks defined in the Electricity Act, No. 65/2003.

In accordance with the Act on the National Energy Authority, No. 87/2003, as well as the Electricity Act, the National Energy Authority works on electricity issues under the supervision of the Minister of the Environment, Energy and Climate. The NEA shall monitor that companies operating in accordance with the Electricity Act meet the conditions that apply to the operations. Furthermore, the NEA sets revenue limits for the transmission system operator (TSO) and distribution utilities in order to achieve efficiency in their operations. The Electricity Act also provides for the Competition Authority's supervision of the economic activities covered by the Electricity Act.

The Electricity Act also stipulates that the NEA grants licenses for electricity production (Chapter II), licenses for the operation of the (TSO) (Landsnet) (Article 8), licenses for the construction of transmission infrastructure (Articles 9 and

11), licenses for to construct and operate a distribution network (Article 13) and a license to conduct electricity trade (Article 18). The NEA's decisions regarding licenses to build transmission infrastructure that have not been discussed in the Systems Plan, licenses to grant power plant permits as well as licenses to build independent transmission infrastructure and transfer electricity directly from power plant to users can be appealed to the Environmental and Natural Resources Board of Appeal. Decisions to grant licenses under the Electricity Act concerning the approval of the Systems Plan, licenses for the operation of the (DSO) and the TSO, as well as licenses to conduct electricity trading, can all be appealed to the Electricity Judical Committee. Licenses under the Natural Resources Act, the Act on the Icelandic State's ownership of the seabed and the Hydrocarbon Act can be appealed to the Environmental and Natural Resources Board of Appeal.

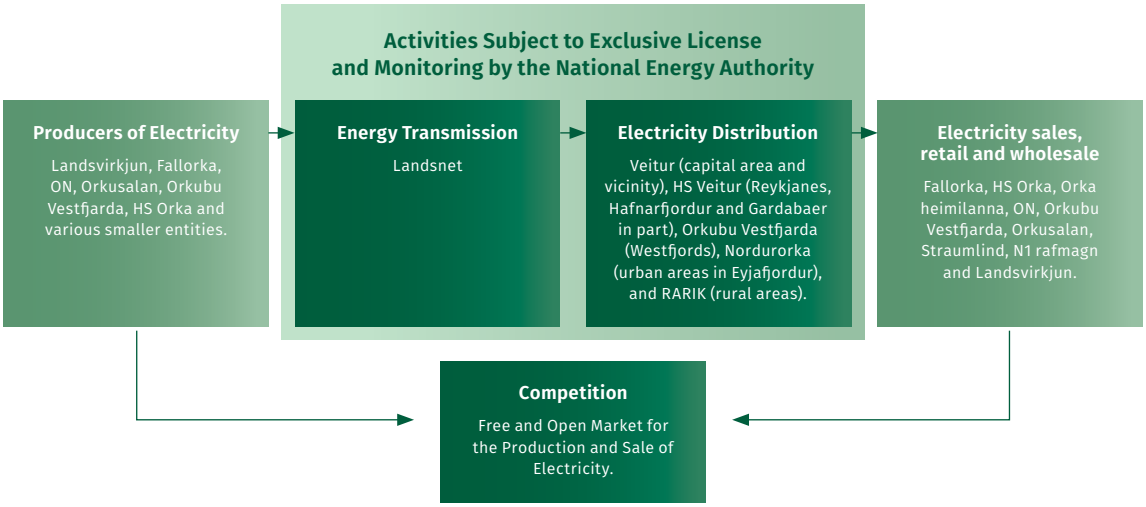


Figure 26. The Energy Market. *Source: Landsvirkjun.*

6.3 Energy Market

With the enactment of the Electricity Act, a distinction was made between competition and exclusive license aspects, which meant that companies involved in these activities had to be split up. Landsvirkjun, HS Orka and Orka natturunnar sell electricity to energy-intensive consum, with direct agreements between processors

and consum. In the wholesale electricity market there is little direct competition. As Landsvirkjun is the most active company in it. Many other electricity producers also engage in retail but almost all of their electricity goes to serve their customers and therefore they have little left for the wholesale market unless they buy it from Landsvirkjun. Thus, it can be considered that indirect competition exists in the wholesale market, where new power plants of other electricity generation companies, HS Orka and Orka natturunnar, can meet part of the demand that was previously met with acquisitions from Landsvirkjun. Increased demand for electricity in recent years has, however, put a lot of pressure and increased consum competition for electricity. The market is growing and the demand of larger consum for renewable electricity has increased so much that it could affect the energy security of the public and smaller companies for a secure supply of energy. The situation now is that there is a lot of competition between general consum in the market and energy-intensive consum.[41]

Overview of the Electricity Market in Iceland

The National Energy Authority has a supervisory role in the electricity market in accordance with law

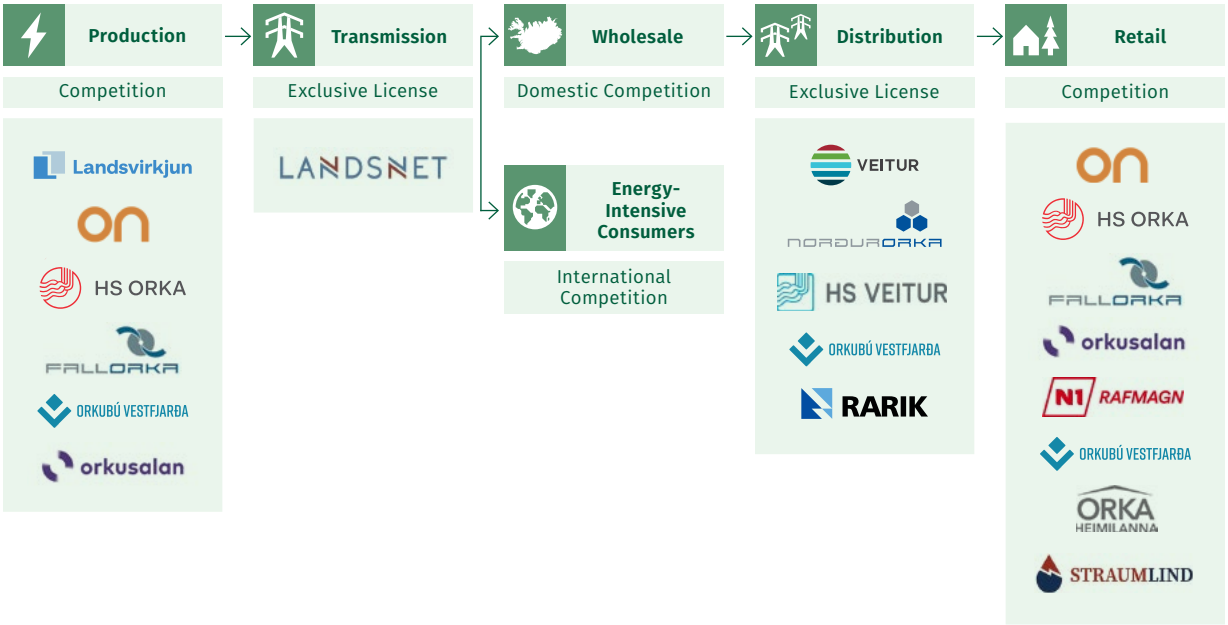


Figure 27. The Energy Market. *Source: The NEA and Landsvirkjun 2021.*

[41] https://www.stjornarradid.is/library/02-Rit--skyrslur-og-skrar/190410%20%C3%9Er%C3%B3un%20raforkuver%C3%B0s%20og%20samkeppni.pdf

6.3.1 Transmission System

Electricity transmission is a concession operation and according to the Electricity Act, one company shall handle the transmission of electricity and system management. That company is Landsnet hf. which was established by the Act on the Establishment of Landsnet hf., No. 75/2004, but the company formally began operations on 1 January 2005.

The electricity transmission system is now entirely in the hands of the DSO Landsnet hf. Landsnet's owners are Landsvirkjun, RARIK, Orkuveita Reykjavikur and Orkubu Vestfjarda. By far the largest electricity producer, Landsvirkjun, has handled wholesale to sales companies and sales to energy-intensive consum. In recent years, Orka natturunnar and HS Orka have also started electricity production for power-intensive industry consum, and even more electricity production can be expected in the coming years.

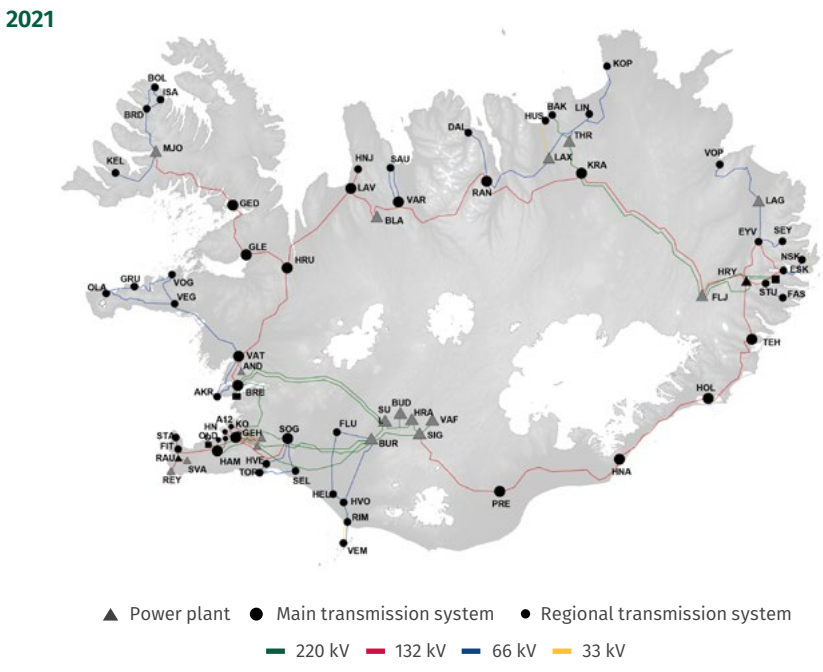


Figure 28. The Transmission System. *Source: Landsnet.*

6.3.2 Distribution System Operators (DSOs)

The distribution of electricity through the distribution system to buyers is a concession activity according to the Electricity Act. A license is required to build and operate a distribution system in a specific distribution area as well as to cease such operations. The DSO handles the distribution of electricity and system management in its distribution area and is intended to maintain, improve and build the distribution network in an efficient manner, taking into account the safety, efficiency, reliability of delivery and quality of electricity.

The following concession companies are electricity distributors:

RARIK ohf.: electricity distribution and district heating in the countryside.

Veitur ohf.: energy distribution, district heating, water supply and wastewater in the capital area.

Orkubu Vestfjarda ohf.: electricity distribution and district heating in the Westfjords.

HS veitur hf.: electricity distribution, district heating and water supply in Southern Peninsula and the Westman Islands.

Nordurorka ohf.: energy distribution, district heating, water supply and wastewater in North Iceland.

Figure 29. DSOs. *Source: Orkustofnun (The National Energy Authority)* [42]

[42] Rafveita Reydarfjardar is now Rarik.

6.3.3 Electricity Sales

The sale of electricity is a competitive operation according to the Electricity Act. Users can choose the retailer of their choice, but must do business with the distributor in the relevant area regarding the distribution of electricity and at a price according to the tariff of the distributor in question.

Competition in the electricity market has been legalised in stages according to the Electricity Act. From 1 January 2006, all electricity users had the right to choose an electricity seller.

New retailers have started operations in recent years, N1 rafmagn, Straumlind and Orka heimilanna, thereby joining the group of retailers in the Icelandic electricity market. There are therefore eight retailers in Iceland. The other companies are Orkusalan, Orka natturunnar, HS Orka, Fallorka and Orkubu Vestfjarda.

6.4 Benefits of Competition – Price Trends

In an audit by the Ministry of Industry[43] from 2010, it was stated that in the early years of competition there was a real reduction in prices to the public. The price of electricity to the general public and companies is still lower than the adjusted price (with the consumer price index) since before the opening of the market in 2005. Efla also analysed electricity prices and the development of competition in the electricity market for the Ministry of Industries and Innovation in 2015. It stated, among other things, that changes made to the system in 2003 had resulted in fairly stable electricity prices in the general market and that competition in electricity sales had given companies in the production and sale of electricity restraints.

Many larger companies and public institutions have in recent years tendered for the purchase of electricity, and competition between retailers has increased with such tenders. Thus, the retailers have offered larger companies discount terms and therefore the benefits for electricity consum from such tenders have increased. Such competition has been achieved despite the fact that almost only one entity is engaged in wholesale in the electricity market. In recent years, new companies have started operating in the electricity retail market. With the introduction of these parties to the market, competition for consumers has increased significantly. At the same time, it can be asserted that with the introduction of the choice of retailer for last resort and the enactment of the Regulation on Electricity Trading and Measurments, the battle for consumers really began. At the enactment of the Regulation on Electricity Trading and Measurements, No. 1150/2019, the NEA was

[43] https://www.stjornarradid.is/media/atvinnuvegaraduneyti-media/media/Acrobat/Throun_raforkuverds_20100319.pdf

given the role of nominating a specific company as a retailer for last resort on the basis of, among other things, the lowest price. Despite the fact that the main goal of this last resort trade is for consumers to receive electricity despite not having chosen an electricity seller, such an arrangement has created incentives for increased price competition in this market. In 2017, 370 households changed sellers, according to Efla's report on electricity prices and the development of competition, which was published in 2019. According to information from Netorka, seller changes for the year 2021 were much more frequent.

6.5 Gain from Energy Resources

Iceland's Energy Policy aims for the nation to enjoy, directly or indirectly, the benefits of the country's energy resources. The value creation of society is, among other things, in the form of export revenues from high-energy industries, electricity sales and dividends from publicly owned energy companies. In the case of wind power, the vast majority of cases are privately owned companies that are interested in establishing long-term energy production in Iceland. Many of the power development options submitted for the hydropower and geothermal Masterplan (for Nature Protection and Energy Utilization) are also from privately owned companies. Both public and private parties seek to get a return on their investment in energy production. When there is equality between parties in the market, it is likely that the return on total capital and return on equity is similar between public and private parties, provided that the capital structure in general and interest terms are also similar between parties. The nation's benefit from energy resources, however, is only to a small extent measured by the return on equity in energy production.

It must be noted that the basis of commercial companies is to create value for their customers, and the same applies to energy companies. Households and general consum in Iceland have e.g. been fortunate in terms of living with relatively low energy prices for both geothermal heat and electricity, which has been one of the key aspects of living standards in Iceland. Energy used in economic activities in all kinds of production processes of goods and services plays a part in the value creation of the economy, which is spread throughout society through employees' wages, dividends, interest payments and tax payments in addition to the benefits created by buyers of the goods and services in question. Thus, the benefits of energy production and energy resources are distributed to the entire nation.

If the energy market is open and new producers can enter it and the existing ones can increase their production, there is less reason to expect a profit to be generated in the operation that exceeds what is generally customary in economic activi-

ties, given the nature and risk of the operation. Excess profits in the energy sector that are not distributed normally to the nation occur first and foremost when limiting factors arise and the path to increased supply into the market is not easy enough.

In the case of wind power in particular, there is no excess profit generated due to lack of wind because it is not depletable, no matter how much is taken. Excess profits could potentially be generated if land use for wind farms is so limited that the value of land under wind farms increases significantly (which is rather unlikely as e.g. 100 square kilometers under a wind farm is 0.1% of the area of Iceland). Further more, if licenses for wind farms become so limited that they create special opportunities for excess profits. It will also be tested whether the reluctance to issue power development licenses due to public policy or other reasons creates such a situation.

In other respects, there is no need to worry about the benefits of energy production outweighing other economic activities. It must also be borne in mind that Icelandic energy producers are in competition with foreign producers, despite the fact that the electricity networks as such are not interconnected.

6.6 Heating Utilities and Their Value

Geothermal district heating utilities replace district heating utilities with electricity or fossil fuels. Iceland's economic benefit from the utilisation of geothermal energy instead of oil for space heating in 2020 was ISK 109.4 billion or 4.3% of GDP, according to figures from the National Energy Authority.

6.7 Transmission Losses

Transmission loss is the electricity lost due to natural resistance in power lines and voltages in the transmission system. About 2% of the electricity fed into the

system is lost on the way to consum. This electricity corresponds to about 400 GWh/year, which is equivalent to the production of Krafla Power Station or electricity consumption of about 150,000 electric cars in one year. According to the Electricity Act, No. 65/2003, Landsnet is required to provide electricity to replace what is lost in the system. As a result, Landsnet requests two types of products on a quarterly basis.[44] One of these is base transmission loss with maximum utilisation time and the other is additional transmission loss with variable utilisation time and flexibility.

Average Prices of Transmission Losses by Quarter

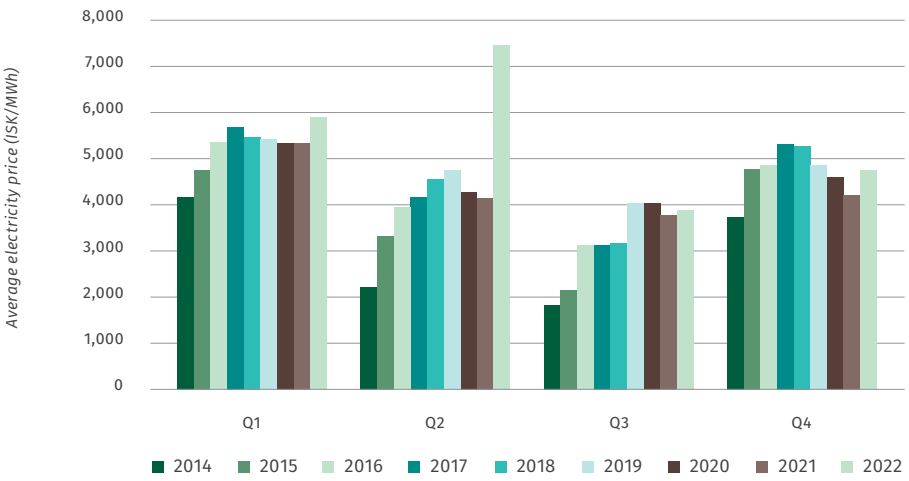


Figure 30. Average Energy Prices. *Source: Landsnet.*

In order to be able to participate in electronic tenders for electricity due to transmission losses, electricity retailers must enter into a framework agreement with Landsnet. However, a framework agreement does not oblige companies to participate in the tenders, as it is the choice of each retailer each time. Today, there are 6 electricity retailers who have a framework agreement with Landsnet: HS Orka, Íslensk orkumidlun (N1), Landsvirkjun, Orka natturunnar, Orkusalan and Straumlind.

For the first quarter of this year, about 98 GWh of electricity was tendered, which is the electricity that is expected to be lost in the transmission system during the quarter.

[44] http://os.is/gogn/Skyrslur/OS-2017/Electricity-Security-of-Supply-in-Iceland-Final-Report.pdf

Landsnet's tender market for electricity due to transmission losses is now in many respects the most open and competitive market for electricity in Iceland. Although there are hints of oligopoly. Electricity is now scarce, which meant that only one party participated in Landsnet's last tender. Figure 30 shows the development of electricity prices in Landsnet's tenders by quarters from 2014.

In a recent tender for electricity due to transmission losses for the second quarter of this year, Landsnet requested a bid for over 89 GWh, but only received a bid for about 3% of the electricity.

As previously stated, Landsnet is obliged to purchase electricity due to transmission losses, but the market does not meet that need, i.e. there is not enough quantity available.

On this occasion, it is worth recalling that since its establishment, Landsnet has drawn attention to the fact that it is not clear who is responsible for the availability of sufficient power and energy in the country. That uncertainty is still present and it is important to get it resolved.

6.8 Industry and Economy

Three main currents affect the demand side of electricity. Energy transition (1), industry and export activities (2) and community and general use (3).

Driving forces of energy demand

1. Energy transition is a prerequisite for achieving Iceland's climate goals. Successful energy transition drives demand for renewable energy and a contraction in fuel imports in turn.

2. High-energy industry now generates about a quarter of export revenue and is one of Iceland's most important export pillars. According to Iceland's Energy Policy until the year 2050, energy should be the driving force behind a variety

of economic activities. High-energy industry has developed in Iceland in recent years and diversity has increased, among other things with the advent of data centres in this country. It is anticipated that more energy-intensive consum of electricity will be added in the coming years, examples include the boom in food production, the biotechnology industry, salmon farming on land and the data processing industry.

3. Community/general use. The development of general use will depend on other developments, cf. population growth, economic growth and plans in other areas. Reference is made here to energy forecasts, e.g. Orkustofnun's basic energy forecast, which sets out in detail the assumptions for the development of the general market.

6.9 Export Revenue and Value Creation

Export revenue from high-energy industries, aluminum, aluminum products and ferrosilicon amounted to ISK 308.4 billion in 2021. Revenue increased significantly from 2020, partly due to higher product prices and increased production. According to an analysis by the Federation of Icelandic Industries in 2019, the aluminum industry's contribution to the economy amounted to ISK 1,150 billion over a 50-year period, of which the indirect contribution of aluminum production in Iceland amounted to ISK 880 billion during the period. The export revenue of the data centre industry, direct income from services to data centre customers, is estimated at ISK 15–20 billion per year. This does not include indirect export revenues due to the operation of data centres, due to increased trade in information technology and telecommunications.

The electricity network has been developed in parallel with the development of aluminum production in Iceland. There has also been a great deal of asset formation by energy companies in recent decades, which are for the most part publicly owned. Landsvirkjun's Financial Statements for 2021 state that the company's operating income increased by over 23% from the previous year and has never been higher. Landsvirkjun's announcement stated, among other things, that the improved profit can be entirely attributed to an increase in revenue from sales to energy-intensive users.

Various policies and projects on behalf of the government, in collaboration with stakeholders and the business community, are related to energy utilisation and energy-related activities.

- Export Policy (2019).
- Declaration of intent by the government, power-intensive industry and OR on carbon purification and sequestration (2019).
- Green Industrial Parks (2021).
- The Green Carpet (2021).
- Regional Development Plan 2018–2024.

Long-Term Policy for Icelandic Export Industries

In the autumn of 2019, a new future policy of the government and the business community for Icelandic exports was presented, which was prepared by Business Iceland.[45] The policy is based on six strategic emphases. One of them is Energy and Green Solutions. It states that energy from renewable resources is a growing value that has, among other things, attracted new foreign investment to Iceland. Knowledge and experience in the field of renewable energy also create export value for Iceland. Emphases in this area includes Graenvangur, a collaborative platform on climate issues and green solutions. Emphasis is also placed on data centres and other high-energy operations, energy transition, utilisation of wind energy/tides and multi-use of chemical and energy flows of geothermal plants and the waste heat industry. The government's Tourism Policy is in place and there are policies that cover energy and energy efficiency.

Letter of Intent by the Government and Power-Intensive Industry

On 18 June 2019, the government, representatives of power-intensive industry and Orkuveita Reykjavikur signed a letter of intent on carbon purification and sequestration. According to the letter of intent, it should be thoroughly investigated whether a method called "CarbFix" can be a viable option, both technically and financially, to reduce carbon dioxide (CO_2) emissions from power-intensive industry in Iceland. Furthermore, each company will seek ways to become carbon neutral by 2040. Emissions from aluminum production are the lowest in Iceland, and emissions per tonne in Icelandic smelters have fallen by 75% since 1990.

Green Carpet and Industrial Parks

In 2021, the government launched two ambitious projects, the Green Industrial Park and the Green Carpet. Their goal is to promote green new investment in the economy.[46]

[45] https://www.islandsstofa.is/aherslur-i-utflutningi
[46] https://www.islandsstofa.is/frettir/graenn-dregill-og-idngardar-efli-graena-nyfjarfestingu

The Green Carpet is a collaborative project between the then Ministry of Industry and Innovation (MII) and Business Iceland, formulated in extensive consultation with business development associations in all parts of the country, where the goal is to improve services and the environment for new investment projects and make processes more continuous, simpler and more efficient. to operation. This is a follow-up of the government's detailed policy-making in the field of exports, innovation and energy, as well as increasing value creation and increasing the number of jobs in a sustainable manner. The project also involves the Association of Local Authorities in Iceland and representatives of ministries and key institutions involved in the process of investment projects.

Green Industrial Parks are a joint project of the then Ministry of Industry and Innovation, Business Iceland, Landsvirkjun and Nordurthing on Iceland's opportunities in the field of green industrial parks and as previously stated, Landsvirkjun and Nordurthing are already examining the construction of a green industrial park at Bakki by Husavik. In order to maximise this synergy and highlight opportunities for the development of green industrial parks and cycle solutions in many parts of the country, it was decided to carry out a joint project in which the Ministry and Business Iceland take an active part.[47]

The Regional Development Plan, a parliamentary resolution on a strategic Regional Development Plan for 2018–2024, was submitted to the Parliament and approved on 11 June 2018. Various emphases in the field of regional affairs are stated in the Regional Development Plan, including:

- That electricity transmission and distribution systems meet the needs of the economy and the general public throughout the country in terms of transmission capacity and security of supply, and the benefits of small power plants will be examined.
- The use of enovironmentally friendly energy instead of fossil fuels will be encouraged.

Among the measures in the action plan is the development of infrastructure for renewable energy on land and in ports, but the goal is to reduce greenhouse gas emissions and increase the proportion of environmentally friendly energy sources.

[47] https://www.islandsstofa.is/frettir/graenir-idngardar-a-islandi-1

6.9.1 Future Growth

Scenarios of society's additional energy demand until 2050 do not provide for increased electricity consumption or future plans for energy-intensive electricity consum in Iceland.

There are currently ten energy-intensive consum in Iceland:

- 3 aluminium smelters
- 2 silicon smelters
- 1 capacitor plant
- 4 data centres

According to Landsvirkjun, the company's customers generally intend to continue operating in Iceland and have secured electricity for their operations for the next few years and decades in some cases. Landsnet agrees with this and states interest and plans for growth among current customers such as data centres and aluminium smelters.

Landsnet also points out that a variety of industries have approached the company regarding connections to the transmission system in recent months. There are plans and interest in food production, algae cultivation, biotechnology, aquaculture and green cement production. There are also plans for hydrogen production and interest in building new data centres.

Based on the plans for development, inquiries and demand that energy producers and transmission companies have on their hands and the plans of municipalities all over the country, all indications are that the diversity of energy-intensive electricity users will increase significantly in the future. Main industries:

Current energy-intensive consum:

- Metal
- Silicon
- Data centres

Potential energy-intensive consum:

- Hydrogen production/E-fuel
- Food production and high-tech foodstuffs
- Biotechnology
- Algae cultivation
- Aquaculture on land
- Cement production

According to Landsnet, around 14 companies are actively developing and preparing for connection to the transmission system and their total power demand is in the range of 600–1300 MW. For comparison, energy-intensive consum today have a total power consumption of around 1900 MW. There are six companies that are well underway in development and their power demand is in the range of 60–90 MW with projects that are planned for operation in 2022–2025.

Projects related to aquaculture and hydrogen production aim for operation in 2026–2030 and their total power demand is in the range of 450–1100 MW.

Among the projects in preparation:

- Landsvirkjun's and Rotterdam Port Authority's project on hydrogen production by electrolysis. Power demand in the range of 200–400 MW (before 2030).
- Landsvirkjun's, CRI's, Elkem's and Þrounarfelag Grundartanga's project on inspections of green methanol production. Power demand is not available.
- Samherji's and HS Orka's project on 40 thousand tonnes of aquaculture on land in Audlindagardur in Reykjanes.

Lost Opportunities

Both Landsvirkjun and Landsnet, along with a number of municipalities, stated in their responses to the working group that a number of projects had to be rejected in recent months due to the state of the transmission system and/or the lack of supply of electricity. News of lost job opportunities due to the limitations of the

energy network has reached the government from many sources. The working group has received resolutions and statements that report on this, e.g. from the board of Vestfjardastofa and the town council of Reykjanesbaer. This has also been reported in North Iceland (from Eyjafjordur). Landsnet has assessed the value of lost opportunities due to inquiries received by them in the years 2018–2021. Based on more moderate scenario, Landsnet's assessment is that six of the aforementioned projects would most likely have been realised if Landsnet's transmission system had not run them aground. Their power demand is in the range of 150–200 MW. To put this in context, it equates to the total activity of data centres and the annual energy sales alone of such activities would most likely be in the range of ISK 4–6 billion.[48] Not to mention other value creation, jobs and export earnings. Numerous examples could be added. According to Landsnet's statistics, a total of 108 inquiries have been received during this period regarding connections from producers, electricity brokers and energy-intensive consum. More than half of them were from energy-intensive consum, or around 60. Of these, it could be assumed, according to Landsnet, that 27 would have been realistic, with a total power in the range of 500–900 MW, if bottlenecks in the transmission system had not caused applications to be rejected.

Metal Production

Revenue from exports of aluminum, aluminum products and ferrosilicon was ISK 308.4 billion in 2021. This amounts to just over 39% of Iceland's total revenue from exports of goods that year. This underlines the importance of the industry for the national economy. Revenue increased significantly from 2020, when they were ISK 224.3 billion, both due to higher product prices and increased production.

In 2021, the expansion of Nordural's factory in Grundartangi was announced, a new cast house that is planned to be put into use by the end of 2023/2024, which includes increased electricity consumption in the coming years by 10 MW annually, according to information from Nordural.

Data Centres and Information Technology

The fourth industrial revolution is powered by electricity, the amount of data is constantly increasing globally, and in parallel with the increase in the amount of data, the demand for data processing and hosting, and consequently the energy and services of data centres, is increasing. The data centre industry in Iceland generates around ISK 15 billion in direct export revenue. Not to mention the unintended effects of data centre operations, including increased demand for the services of telecommunications companies and companies in software and information technology.

[48] https://www.landsnet.is/um-okkur/utgafa-og-samskipti/frettir/stok-frett/2021/09/16/Saga-um-glotud-taekifaeri/

The data centre industry gained ground in Iceland over a decade ago. Today, there are 5 data centres in Iceland and other companies operate smaller data centres. Four of these data centres fall under the definition of energy-intensive consum of electricity with a consumption of more than 10 MW. Numerous IT companies in Iceland, along with telecommunications companies, provide data-related services and advice to customers of Icelandic data centres.

Recently, a marketing project was launched where the Icelandic data industry and stakeholders have joined forces for the first time and marketed Iceland as an ideal place for hosting and processing data. Participants in the project include the Association of Data Centres, IT companies, Orka natturunnar, Farice and Landsvirkjun. Business Iceland handles the implementation and operation of the project.

A new telecommunications submarine cable is also being prepared as the Icelandic state decided to finance the construction of a new telecommunications submarine cable in September 2020. The cable, which will be owned and operated by Farice ehf., a company wholly owned by the Icelandic state, will be called IRIS and will lie between the southwestern part of Iceland and Galway in Ireland and will be the third telecommunications cable connecting Iceland to Europe. It is planned to take the cable into use before the end of 2022. The new cable opens up many opportunities for the data centre industry in Iceland, and an increase in demand for electricity can be expected in the coming years due to new business and opportunities that it entails. It is clear that there is a strong will for continued development in the data centre industry in Iceland with the laying of a new telecommunications submarine cable and a marketing project between stakeholders and Business Iceland to attract more and more diverse customers to Icelandic data centres.

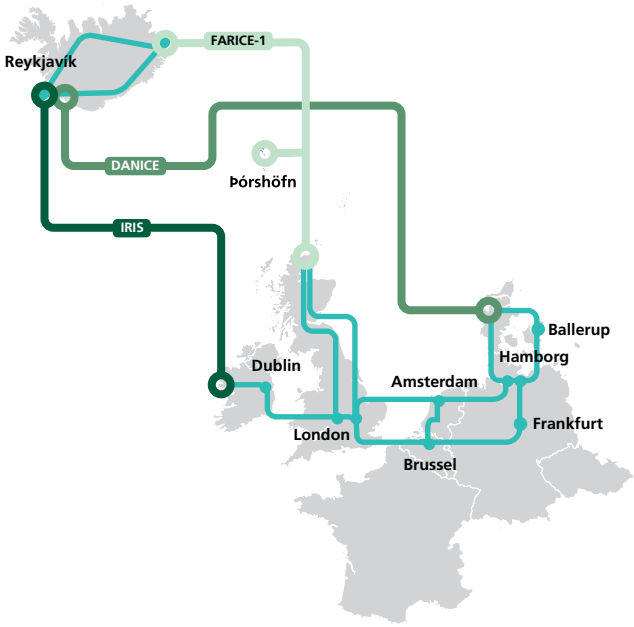


Figure 31. Telecommunication Submarine Cables.

Biotechnology

The biotechnology industry is a recent industry in Iceland, but many companies in that field have been growing in recent years. The biotechnology company Algalif uses, e.g. electricity for the cultivation of microalgae at Ásbru in Reykjanesbaer. In 2021, it was announced that the company intends to more than triple its production in the next few years, and the energy demand after expansion is expected to be around 15–18 MW. It is therefore anticipated that the company will be added to the group of energy-intensive consum of electricity within a few years.

Food Production

Increased domestic food production, including the development and production of high-tech foodstuffs, will require increased electricity in the coming years. An example of projects that have been launched in this field is Orkidea, a collaborative project on innovation in South Iceland. Participants are Landsvirkjun, the Association of Southern Municipalities, the Agricultural University of Iceland and the Minister of Fisheries and Agriculture (now the Minister of Food, Agriculture and Fisheries). Orkidea is about building energy-related opportunities in South Iceland in food production and biotechnology.

Batteries

The number of electric cars is increasing rapidly, which calls for increased production of batteries. International battery companies look for suitable production sites in Europe, and in Landsvirkjun's opinion, Iceland has a lot to offer companies that produce batteries. Battery production uses a lot of energy, is labour intensive and requires a large area, so in Landsvirkjun's opinion there are optimal conditions for such production in Iceland.

Aquaculture/Salmon Farming on Land

Fiskeldi Ölfuss is preparing the operation of a fish farm that will be able to produce about 20,000 tonnes of farmed salmon per year on a 200,000 square meter plot near Þorlakshofn. The company Landeldi is also well on its way to preparing for salmon farming with an annual production capacity of up to 20,000 tonnes at later stages.

Hydrogen and E-fuel – Also Related to Energy Transition

Numerous projects related to the production of hydrogen and electric fuels are currently being prepared. An example of this is a 300 MW hydrogen project in the Northwest. Refer to section 4.3.7. regarding an overview of development projects in this field.

6.10 State of Energy Affairs in Regions of Iceland

Electricity is one of the basic infrastructures of the country and one of the main prerequisites for rural development and economic development. The following is a brief summary of the state of energy issues in individual regions, but the list is not exhaustive. At a meeting of representatives of the local area associations of municipalities with the work group and in submissions, a clear call was made for increased electricity supply and strengthening of the transmission system due to energy transition and various opportunities for job creation throughout the country.

6.10.1 South Iceland

There is limited transmission capacity in South Iceland, especially in the eastern part of the South. The local area association has made suggestions regarding Landsnet's plan for strengthening that area in particular. Job opportunities in South Iceland include horticulture, grain processing, new protein sources, sea and aquaculture, aquaculture and freeze-drying of food. Numerous projects are under development that require over 10 MW of energy. South Iceland calls for a holistic strategy for wind farms.

6.10.2 Westfjords

The NEA's electricity forecast is not thought to capture positive changes in the Westfjords. According to the Westfjords' expansion plan, there are growth industries in the area, e.g. aquaculture, tourism, fisheries and energy-related activities. Energy-related activities will grow in line with this development. In the coming years, energy demand will have to be met for the calcareous marine algae factory in Sudavik, packaging production for aquaculture and energy transition. Hvalarvirkjun is the furthest along in preparations in the area. A wind power plant in Garpsdalur in Reykholasveit is also being prepared. The National Association has made detailed proposals for improvements to the area's transmission system, which has been a barrier to development.

6.10.3 Northeast Iceland

A feasibility study for bioenergy plants in the area is being carried out, and the Association of Local Authorities and Business Development in the North East (SSNE) believes that support for the development of such power plants should be seriously considered. The electricity transmission system is the area's concern, as the transmission system in the North is the oldest part of the regional transmission line and not in line with modern requirements. SSNE believes that by renewing the transmission network from Hvalfjordur to Fljotsdalur, it would be possible to ensure electricity security in the main transmission network and reduce losses. It is also stated that work and preparations for the laying of Blondulina 3 have been going on for a long time and little progress has been made. The decision-making process of such projects is cumbersome and there is reason to examine the possibility of simplifying the process and facilitating decision-making.

6.10.4 Northwest Iceland

Electricity shortage hinders development in the region. Energy transition in the area's base industries, agriculture and fisheries, is not far along. Efforts are being made to attract larger investment projects to the area with the aim of increasing jobs and increasing economic growth, but electricity for these projects is not currently available. The expansion of the Blanda power plant has stalled on the transmission system, but municipalities in the north-west have emphasised that the expansion of the power plant will be undertaken and that energy will be used in the area. It is emphasised that the options for electricity production that have been examined will be implemented and that the electricity will be used for economic development in the region. According to SSNV, it can be estimated that in the next 5–10 years the area's additional power demand will be around 400–600 MW. There are also ambitious plans for industrial parks in the region that require more electricity as well as an increase in car charging stations and electrification

of ports, in addition to general energy transition. Efforts are being made to increase the number of energy-intensive electricity consum in the area and to strengthen industry. The Northwest has missed out on a number of opportunities that can be directly attributed to weaknesses in the electricity transmission and distribution networks.

6.10.5 East Iceland

Fjardaal is the largest electricity user in East Iceland with over 90% of the area's electricity consumption. Electricity sales of renewable energy have grown in recent years with the electrification of fishmeal factories. There are opportunities in heat production in East Iceland, but it is considered both technically possible and financially viable to recycle heat from Fjardaal's potroom. The thermal energy that can be captured is estimated to be around 20 MW. Representatives of local authorities in East Iceland also report on opportunities for biofuel production in the area.

6.10.6 Greater Reykjavik Area

The Association of Municipalities in the Capital Area is working on a climate policy for the capital area. In parallel with the policy, a summary was presented of the main measures taken by the state and institutions in the capital area that could lead to a reduction in greenhouse gas emissions. The project is part of the capital area's expansion plan. The capital area's land-use plan sets out a clear policy on the competitiveness of the area on the basis of efficient land use and efficient transport. The lynchpin is the development of a high-quality public transport system that supports changed travel habits and improved land use.

6.10.7 West Iceland

In Dalabyggd, it has been considered to build wind farms under the auspices of private parties and this project is in the planning process. There has also been talk of building a wind farm in Borgarbyggd. It has also been considered to use waste heat at Grundartangi to produce electricity and E-fuel. It is pointed out that delivery security needs to be improved and reserve power built up in the West, and that trunk line and distribution networks need to be strengthened.

6.10.8 The Southern Peninsula

In the Southern Peninsula, two large data centres are operated and great emphasis has been placed on Sudurnesjalina 2 for development in the area. A feasibility study has been carried out on a green industrial park in the Southern Peninsula. There are also biotechnology companies operating in the Southern Peninsula, including Algalif, which will be added to the group of energy-intensive electricity consum in the coming years.

6.11 Matters of Opinion and Decision-Making Issues

There is a lack of a clear political vision for the future of high-energy industry in Iceland. Various policy-making at the government level calls for increased energy, for example the Green Carpet. High-energy industry generates about a quarter of Iceland's export revenue and there are many future opportunities for diverse development across the country. Uncertainty about the electricity supply and the status of the transmission network is already limiting development and it is important to increase predictably in the future.

The state of the electricity market has long been that there has not been much concern about the supply of electricity for general use by households and companies. Developments in recent years, however, show that the situation may arise that the supply of electricity will not be able to meet demand and that this may particularly affect consum in the general market. Demand for electricity in the general market has grown in recent years without the market reacting in a significant way, i.e. changes in the energy balance have had a limited effect on changes in pricing. From this it can be deduced that messages from the market have not found their way into society. The work group's report on energy security in the wholesale market points out that various ways can be taken to ensure a balance between supply and demand. On one hand, ways to increase the efficiency of the wholesale market with electricity. On the other hand, a regulation that primarily deals with clarifying the responsibilities and roles of the government and market participants and giving the government the authority to respond is necessary to ensure that the supply of electricity can meet demand. According to EEA rules, such authorisations will generally not be applied unless it is clear that the market cannot guarantee adequate security. However, special considerations apply to households and small businesses that may be subject to universal service rules.

All over the country, municipalities and companies are investing money and effort in the development of the economy, which calls for increased electricity. It is necessary for all these entities to receive a clear message from the government, electricity producers, Landsnet and distribution utilities about what future expectations for electricity supply and transmission can be based on. It must be ensured that the municipalities, companies or associations concerned are consulted.

Institutions that handle the administration and licensing of energy projects must have the capacity to process applications efficiently and with professional ability.

7. Environment and Nature

Energy Policy: **Nature conservation is taken into account in energy use**

7.1 Summary

- Opinions are divided on how wind energy should be included in the current regulatory framework, i.e. whether it belongs in the Masterplan (for Nature Protection and Energy Utilization) or should be processed by another type of implementation.
- Opinions are divided on whether hydropower and wind power plants with a power range of approx. 1–2 MW to almost 10 MW shall be classified according to the Masterplan as small power plants due to environmental impact.
- Opinions are divided on how to achieve energy transition, e.g. how much electricity is needed for it and on where and how additional energy should be procured.
- There are indications that the licensing process is time consuming. Various improvements await processing by the Parliament.
- The preparation of larger power plants usually takes 10–15 years. In electricity distribution networks, underground cables are usually used. The transmission network has other and in some cases more technical, environmental and financial challenges related to underground cables.
- There is a call for a review of communication processes for preparation and licensing on the basis that the public is guaranteed access in accordance with the obligations of the Aarhus Convention without leading to excessive delays in construction. It needs to be examined whether it is possible to build on a realistic model of the timeframe for the progress of public processes where the legal status of the public is guaranteed. It is also stated that public institutions will be strengthened so that the handling of predictable tasks will be more efficient and a precaution rule in environmental law will be ensured.

- The Parliament has not approved a Masterplan (for Nature Protection and Energy Utilization) since 2015. It is necessary to cut the knots that have formed in the handling of the Masterplan or to find another arrangement that results in improved processing of energy projects.
- An updated energy transition plan needs to be presented in the light of the 2021 government agreement.
- A proposal for a parliamentary resolution on a revised National Planning Strategy needs to be passed.
- The sooner a bill on wind energy is submitted for consultation and consideration by the Parliament, the more likely it is that the bill will be fully approved during the current electoral term.

7.2 Energy Policy and Environmental Issues

7.2.1 Uniqueness of Iceland

Energy acquisition is an important factor in the utilisation of Iceland's natural resources, which has diverse energy resources in large areas of the country. Furthermore, Iceland is characterised by a unique nature and landscape that has a high conservation value. Utilisation of regional energy resources therefore weighs heavily in the important strategy of seeking a balance between utilisation and

nature conservation. The urban structure, largely coastal and sparsely populated inland, means that the diverse and in many ways unique nature is brought forward in the wilderness. The wilderness currently has a clear economic value as such, but is also the site of many of the main hydropower and geothermal areas in the country. In recent years, there have also been plans for wind energy and tidal options. The demand for electricity is high and growing, mainly due to energy transition and societal growth, and there are many indications that the demand for electricity in Iceland has never been higher. Climate action is directly related to energy transition and, in turn, to electricity generation in the coming years and decades. This development is causing a wider debate and a significant difference in opinion in society about the extent to which electricity should be generated, where, how and in what kind of pace with societal development, both economically and socially, in addition to the state of technology and nature conservation.

7.2.2 Main Targets

The current Energy Policy has three main environmental targets: That consideration is given to nature conservation in energy utilisation, the environmental impact of projects at power plants and transmission networks, as well as operations, is minimised and the utilisation of energy resources is sustainable. The content of the targets includes compliance with laws, international agreements and law-related regulations on energy utilisation, as well as seeking a balance between the utilisation of natural resources and nature conservation with the least possible environmental impact. The results of the environmental impact assessment of the plans and projects that emerge from that work shall also be followed, taking into account and assessing the sustainability of energy utilisation, all three aspects of sustainability. Furthermore, the precaution rule in environmental law should be respected.

7.2.3 The Masterplan (for Nature Protection and Energy Utilization)

The Act on the Plan for the Protection and Energy Utilisation of Land Areas (Masterplan (for Nature Protection and Energy Utilization)) from 2011 (48/2011) aims to ensure that the utilisation of land where power development options are available is based on long-term perspectives and a comprehensive assessment of interests. It will take into account the conservation value of nature and cultural heritage, the efficiency and profitability of different utilisation options and other values that affect the national interest, as well as the interests of those who use these same qualities with sustainable development in mind. The project management submits phase proposals to the Minister and the government, then to the Parliament for discussion and processing. Emphasis on nature conservation is reflected in e.g. a special conservation category that around 170 power development options are ranked in at this point. In the current conservation category of Phase 2, there are now 20 power development options (11 hydropower

options and 9 geothermal options). A total of 10 areas with power development options in the conservation category have been protected, from the Geysir area and Kerlingarfjoll to part of the catchment areas of Jokulfall/Hvita and Jokulsa a Fjollum.

The parliamentary resolution proposal for the approval of the third phase of the Masterplan (for Nature Protection and Energy Utilization), which is being discussed and processed by Althingi from 10 February 2022, includes 16 power development options in the conservation category (14 hydropower options and 2 geothermal options). They decreased by eight compared to the parliamentary resolution proposed in 2016 due to their protections.

7.2.4 Role of the Environment Agency of Iceland

The Environment Agency oversees protected areas, prepares declarations of protection and works on the action plan for the Registry of Sites of Natural Interest, which the Minister then submits to the Parliament as a parliamentary resolution on protected areas for the next 5 years. The Environment Agency is thus involved in the protection of areas that are approved in the conservation category of the Masterplan. The Environment Agency also handles water management. The first River Basin Management Plan for Iceland is expected to take effect this year.[49] On the basis of the Water Management Act, the agency assesses the strain on the ecosystem and landscape due to power plants. This is done by examining whether a lake, a reservoir, a pond and the like, i.e. water bodies, need protection or not, cf. Article 13 of this Act from 2011.[50]

The Environment Agency is responsible for preparing a national report on greenhouse gas emissions and projections of emissions submitted to the EU and the UN Climate Council, on the basis of which it is assessed whether Iceland will meet its obligations under the Kyoto Protocol and the Paris Agreement. The Environment Agency oversees the European Emissions Trading Scheme (ETS) on behalf of Iceland. The Environment and Food Agency implements the number of emission reduction measures mentioned in the Climate Action Plan. The Environment Agency is an opinion maker in assessing the environmental impact of plans and projects.

[49] http//vatn.is

[50] https://www.althingi.is/lagas/nuna/2011036.html

7.3 Environmental impact and Organisation

Energy Policy: **Environmental impact is minimised**

7.3.1 The Icelandic National Planning Strategy

The Icelandic National Planning Agency is responsible for policy formulation, administration and guidelines for planning and construction, with the sustainable utilisation of resources and high-quality settlements as a guiding principle.

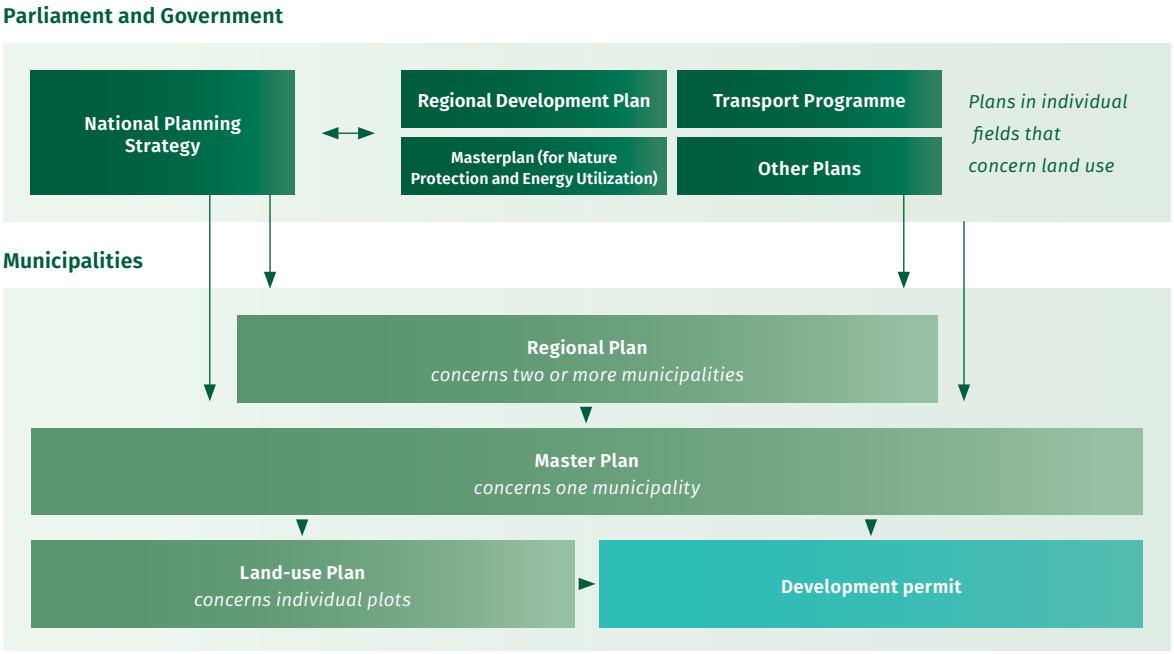
Planning issues, laws and their regulations, are intertwined with environmental issues and nature conservation as one of the foundations of planning issues.

The National Planning Agency prepared a proposal for the National Planning Strategy 2015–2026, which was approved by the Parliament in 2016.[51] The subjects of the National Planning Strategy are:

1. Planning in Iceland's central highlands
2. Planning in rural areas
3. Residency trends and distribution of settlements
4. Planning of ocean and coastal areas

The National Planning Strategy is first and foremost enforced in the zoning plans of municipalities and is reviewed regularly. It is related to the Regional Development Plan, the Masterplan, Transport Programmes and other plans. A parliamentary resolution on a revised National Planning Strategy was submitted in 2021 but did not reach the Parliament. Section 5 of the proposal discusses climate-oriented planning, including climate-friendly transport, planning that supports energy transition and climate-friendly construction.[52] The parliamentary issue is not in the government agreement.

[51] https://www.landsskipulag.is/media/pdf-skjol/Landsskipulagsstefna_2015-2026_asamt_greinargerd.pdf
[52] https://www.althingi.is/altext/151/s/1184.html



The relationship between the National Planning Strategy and other national planning and municipal planning

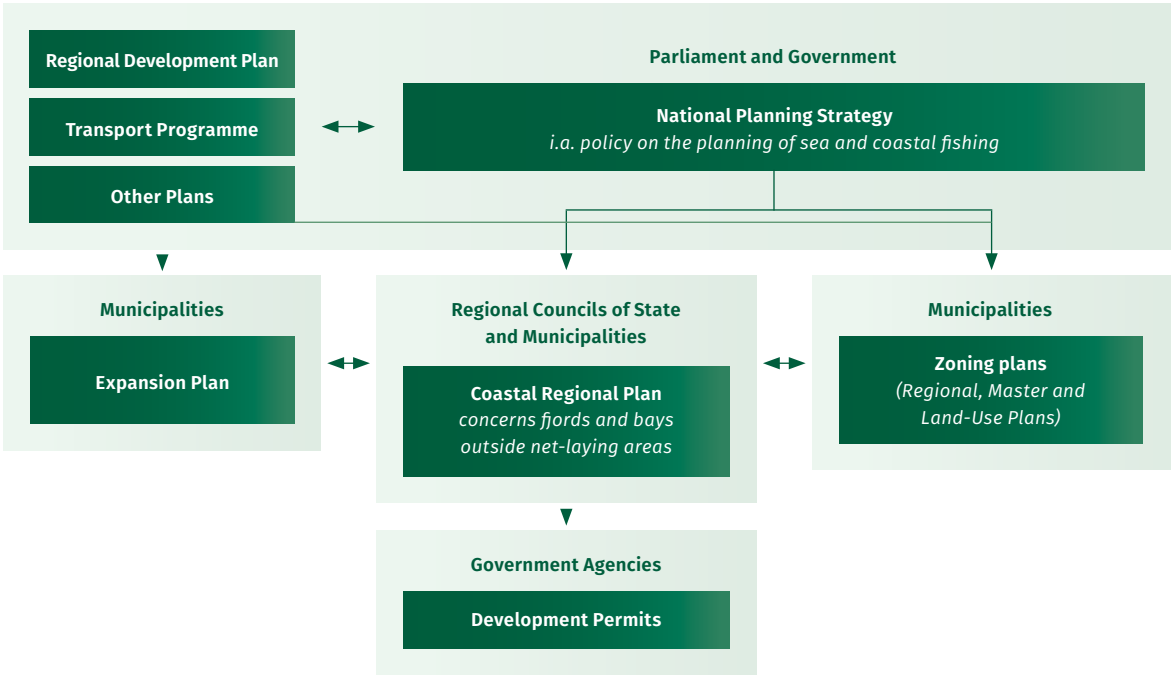


Figure 32. National Planning Strategy. *Source: The Icelandic National Planning Agency.*

7.3.2 Process of Licensing for Transmission Lines and Power Plants

The National Energy Authority discusses the licenses for energy acquisition granted by the NEA. The licensing process for power plants differs depending on the resource in question. Thus, for geothermal power plants, a utilisation permit must be obtained from the NEA for the utilisation of the resource, in addition to a power development permit. Hydropower and wind power development only requires a power development plant license from the NEA.

Licenses for the transmission network are part of the process of Landsnet's network plan and are handed over to the NEA for review at least every two years. The average waiting period for licensing applications from the NEA varies due to their different nature, legal requirements and level of complexity. The processing period for applications is caused not only by the processing of the case by the NEA but also by the applicant's data submission, whether the application is satisfactory, the collection of comments from statutory consultation bodies, the nature of the comments submitted and much more.

According to information from the NEA, the procedural period is generally between 8–12 weeks, including deadlines for other parties, provided that the parties submit satisfactory data and the consultation bodies meet the deadlines. There are different requirements for reviews, advertising and other such things. Depending on what kind of license applies, i.e. prospecting license, utilisation license or power development license. The NEA points out that the licensing process could be more automated and it should be possible to simplify the submission of data for applicants and integrate them with the government for one and the same project. Developers usually obtain a prospecting permit in the run-up to power development plans, although this is not required by law. However, with regard to wind, the law does not provide for the granting of prospecting permits for wind power generation. This must be improved.

According to HS Orka, it is possible to improve the licensing process. The company points out that larger projects usually have to go through all the authorisation and licensing processes, i.e. changes to the Municipal Plan, new Land-Use Plan, environmental impact assessment, power development permit and construction permit. Here is an opportunity to harmonise in such a way that at the beginning of the process the project is defined and broken down into project components, they are connected into one continuous processing process with the involvement of professional bodies, stakeholders and the public. At the end of this harmonised process, the zoning plans for the construction, the assessment report and the opinion of the National Planning Agency are presented with proposals for improvements and with conditions, power development permits and construction permits that are harmonised with the results of the environmental impact assessment.

7.3.3 Changes to Licensing Process

There have recently been changes in the legal framework that applies to the licensing process for power plants and the transmission network. With the Act on Environmental Assessment of Projects and Plans, No. 111/2021, the process of environmental assessments of projects was simplified from what had been valid according to the previous Act on Environmental Impact Assessment, No. 106/2000.

The process of environmental assessments of projects is described in Article 17 of the Act:

> The environmental assessment of a project is a process that consists of the following factors:
>
> a. preparation, presentation and processing of an assessment plan,
>
> b. preparation of the developer's environmental assessment report,
>
> c. presentation and consultation on the environmental assessment report with consulting bodies and the public and, as appropriate, across borders,
>
> d. the National Planning Agency's examination of the developer's environmental assessment report, as the case may be, additional information, cf. Paragraph 2, Article 21, together with the comments of the consulting bodies and the public, and the Agency's opinion on the environmental assessment of the project,
>
> e. that the National Planning Agency's opinion on the project's environmental assessment is used as a basis for processing applications for construction permits.

The Act includes a somewhat clearer and more efficient procedure than previous Acts. It is still permissible to appeal a decision on the obligation to make an assessment. Decisions of the licensor on the granting of a construction permit are still subject to appeal to the Environmental and Natural Resources Board of Appeal. Among the things emphasised in the current Act is that when deciding on a permit for a project, the licensor, usually municipalities, must read the developer's environmental assessment report on the project and take into account the National Planning Agency's opinion on the environmental assessment.

7.3.4 Data and Planning Portal

According to the Act on Environmental Impact Assessment of Projects (Article 7), the National Planning Agency operates a geographical data and planning portal on planning, environmental assessment and licensing. It shall publish data, decisions and comments on the environmental assessment of projects and plans and construction permits. All comments should be received there and access should be open to all and free of charge. There have been proposals and ideas submitted to strengthen and expand this portal, such as in a bill on amendments to the Planning Act that did not succeed in 2021 and in discussions about them.[53] Among other things, it was stated that the portal will keep track of all data related to environmental impact assessment in one place and that it will be able to facilitate and explain all processes and improve public access to data, in accordance with the objectives of the Aarhus Convention.

7.3.5 Wind Power, Planning and Nature Conservation

It is clear that many companies and private entities, both domestic and foreign, are interested in building wind power plants on land, that would in total generate more electricity than is currently produced in the country, i.e. well over 2,800 MW. Large-scale ideas at different levels are presented for floating but fixed-bottom wind farms on the high seas off Iceland, e.g. from the East and the Southeast of Iceland. They would be directly linked to the United Kingdom.

The NEA has sent the project management of the Masterplan (for Nature Protection and Energy Utilization) 34 wind energy options to process. In the government's bill on amendments to the Act on the Masterplan (for Nature Protection and Energy Utilization) for the Classification of Land for Wind Energy Acquisition and the accompanying draft parliamentary resolution from the spring of 2021, the whole country was divided into three regional categories.[54] First in the classification order were areas where wind farms are not allowed, i.e. all protected areas and places in Part A of the Registry of Sites of Natural Interest (around 120). Within Class 2, were areas that could be considered sensitive to wind farms, but could however be considered in the light of the Masterplan. The third classification area was land that does not fall into Classes 1 and 2 and was under the jurisdiction of municipalities, i.e. would undergo a traditional process there and with other parties according to general law.

The comments of consulting bodies before the parliamentary committee were either positive or negative. The proceedings did not end before the closing of Parliament. Among other things, the views were expressed or have recently been expressed that wind energy acquisition should be subject to the National Planning Strategy, with reference to foreign models, e.g. Scotland. Other parties have empha-

[53] https://www.althingi.is/altext/151/s/1809.html
[54] https://www.althingi.is/altext/151/s/1186.html

sised the overall organisation of the government, as with other electricity acquisition, and the specific wind energy licensing processes. Environmental factors such as visual and sound pollution, effects on bird life and the fact that recycling of wind turbines is still in its infancy have also been pointed out, i.a. due to how fast wind energy technology has advanced.

The Minister for the Environment and Natural Resources presented the bill on the division of areas into wind farms at the spring session of 2021 (151st session). It only reached the first steps of processing with the Environment and Transport Committee. The current government agreement of the government announces comprehensive legislation on wind energy in Iceland. It will probably discuss, i.a. the licensing process of wind power plants and the overall organisation and status of such plants in the electricity network.

7.4 Sustainable Energy Transition

> *Energy Policy:* **Sustainable use of energy resources**

7.4.1 Nature and Energy Transition

Sustainability and sustainable development, concern society and the economy in addition to the environmental impact, according to the three pillars of sustainability. The United Nations defines them as economic growth, social welfare and equality, and environmental protection. The government has shaped the policy of a sustainable society in the light of these definitions. Energy transition changes the concurrence of society and nature. Energy transition is accompanied by e.g.

reduced emissions of various gases and greenhouse gases and less mining and processing of fossil fuels. On the other hand, they put more strain on the mining of various other minerals, which are the basis of energy transition, such as the production of batteries. Concurrence like this, in both ways, must always be as clear as possible. There is also a concurrence between social welfare, nature and the economy, and the same applies to its clarity.

7.4.2 Involvement of the Public and Public Organisations

The social aspect of sustainability is multifaceted. It is agreed that the public has easy access to the process of energy transition and sustainability issues, on different grounds. This applies to individuals as well as organisations. To this end, an official government consultation portal has been set up where government proposals to the Parliament are presented, along with regulations, policy documents, reports and more.[55]

Environmental issues are accessible in other ways. Parliamentary committees send out requests for comment on parliamentary matters to so-called stakeholders, but everyone is allowed to send unsolicited comments to the Parliament. The public, associations and companies can be involved in local councils, whether e.g. due to planning or environmental issues. It is common for the government to appoint consultation groups for parliamentary issues or policy formulation. Action Plans and projects that are subject to special legislation on planning, various laws on other projects or environmental issues have provisions on public participation as well as independent interest groups that are independent of the government.

7.4.3 Economy, Standard of Living, Healthy Environment and Energy Transition

Energy transition affects the economy both for growth and contraction and is thus a large part of sustainable development. They incur costs and they create value. Standards of living are partly dependent on energy transition. Energy transition counteracts harmful climate change, improves the atmosphere, and can have a positive effect on the public economy with energy savings and lower energy costs. Energy transition is in line with Public Policy and the Circular Economy Act adopted in the spring of 2021.

Pollution in the earth, fresh water and sea caused by the production and use of oil, gas and coal decreases in line with reduced use as increased energy efficiency and environmentally friendly energy sources become more widespread. Developments in all these areas are subject to increased ecological energy, produced in Iceland and elsewhere, as appropriate, resulting in the necessary energy transition agreed upon.

[55] https://samradsgatt.island.is/um-samradsgatt/

7.5 Underground Cables in Distribution and Transmission Networks

The underground cable installation of the electricity distribution network is underway. A large part of it, with up to 33 kV voltage, is already underground. The same goes for the lines with higher voltages. The transmission network, almost exclusively with 66 kV, 132 kV and 220 kV overhead lines (some of which can be upgraded to 400 kV), is about 3,400 km long. Of this, underground and submarine cables account for just over 7%, mainly in urban areas. Laying underground cables in the distribution network is relatively easy and ground disturbance is rather limited in most cases. Changes from overhead lines, mainly on wooden poles, to underground cables are economical in the long run and improve electricity security everywhere.

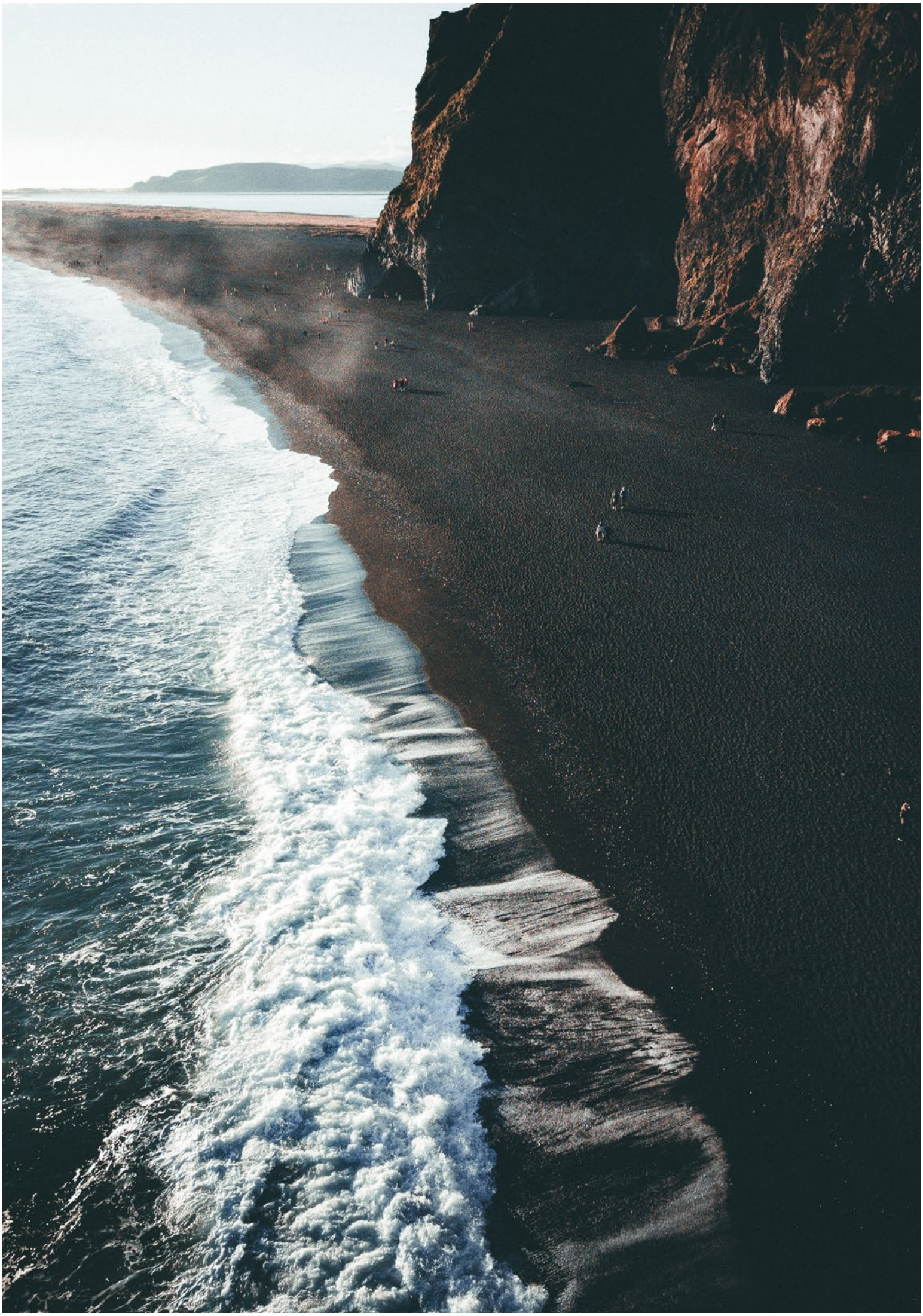
Laying underground cables in the transmission network is technically more complex and expensive than laying cables in the distribution network. Challenges related to the operation of underground cables are greater the higher the operating voltage is, so that the cables are a limited solution in higher voltage ranges. The challenges are much greater in the transmission network than in the distribution networks, as the voltage in the transmission network is 66–220 kV and 11–33 kV in the distribution networks. Among the things that need to be assessed in terms of cost and technical issues at any given time are the following: Structures and installation of each unit length, operation and disposal. Other assessment issues concern in particular energy security and the environment, e.g. disruption caused by the laying and benefits of lower visibility of underground cables than overhead lines and finally what is involved in the disposal of underground cables. It is mainly the price of piping materials and the laying of underground cables that differs from the laying of overhead lines. Each unit of length of a high-voltage underground cable is much more expensive than an overhead line. However, prices have fallen. The protective zone of the underground cable is less than a comparable overhead line's. One three-string set corresponding to an overhead line with three conductors (132–400 kV) utilises 10–20 m wide strip for a path, work area and ditch that is dug in loose strata but blasted into rock or cleared/ripped in jagged lava. It requires special heat-conducting sand. In order to equalise the non-active power generated in alternating current underground cables, special coil actuators are required. They are usually at either end of the underground cable (or both) and even at several tens of km intervals on the cable route if necessary and not useful. There are special and much larger terminals at high-voltage direct current cables, but they do not generate non-active power. Their purpose is to convert alternating current to direct current and vice versa. Underground cables are laid in the straightest line possible, like overhead lines, and usually through uneven heights.

7.6 Matters of Opinion and Decision-making Issues

There is no general consensus on the main emphases in nature conservation and other environmental issues when it comes to energy projects. It is important to create the greatest possible social harmony about the electricity system and society's energy demand. This is where the tasks and decisions of the government, companies, associations and individuals lie, as is the case when it comes to energy transition.

The main criticism is of the organisation of the public licensing process, where the procedural period is considered too long and the Masterplan (for Nature Protection and Energy Utilization) method does not work due to the long processiong period of the Parliament. Efforts have been made to address criticism by amending the Environmental Impact Assessment and the Planning Act. However, further ways for improvement are still pointed out, e.g. by defining tasks at the beginning of the process, breaking them down into work components and linking them together into one processing process with the involvement of all parties involved. At the end of the harmonised process, zoning plans, an assessment report, the National Planning Agency's opinion, a power development permit and a construction permit are all available with the appropriate conditions. A decision needs to be made on whether to continue working to improve the process in consultation with stakeholders, as appropriate.

It is important that the handling of wind farms is clear, including the Masterplan (for Nature Protection and Energy Utilization), planning issues, environmental aspects, licensing and other items as appropriate. The processing and submission of the announced bill in the government agreement needs to be accelerated. It is generally assumed that energy transition will take place over the next two to three decades. There are various opportunities therein for Iceland as the nation no longer needs to be an importer of energy. It is important for the government to take the lead in creating the greatest possible social harmony on the changes that the energy transition and other future energy demand entail.



8. Foreign Currents and Trends

8.1 Summary

- It seems that carbon emissions will have to be halved by 2030 if the climate goals of keeping global average temperatures below 1.5°C are to be achieved and that man-made warming could be reduced thereafter.
- The problem grows faster than the implementation of solutions. But there are solutions. Decisions by public authorities and the economy are needed to implement them.
- Reducing the cost of producing wind and solar energy, batteries and various other production processes strongly supports the development of sustainability. Realistic results are beginning to be achieved. Wind and solar energy is now the cheapest energy option in two thirds of the world, but will probably be the cheapest option everywhere in 5 years.
- There is now a lot of innovation worldwide. Traffic, food production, agriculture and all kinds of production processes for goods, transport and distribution and services are being examined. Investments are increasingly limited to activities that meet the requirements of sustainability and are a contribution to the climate goals.
- Although solutions are still not being implemented quickly enough, the momentum is great. There is reason to expect that this momentum will continue to increase and that the economy and public authorities will work together to make the road to carbon neutrality a success.
- The latest industrial revolution is the "sustainability revolution", which is the equivalent of previous industrial revolutions combined.

8.2 Carbon Neutrality

It is generally considered possible to achieve carbon neutrality by 2050 in the discussion of those entities discussing measures to curb global warming. The world economy is beginning to expect all developments to go in this direction. There has been a great deal of momentum in investments and all kinds of innovation in order

to transform the economy in order to meet the changing needs and demands of societies. This is especially true of the developed part of the world. It can be said that a green industrial revolution has begun. Now the competition is who will be the first to come up with the solutions to serve the demand for emission-free goods and services and other things that accompany man's life on earth. The main question is whether the governments of the countries of the world that have launched this wave in the economy will be able to follow it through and ensure that the goal of carbon neutrality by 2050 is achieved.

Many government, professional and conservation actors have created scenarios and sought to create a clearer view of this journey of humanity. These include:

- IPCC (Intergovernmental Panel on Climate Change)
- IEA (International Energy Agency)
- IRENA (International Renewable Energy Agency)
- Bloomberg NAF
- Environmental organisations, i.e. Friends of the Earth and 350.org
- National government agencies that submit national reports based on IPCC reports
- The European Union

8.3 A Few Main Scenarios

8.3.1 Intergovernmental Panel on Climate Change (IPCC)

The IPCC operates under the auspices of the United Nations. The Agency issued a comprehensive report in 2018, which has been the basis for public and economic policy-making.

In the report, the IPCC presents calculations of the probability that global warming will be limited to 1.5°C in 2100 (compared to 1850–1900) if carbon neutrality is achieved in 2055.

The report presents four main scenarios for achieving carbon neutrality:

1. Technological advances that reduce the demand for energy at the same time as living standards improve.
2. Emphasis on sustainability, better energy efficiency, healthier consumption habits, technological advances and improved land use.
3. A combination of many actions but special emphasis on alterations to how energy is produced.
4. No less energy demand is expected, but the main emphasis is on carbon disposal.

The report also assesses the impact of carbon neutrality actions on the United Nations Global Goals, which in most cases is such that the evolution of carbon neutrality supports the Global Goals.

8.3.2 International Energy Agency (IEA)

The IEA is an organisation of 30 countries, in addition to which several countries have additional membership or are seeking full membership. Iceland is not a member.

The Agency's main report is World Energy Outlook. The latest report discusses the aim of the Paris Agreement 2015, which is to keep global warming at 1.5 °C higher than before the Industrial Revolution.

The IEA presents four scenarios:

5. In the STEPS (Stated Policies Scenario) the temperature rises by 2.6°C in 2100 and keeps rising. This scenario is calculated on the basis of the current policy of the countries of the world.
6. In the APS (Announced Pledges Scenario), the temperature rises by 2.1°C in 2100 and keeps rising. This scenario is calculated on the basis of the promises (commitments) of the countries of the world.
7. In the SDS (Sustainable Development Scenario) the temperature will be up to 1.7°C higher but then decreases. This scenario is calculated by the IPCC.
8. In NZE (Net Zero Emissions) the temperature will be 1.5°C higher in 2100 but decreasing. This scenario is calculated by the International Energy Agency (IEA).

The report outlines what needs to happen in the next 10 years to get back on track after 2030 and then embark on a path to achieve carbon neutrality by 2050.

- Significantly increased efforts in clean electrification. Doubling of current plans for wind and solar energy. More low-emission energy production incl. nuclear energy, the development of flexible infrastructure, incl. hydroelectric power plants (+80% based on 2020).
- Endless emphasis on better energy efficiency as well as better chemical use and changed consumption habits (-33% based on 2020).
- Efforts to reduce methane emissions when using carbon fuels (-77% based on 2020).
- Faster innovation in clean energy production. Increased investments (+180% based on 2020).

The IEA highlights that investment capital in developing countries is a major obstacle to success for humanity as a whole, as they have much less confidence and a higher risk rating than the developed part of the world.

The IEA believes that the years up to 2030 will be crucial for the success of carbon neutrality in 2050 and believes that stronger action is needed. The Agency provides a roadmap for carbon energy, which aims to adapt more quickly by further reducing emissions. It underlines the importance of:

- Shutting down dirty power plants earlier.
- Reducing emissions from dirty power plants.
- Investing in less dirty technology.
- Reducing the demand for dirty energy.

According to the IEA, fossil fuels will decline significantly. The NEZ scenario for 2050 states:

- Oil consumption falls below 30 million barrels per day, but was close to 90 million barrels per day in 2020. The rest will be used primarily in low-emission operations and transportation.
- Gas consumption will fall from 4,000 billion cubic meters in 2020 to well below 2,000 billion cubic meters. Gas will mainly be used in low-emission operations.
- Coal consumption will fall from the equivalent of over 5,000 million tonnes in 2020 and will be in the range of 700–800 million tonnes. Coal will then mainly be used for low emission operations.

The IEA calls on the public to change their consumption habits regarding

- Cars
- Housing
- Flights

All of these are lifestyle-related factors that have varying degrees of significance. The four most important factors are that business flights and long-haul flights due to holidays do not increase compared to 2019, that housing will not be heated above 19–20°C and that geothermal heat will enter houses at 10°C lower than currently.

The IEA emphasises that these changes will be implemented before 2030 and believes that their significance and corresponding changes in the economy can reduce emissions by 1700–1800 Mt.

(In fact, the IEA is not alone in this, as many parties are calling for better utilisation of general products, less food waste and increased emphasis on a circular economy.)

8.3.3 International Renewable Energy Agency (IRENA)

IRENA is an international agency of states that supports them in the transformation of society into the utilisation of renewable energy. Iceland is a member of this agency.

The agency has published a scenario in the publication World Energy Transitions Outlook 2021 on the key things needed in order to achieve carbon neutrality in 2050:

- The energy consumption coefficient decreases by 3% per year instead of 1.2%.
- The share of renewable energy needs to grow eightfold compared to current developments.
- Renewable energy production needs to increase from 2,800 GW now to 27,500 GW by 2050.
- Electric cars must achieve a 100% market share which is now 4%.
- Demand for pure hydrogen (green or blue) needs to increase to 614 GW by 2050 from 120 GW now.
- The supply of sustainable biomass needs to triple by 2050.
- Carbon capture and storage (CCS) needs to increase from 0.04 Gt now to 7–8 Gt by 2050.

The IRENA scenario (1.5-S) discusses in more detail how to achieve carbon neutrality by 2050 and maintain the temperature at a 1.5°C rise above what it was before the Industrial Revolution.

- In this scenario, it is estimated that the PES (Planned Energy Scenario), which is based on current energy policies of countries, results in 36.5 Gt of CO_2 emissions. To achieve this, the reduction in transport emissions needs to amount to 8.4 Gt, in buildings 2.3 Gt, in energy and heat production by 13 Gt and in industry by 11 Gt.
- IRENA estimates that 25% of the reduction in carbon emissions will be due to the production and direct use of renewable energy. Another 25% is due to better energy efficiency, 20% due to increased electricity use and 10% due to hydrogen.
- IRENA estimates that more than half of energy consumption by 2050 will be electricity, 18% modern biomass and 12% hydrogen and E-fuel.

IRENA has compiled scenarios from various sources on the share of renewable energy in TEPS (Total Primary Energy Sources).

The scenarios assume different total energy consumption and a different share of renewable energy. It clearly shows that the scenarios IEA-NZ and IRENA-1.5-S are similar and not far from the IPCC scenarios.

8.3.4 Other Parties

Numerous other parties are drawing up scenarios, such as environmental organisations, consulting companies and other companies, e.g. BP. All of these scenarios have similar emphases to those that have come from the public bodies described here.

It is interesting to see, e.g. the strategy that BP has set itself to achieve carbon neutrality by 2050, but the company sets investment targets for new energy sources in 2025, which corresponds to 50–70% of total investments in Iceland now and in 2050 is expected to invest annually for up to a similar amount as in total investments in Iceland, which is between 5 and 6 billion dollars. In fact, it is also interesting in the context of the discussion on clean energy investments that the price tag on the new SOFI stadium in Los Angeles was exactly 5 billion dollars.

Furthermore, it is interesting to see how BloombergNEF defines scenarios for achieving carbon neutrality by 2050. All of these scenarios are based on the increased use of electricity, clean electricity, batteries, clean technology, carbon capture, disposal and storage, hydrogen, nuclear energy, biofuels, recycling and better energy efficiency.

- ***The Green Way:*** Wind energy, solar energy and hydrogenation in the main role.
- ***The Grey Way:*** Clean electricity and carbon capture and storage (CCS) are very important, i.a. in electricity generation. Blue hydrogen and biofuels are important.
- ***The Red Way:*** Similar to the green way except that nuclear energy also plays a significant role with smaller nuclear power plants. Red hydrogen produced by nuclear energy.

8.4 Important Factors

8.4.1 Renewable Energy has Become the Most Economical According to IRENA Assessment[56]

- Wind energy produced on land is the cheapest energy option in new investments where kWh costs 3.9 cents (4.89 ISK) as a reference.
- Hydropower is the second cheapest and costs 4.4 cents (5.51 ISK) as a reference.
- Solar energy costs 5.7 cents (7.14 ISK) as a reference, which is one of the cheapest investment options for energy production with fossil fuels.
- The reference cost for investments in energy production with offshore wind turbines, geothermal energy and fossil fuels is similar, or 0.71–0.84 cents (8.89–10.52 ISK).

8.4.2 Price of Car Batteries Decreasing Quickly According to BloombergNEF Assessment[57]

- BloombergNEF's annual survey in 2021 shows that the price of car batteries has fallen by 6% between years.
- Since 2010, prices have fallen by 89% in real value.
- Prices vary by market, lowest in China.
- LFP (Lithium, Iron, Phosphate) batteries have gained market share.

[56] https://irena.org/publications/2021/Jun/World-Energy-Transitions-Outlook
[57] https://about.bnef.com/

- The average price was 132 dollars per kWh in 2021. At the $100 mark, electric cars will be at a price comparable to cars with an internal combustion engine.
- Large car manufacturers (Ford, Renault) aim for 80 dollars per kWh by 2030 (nearly a 40% reduction from 2021).
- Electric cars commonly use 15 kWh per 100 km. The current reference price for a battery for 60 kWh is therefore 7,920 dollars or almost 1 million ISK which would be ISK 600 thousand in 2030.
- Comparable price developments are on the utility scale of the battery.

8.4.3 Increased Investments Necessary

The IEA considers that climate-related investments need to quadruple from the period 2016–2020 to the period 2026–2030. This is 75% more investment compared to the APS scenario (Announced Pledges Scenario).

More than two-thirds of the investment needs to come from the economy, but total investment needs to be almost 4,000 billion dollars.

IRENA sends a similar message. In 2019, more than $2,100 billion was invested in climate-related projects.

According to the PES (Planned Energy Scenario), annual investments in the current decade will be over 3,500 billion dollars and then over 3,100 billion dollars in the period 2031–2050.

The big issue is that a much more vigorous investment effort needs to be made in the period 2021–2030, or almost 6,700 billion dollars annually, but that amount can then decrease to almost 3,700 billion dollars annually after that.

This investment needs to be put in the context that the combined GDP of all countries in the world is about 85,000 billion dollars, so the need for investment in climate-related projects is between 4% and 8% of world production.

The problem is that it is difficult to finance investment in developing countries. Public investors are not prepared to risk their capital for investment in countries where governance is considered insecure (IEA).

There are significant differences in interest terms between countries, as shown in Figure 33. It is such an important task for international financial institutions, e.g. The World Bank to figure out how to stimulate investment in this field in developing countries.

Indicative cost of capital by economy (nominal base rates plus market risk premium), 2020
Financing Clean Energy Transitions in Emerging and Developing Economies

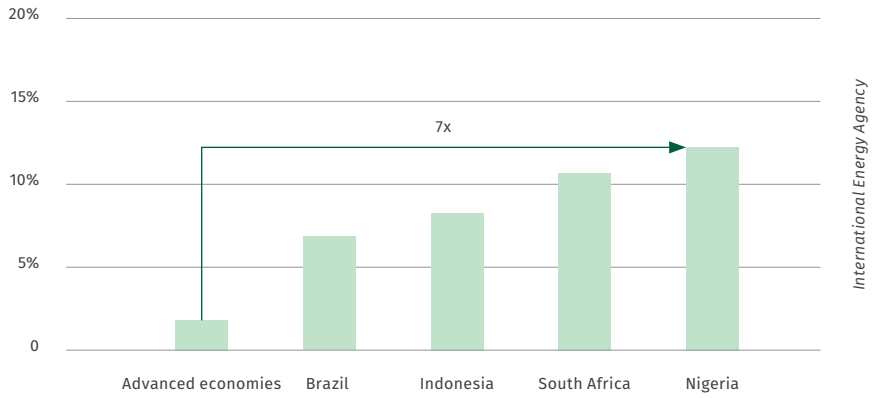


Figure 33. Interest Terms. *Source: IEA.*

8.5 Climate Issues in the Field of Economic Organisations

8.5.1 World Economic Forum (WEF)

The World Economic Forum has recently released the Global Risk Report 2022, which addresses how corporate executives around the world view key risk factors for the economy over the next 10 years.

Environmental risk factors are in 5 out of the top 10 places and in first place is the risk of Climate Action Failure.

Within the economic sector around the world, there is a high level of awareness and consensus on the need for action to achieve carbon neutrality by 2050.

The top 10 main risk factors are:

- Climate Action Failure
- Weather extremes
- Biodiversity is impaired
- Societal solidarity disappears
- Economic crisis
- Infectious diseases
- Man-made damage to nature
- Resource crisis
- Debt crisis
- International business disputes

8.5.2 International Chamber of Commerce (ICC)

From the International Chamber of Commerce's Declaration on the Next Century in International Trade (2019):

- We believe that climate change is approaching a state of emergency, and we wholeheartedly support the conclusions of the Intergovernmental Panel on Climate Change (IPCC) on the urgent need to keep global warming below 1.5°C. Through our operation network, we will pursue policies that support the adaptation of the economy to this goal, which will help us achieve the additional goal of carbon neutrality in many countries by 2050.
- We readily acknowledge that this calls for wide-reaching economic transformation and significant changes in the financial markets in order to create satisfactory conditions for long-term sustainability and environmental protection. We also support the growth of new industries brought about by this transformation and the millions of new jobs being created around the world.

8.5.3 BusinessEurope

The report Greening of the Economy states among other things: The functions and competences of the green economy are common to all major transformations. Such transformations create a need to monitor, anticipate, raise awareness, adapt professional training, facilitate transformations, and take action on the ground. But the ecological transformation, even more so than the technology-driven digital transformation, takes on a systemic form, disrupts production methods, consumption, travel and work organisation, and is also strongly influenced by regulation.

From advice to companies:

- Define policies that support the adaptation of the company's employees to the realities of green production and, where appropriate, the use of public support measures and/or funding from the private sector, e.g. opportunities for sustainable financing, to support progress.
- Invest together in the necessary professional training to support the company's goals and nurture the responsibility of each and every employee to adapt to changing production conditions.
- Engage in regular discussions with trade unions or employee representatives to monitor progress and, as necessary, set policies to achieve better results for the company and its employees.

8.6 Environmental Organisations

8.6.1 World Wildlife Fund (WWF)

At the WWF forum, climate change is widely discussed, but the organisation points out that 13% of CO_2 emissions come from deforestation. The organisation uses various methods e.g. by operating funds to support activities in developing countries. WWF works towards an alliance of parties to work on the advancement of the Paris Agreement and work with companies to reduce emissions. Special emphasis is placed on reducing climate pollution from aviation operations.

8.6.2 350.org

- Store the carbon underground.
- Support the development of a low-carbon economy with greater balance.
- Pressure governments to limit emissions.

All over the world we demand that you:

- Pay your fair share: increase and live up to your promise of funding.
- Do not invest in fossil fuels: stop supporting all kinds of coal, oil and gas industries around the world.
- Fund a righteous transformation: do not let any country or worker suffer, but invest in proven solutions and clean renewable energy for all.

8.6.3 Address from Friends of the Earth

- System change, power to the people.
- Energy as a public good.
- Sufficient energy for everyone.
- Funds for an energy revolution.
- 100% renewable energy for everyone.
- Renewable technology that is climate resistant.
- Energy sovereignty and energy democracy.
- A righteous transformation that protects the rights of people in the current energy industry.
- Public renewable energy is allowed to flourish.
- A climate-just world free from power and all systems of oppression, domination and inequality.

8.7 Denmark's Climate Policy

It is interesting to observe how Denmark approaches climate issues, as Denmark does not have the same abundance of energy resources as Iceland. Their 2019 legislation on climate issues sets out four main policy indicators.

Firstly, it is pointed out that the climate problem is global and therefore Denmark needs to be at the forefront of nations that encourage and influence other nations. Furthermore, Denmark's leadership role is for both historical and moral reasons. Second, Denmark's journey to achieve its climate goals must be based on cost effectiveness as far as possible, taking into account long-term transformations, sustainable and competitive economic development, sound public finances and employment, and the Danish economy must be able to progress instead of contracting.

Third, Denmark needs to show that green transformation is possible alongside a strong welfare state that ensures social cohesion and balance.

Fourth, measures to reduce emissions should lead to a real reduction in domestic prices, but at the same time it must be ensured that Danish measures do not push emissions beyond the borders.

9. Appendix

9.1 Definitions

Transmission System Operator (TSO)

A company that operates structures, e.g. transformer stations, overhead lines and underground cables and transports electricity from the production site, in the voltage range from 66 kV to 220 kV, for sale on the general wholesale market or directly to energy-intensive consum.

Distribution System Operator (DSO)

A company that has an exclusive license for the distribution of electricity in a defined area.

Distribution Network

Power lines not included in the transmission network, including structures and equipment connected to and including local loops. Furthermore, meters and measuring equipment for users.

Retailer

Retailers handle the final sale of electricity to the consum and are optional, unlike DSOs and they operate under an exclusive license.

Electricity Security

Consumers should have access to electricity when it is needed and where it is needed, taking into account the general government policy and of minimum standard reliability and quality.

Energy Security

Consumers should have access to all kinds of energy, electricity, district heating, other heat energy, fuel, etc., where it is needed, taking into account the general government policy and of minimum standard reliability and quality.

Security of Supply

Regulations, measures, technology and conditions aimed at minimising power outages, voltage fluctuations and any operational disruptions to electricity transmission.

Curtailable Electricity

Electricity sold with terms of the producer's/retailer's authorisation to curtail electricity supply due to more specific events that affect production capacity.

Priority Electricity

Priority electricity has priority in delivery in the event of electricity curtailment. All customers who do not have curtailable electricity contracts have priority electricity.

District Heating Utilities

Power stations where water is heated for heating structures and consumption with oil, electricity or heat pump and lead through pipes to the consum.

Transmission Losses

Power lost during transmission of electricity due to electrical resistance in the conductor material. The longer the overhead line or underground cable, and the more electricity transmitted, the greater the transmission loss.

Energy-Intensive Consum

A party that utilises at least 80 GWh of electricity in one place for at least three years at a time.

Installed Capacity

Energy figure (in kW or MW) obtained by determining how much electricity a power plant's equipment can deliver at full load based on its design.

Production Capacity

Annual energy figures (in kWh, MWh, GWh or TWh) calculated on the basis of the potential capacity of a power plant or measured on an annual basis.

Control Systems

A digital, centralised high-tech system that coordinates the operation of a power plant and its transmission network in an interconnected electricity system, often with more than one type of power plant.

Electric fuel (E-fuel)

Fuel produced with renewable energy, either gas or liquid, and does not cause additional carbon dioxide emissions during use. The basic ingredient in E-fuel is hydrogen.

Heat Pump

A device that uses energy, such as renewable electricity to absorb heat from e.g. warm groundwater or seawater at relatively low temperatures and deliver heat at higher temperatures, i.e. more energy than the heat pump uses. A heat pump utilises processing fluid that is suitable for maximising heat exchange, e.g. ammonia or organic matter, in a closed system. Refrigerators are also heat pumps but with the opposite purpose.

Hydrogen-Powered Machinery

Machinery powered by internal combustion engines or fuel cells with hydrogen fuel or hydrogen fuel derivatives like ammonia or methanol.

Biofuel

Fuel made from biomass. Renewable biofuel reduces greenhouse gas emissions compared to fossil fuels.

Carbon Sequestration

A process where carbon in the atmosphere binds in the long term to vegetation, soil, ocean or bedrock. Carbon sequestration takes place constantly in nature, but is also man-made, e.g. with forestry, and can thus contribute to carbon neutrality, i.e. a balance between carbon emissions and their storage in nature.

Blending

Blending renewable fuels or renewable biofuels with fossil fuels to reduce carbon emissions from their use.

Obligation to Sell

According to Act No. 40/2013 on renewable fuels in land transport, the seller of fuel must ensure that a certain percentage of their annual sales of fuel for use in transport is renewable fuel.

Energy Efficency

The ratio between the performance of electrical appliances, services, product or energy production and the energy required. Good energy efficiency reduces the environmental impact of energy consumption.

Energy Savings

Various measures that lead to efficient energy consumption.

Multi-Use

Processes that mean that as many natural resources as possible are utilised efficiently during each period of utilisation.

Waste Heat

Thermal energy generated by production processes that disappears unutilised to the environment.

Resource Park

Local co-operation between institutions, electricity producers and business enterprises, which includes multifaceted co-operation with multi-use of resources as a guiding principle, i.e. utilisation of all or as many resource streams for electricity production and/or other resource utilisation.

9.2 Reports and Plans

9.2.1 Government Policies and Plans

Here is a brief overview of public policies or plans directly or indirectly related to energy issues.

Report of the Minister of Tourism, Industry and Innovation on long-term energy policy and action plan (Minister of Tourism, Industry and Innovation, 2021). Sustainable energy future – Energy policy until the year 2050 (Minister of Tourism, Industry and Innovation, 2020).

An Energy Policy titled "A Sustainable Energy Future" was submitted to Parliament at the 151st Legislative Assembly 2020–2021, in February 2021. The Energy Policy was prepared by a cross-party parliamentary committee in extensive co-operation with the government, institutions and stakeholders. The policy covers the year 2050 and is the first long-term Energy Policy for Iceland that is prepared in this way. The Energy Policy includes a future vision of a country of clean energy. The Energy Policy is accompanied by an Action Plan with defined actions and tasks that are intended to implement the policy and support it.

The government's policy on the development of the electricity transmission system (Parliament, 2018).

According to Art. 39 of the Electricity Act, the Minister submits a proposal to the Parliament every four years for a parliamentary resolution on the government's policy on the development of the electricity transmission network. The current parliamentary resolution was passed by Parliament on 11 June 2018. Its content is divided into three parts. The importance of the transmission network for the long term is emphasised from a macroeconomic viewpoints. The economic, social and environmental impacts of the development of the electricity transmission network, i.e. the three dimensions of sustainable development must be considered equally. Such a balance is one of the basic preconditions for a broader consensus on the importance of the infrastructure contained in the electricity transmission network.

The first part, item A, deals with issues that generally relate to the electricity transmission network and how it should be developed in the long term. These include points of emphasis in fifteen sections that should be taken into account in the development of the electricity transmission network.

Item B of the parliamentary resolution concerns increased independent research and analysis of the effects of different technical solutions on the laying of power lines.

Item C contains general information concerning the structure of the transmission network in 16 sections. These include:

- No power lines will be laid across the highlands.
- The goal is set for N-1 safety in the main transmission network by 2030 and in the regional network by 2040.
- Provisions are made for line routes and the use of electric cables to protect nature.
- Areas that have experienced reduced security of supply are given priority, but they are the Eyjafjordur area, the Westfjords and the Southern Peninsula.

On 2 September 2019, the Parliament approved an amendment to the parliamentary resolution to the effect that the connection of the country's electricity network to another country's electricity network via a submarine cable will not be undertaken without the approval of the Parliament.

Action Plan for Climate Issues

Iceland's Climate Action Plan is a collection of actions to achieve climate goals. There are a total of 50 actions. The Action Plan was published in 2020 and the first status report was published in September 2021.

Action Plan for the Aarhus Convention 2018–2021

The Aarhus Convention is an international treaty linking environmental law and human rights. The treaty is based on the premise that the public has the right to participate in decision-making concerning its immediate environment. The Convention forms three main pillars that impose obligations on the parties to:

- Ensure public access to information on environmental issues.
- Ensure public participation in environmental decision-making.
- Ensure public access to due process and resources under the Convention.

The member states to the Aarhus Convention shall submit a report to Convention Office at regular intervals, reviewing the state of implementation of the provisions of the Convention. On that occasion, the Ministry of the Environment and Natural Resources prepared an Action Plan to follow up on Iceland's national reports on the Aarhus Convention as well as the government agreement. The Action Plan contains a total of fourteen proposals for action, most of which have been completed, some of which include ongoing projects. The most recent member state report of Iceland was submitted in October 2021.

The requirement for a consultation process due to the various public policies and plans concerning energy issues is the result i.a. of the Icelandic state's obligations under the Aarhus Convention.

Masterplan (for Nature Protection and Energy Utilization)

The Masterplan (for Nature Protection and Energy Utilization) assesses the protection and energy utilisation value of land areas and the economic, environmental and social impact of land use, incl. protection.

In the Masterplan (for Nature Protection and Energy Utilization), power development options in the relevant area are classified into an energy efficiency category, protection category or standby category. The Masterplan has a binding effect on the

government in granting permits related to energy research and energy production, but such permits may only be granted for projects that fall into its energy efficiency category.

The standby category includes power development options that are considered to need further information in order to assess whether they should fall into the energy efficiency category or the protection category. Permits related to energy production may not be granted for power development options in the standby category.

The protection category includes power development options that are not considered appropriate to be launched and areas that are considered worthy of protection against electricity production.

According to the Masterplan (for Nature Protection and Energy Utilization) Act, the Minister must submit a proposal for a parliamentary resolution on the classification of power development options at least every four years. The Minister is advised by the project management of the Masterplan. The project management seeks advice from so-called professional groups composed of experts in various fields. The professional groups provide the project management with the advice it needs to be able to prepare proposals for the Minister.

The first parliamentary resolution on the Masterplan (for Nature Protection and Energy Utilization) was adopted on 14 January 2013, ending the second phase of the Masterplan. It was amended by a parliamentary resolution passed on 1 July 2015, in which Hvammsvirkjun in Þjorsa was placed in the energy efficiency category.

The current Masterplan (for Nature Protection and Energy Utilization) includes:

- 3 hydroelectric power development options and 14 geothermal power development options in the energy efficiency category,
- 21 hydropower development options and 9 geothermal development options in the standby category,
- 11 hydropower development options and 9 geothermal development options in the protection category.

Water Management Plan

In the Water Plan, the water bodies of the country are analysed and classified according to their condition. Part of the Water Plan is an action plan specifying

how environmental goals will be achieved. Public plans by the government, such as for planning, nature conservation, energy efficiency and transport, shall be in accordance with the policy on water conservation set out in the Water Plan.

Action Plan for Energy Transition

A parliamentary resolution was passed in Parliament in 2018 on energy transition in all fields. It sets targets for a 40% share of renewable energy sources in land transport by 2030 and a 10% share of ocean-related activities in the same year. An older target of 10% energy transition by 2020 was achieved. According to the government agreement, an updated Action Plan for Energy Transition shall be submitted.

Systems Plan 2021–2030

According to the Electricity Act, No. 65/2003, TSO, Landsnet, must submit a Systems Plan to the National Energy Authority for approval every other year. A Systems Plan includes a long-term plan that shows the aspects of the main transmission network that are planned to be developed or updated over the next ten years and their timetable. The Systems Plan includes an Action Plan showing the investments in the transmission network that have already been made and the investments that need to be undertaken over the next three years and their timetable. In the Action Plan, the analysis of options shall be explained and the option chosen shall be substantiated.

National Planning Strategy

The National Planning Strategy entails a coordinated state policy on planning issues for twelve years. The National Planning Strategy integrates public plans for transport, regional development, nature conservation, energy efficiency and other issues related to land use and the utilisation and protection of marine and coastal resources. Municipalities take the National Planning Strategy into account when drawing up zoning plans or making changes to them.

The National Planning Agency prepares proposals to the Minister for the National Planning Strategy. National Planning Strategy is subject to the approval of Parliament in the form of a parliamentary resolution. A parliamentary resolution on the National Planning Strategy 2015–2025 was passed by Parliament in March 2016. The following points of emphasis are laid down in the National Planning Strategy:

- That the planning of settlements and land-use contributes to sustainable development.

- That the planning of settlements and land-use is flexible and contributes to resilience with regard to social and environmental changes.
- That the planning of settlements and land-use contributes to people's quality of life.
- That the planning of settlements and land-use supports the competitiveness of the country as a whole as well as individual regions.

A proposal for a parliamentary resolution on a revised National Planning Strategy has been submitted to Parliament but has not been approved.

United Nations Sustainable Development Goals

Government plans and policies take into account the United Nations' Sustainable Development Goals. The Goals, which are valid for the period 2016–2030, are 17 in number with 169 sub-goals and cover both domestic affairs and international collaboration during the period of validity. Goal 7 is about sustainable energy and Goal 13 is about climate action. The United Nations Sustainable Development Goals were approved by representatives of all UN member states in September 2015, including Iceland.

9.2.2 Reports With Involvement from Government Offices

- Energy Policy and Action Plan (Parliament, 2021).
- DNV's report on energy demand for energy transition at sea. Ministry of Industry and Innovation, Samorka, Faxafloahafnir and SFS. December 2021.
- Verkis – Electrification of ports in Iceland. Prepared for the Ministry of Industry and Innovation.
- Cultivation and production from energy plants. Prepared for the Ministry of Transport and Local Government.
- Report on the examination of charging infrastructure.
- Report on the feasibility of producing electric fuel in Iceland.
- The macroeconomic impact of electric cars (2018). University of Iceland, RU, the Ministry of Industry and Innovation, Orkusetur, Samorka, Íslensk Nyorka and Graena orkan.

- Energy security in the wholesale market (Ministry of Industry and Innovation, 2020).
- Report on Competitiveness (Ministry of Industry and Innovation, 2020).
- Report on underground cables in the electricity transmission network (Ministry of Industry and Innovation, 2019).
- Security of electricity supply in the Westfjords (2020).
- Electricity prices and the development of competition in the electricity market (Efla, 2019).
- Climate action plan (Ministry of the Environment and Natural Resources, 2020).
- MIT Report on Energy Security (2017).
- Report on charging infrastructure (2021).
- Power and energy balance 2022–2026.
- Development of infrastructure. Measures due to bad weather and other infrastructure development (2020).

10. Letter of Commission

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Reykjavík 11. janúar 2022
Tilv.: UMH22010130/2.3.8

Hér með ert þú skipaður formaður starfshóps sem falið er að vinna að gerð skýrslu um stöðu og áskoranir Íslands í orkumálum með vísan til áherslna og markmiða stjórnvalda í loftslagsmálum.

Markmið og tilgangur skýrslu um stöðu og áskoranir í orkumálum er að draga fram staðreyndir á grundvelli faglegra sjónarmiða og upplýsinga um lykilþætti á sviði orkumála á aðgengilegu formi til upplýsinga fyrir stjórnvöld, hagaðila og almenning. Greiningarvinna starfshópsins vegna gerðar skýrslunnar skiptist í eftirfarandi þætti:

- Stöðutöku, þ.e. greiningu á þeim upplýsingum sem liggja fyrir og mati á þeim upplýsingum sem þau veita.
- Mat á því hvort og þá hvaða upplýsingar skortir til að unnt sé að meta stöðuna með hlutlausum hætti, t.d. hvað varðar orkuþörf m.t.t. orkuskipta.
- Mat á hugsanlegum veikleikum eða hindrunum (gagnvart stefnumótun stjórnvalda) sem fram koma í kjölfar greiningar og stöðutöku.

Skýrsla starfshópsins skal innihalda eftirfarandi lykilefni:

1. Gera skal grein fyrir orkuþörf með vísan til áherslna og markmiða stjórnvalda í loftslagsmálum. Setja skal upp sviðsmyndir um orkuþörf til að ljúka orkuskiptum. Ólíkar sviðsmyndir eftir því hvaða leiðir verða farnar í orkuskiptum og hvaða tækni verður ríkjandi. Í umfjöllun um orkuþörf skal einnig horfa til stöðu hitaveitna við að anna eftirspurn eftir heitu vatni samhliða íbúaþróun.
2. Gera skal grein fyrir stöðunni í flutningskerfi raforku, m.a. út frá þingsályktun um stefnu stjórnvalda um uppbyggingu flutningskerfis raforku. Eru einhverjar hindranir sem koma í veg fyrir að unnt sé að nýta kerfið með bestum hætti og fullnýta þá orku sem sett er inn á kerfið? Meta brýnustu þörfin til úrbóta og ástæður þeirra.
3. Gera skal grein fyrir stöðunni á orkumarkaði á Íslandi með tilliti til loftslagsmarkmiða stjórnvalda í gegnum orkuskipti. Jafnframt gera grein fyrir getu markaðarins til að tryggja orkuöryggi almennings, hvort þörf sé á inngripum stjórnvalda til að tryggja raforkuöryggi og tiltækar leiðir til þess. M.a. út frá skýrslu um orkuöryggi á heildsölumarkaði raforku.
4. Gera grein fyrir núverandi stöðu mála varðandi framboð og eftirspurn raforku sem og hvernig fyrirséð er að þau mál muni geta þróast næstu mánuði og ár. Hverjir eru líklegir kaupendur orkunnar miðað við þróun sem orðið hefur og til framtíðar?

Við greiningarvinnuna og skýrslugerð skal byggja á þeim opinberu upplýsingum og stefnum

stjórnvalda er varða eða tengjast orku- og loftlagsmálum. Má þar nefna orkustefnu, aðgerðaáætlun orkustefnu, aðgerðaáætlun í loftslagsmálum, landsskipulagsstefnu, kerfisáætlun og þingsályktun um stefnu stjórnvalda um uppbyggingu flutningskerfis raforku og skýrslu um orkuöryggi á heildsölumarkaði raforku. Framsetning skýrslunnar skal taka mið af framsetningu og uppbyggingu orkustefnu (sbr. www.orkustefna.is).

Starfshópurinn skal skila til ráðherra tíma- og verkáætlun við upphaf greiningarvinnunnar. Við greiningarvinnuna skal reglubundið samráð haft við lykilhagsmunaaðila vegna hennar en það eru Samorka, Skipulagsstofnun, Orkuklasinn, Grænvangur, Landvernd og Náttúruverndarsamtök Íslands. Skal þeim boðið að koma að athugasemdum við upphaf vinnunnar auk þess að funda með starfshópnum sé þess óskað.

Ennfremur skal hafa reglubundið samráð við sérstakan samráðshóp ráðuneytisins og stofnana vegna vinnunnar en hann skipa:

Halla Sigrún Sigurðardóttir, skrifstofustjóri, umhverfis- og auðlindaráðuneyti,
Steinunn Fjóla Sigurðardóttir, skrifstofustjóri, umhverfis- og auðlindaráðuneyti,
Jón Geir Pétursson, formaður verkefnastjórnar áætlunar um vernd og orkunýtingu landsvæða,
Halla Hrund Logadóttir, forstjóri Orkustofnunar,
Sigrún Ágústsdóttir, forstjóri Umhverfisstofnunar.

Starfshópurinn er þannig skipaður:

Vilhjálmur Egilsson, hagfræðingur, formaður,
Ari Trausti Guðmundsson, jarðeðlisfræðingur,
Sigríður Mogensen, sviðsstjóri hjá Samtökum iðnaðarins.

Erla Sigríður Gestsdóttir, sérfræðingur og Magnús Dige Baldursson, lögfræðingur frá umhverfis- og auðlindaráðuneytinu munu starfa með starfshópnum.

Gert er ráð fyrir að starfshópurinn skili skýrslu sinni og tillögum til ráðherra eigi síðar en 1. mars nk.

Greiðsla fyrir störf í starfshópnum fer samkvæmt ákvörðun Þóknananefndar fjármála- og efnahagsráðuneytisins.

Guðlaugur Þór Þórðarson

Sigríður Auður Arnardóttir

The Government Offices of Iceland
Ministry of the Environment, Energy and Climate