Blámi

Energy transition of feed barges in Iceland

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Summary

In recent years, sea cage aquaculture has grown significantly in Iceland. In 2020 a total of 34,000 tons of salmon was exported from Iceland, of which about 94%[1] came from sea cage aquaculture.

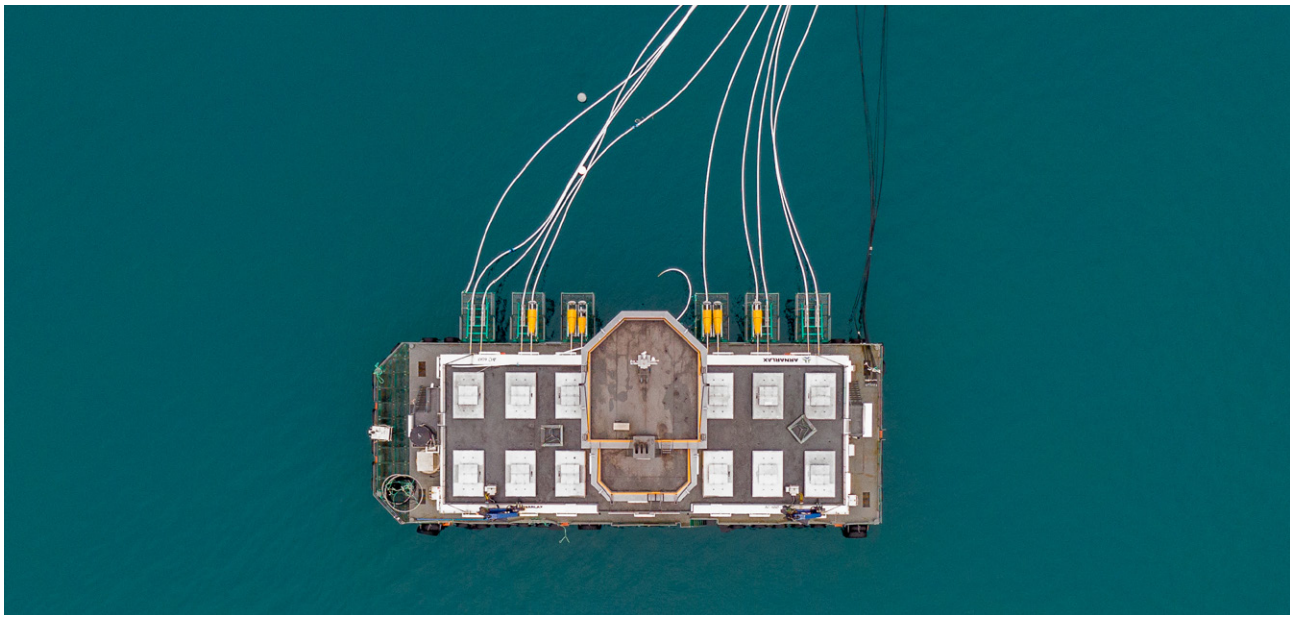
The majority of the production takes place in farming areas where so-called feed barges are used. They are placed by the marine pens and the feed is pumped out of the barge. The feed barges have diesel engines that produce electricity that is used to pump the feed, power the lights and other electrical equipment that is required for the farming. In 2021 there were 15 feed barges in use and their combined oil use is about 1,800,000 liters per year.

It is assumed that production will increase in the future and, based on the assessment of risk with regard to genetic mixing[2], the available license applications and the plans made by the fish farming companies, it may be estimated that annual production will reach 70-100 thousand tons in the next 4-5 years. The estimated oil requirement for feed barges, based on a maximum biomass of 100,000 tons and an annual salmon production of 70,000 tons, is 3,000,000 - 4,000,000 liters per year if green energy solutions are not introduced.

Included in this report is a review of the energy consumption of feed barges and ways in which it is possible to increase the proportion of renewable energy and thereby reduce oil consumption as well as the greenhouse gas emissions that occur from the use of feed barges. Incentives are discussed and also how energy transition can be accelerated in feed barges in Iceland. Among the available solutions are land connections to electricity, batteries and use of electrofuel. It is addressed in the report where it would be possible to introduce green solutions, what solutions could be suitable for each area, with due consideration of infrastructure, technological solutions and the development of the industry.

[1] radarinn.is/fiskeldi

[2] Risk assessment with regard to genetic mixing



Introduction

This report is compiled by Blámi, which is a collaborative project of Landsvirkjun, Orkubú Vestfjarða and Vestfjarðastofa. The primary objective of Blámi is to support and promote innovation and development of energy transition projects by expanding the role of environmentally friendly fuel, hydrogen and electrofuel in transportation and marine-related industry.

Iceland has established the goal of reducing greenhouse gas emissions by 55% by the year 2030[3] and the Ministry of Labor and Innovation has issued an energy policy that will remain in effect until the year 2050[4]. It is stated in the energy policy that the objective of energy transition at sea is that all ships, boats and other seaborne craft, whether used for fishing, transporting cargo or passengers or other purposes, will be powered with energy sources of renewable origin. It is also stated that incentives and direct measures that encourage energy transition shall be employed.

Fish farming is a growing sector in Iceland and like other marine-related sectors it is dependent on the use of fossil fuel. All feed barges in Iceland use diesel oil, but some fish farming companies have started work on electrification in the form of land connections, or by using batteries. This report addresses the current locations and oil use of feed prams, as well as the development and requirements of the next years. There is also a discussion of where and how it will be possible to reduce the use of fossil fuel by using green energy and the ways in which the government can encourage investment and implementation.

Feed barges

Feed barges in Iceland

In Iceland, sea cage aquaculture takes place in the West Fjord region and certain areas of the Eastern Region. In 2020, the salmon production was about 34,000 tons, of which the largest part, 94%, came from sea cage aquaculture.[5] In Iceland, operating licences have been issued for a total maximum biomass of 80,000 tons in nine fjords, and each fjord is divided into sea cage aquaculture areas, with one or more aquaculture areas within each area.

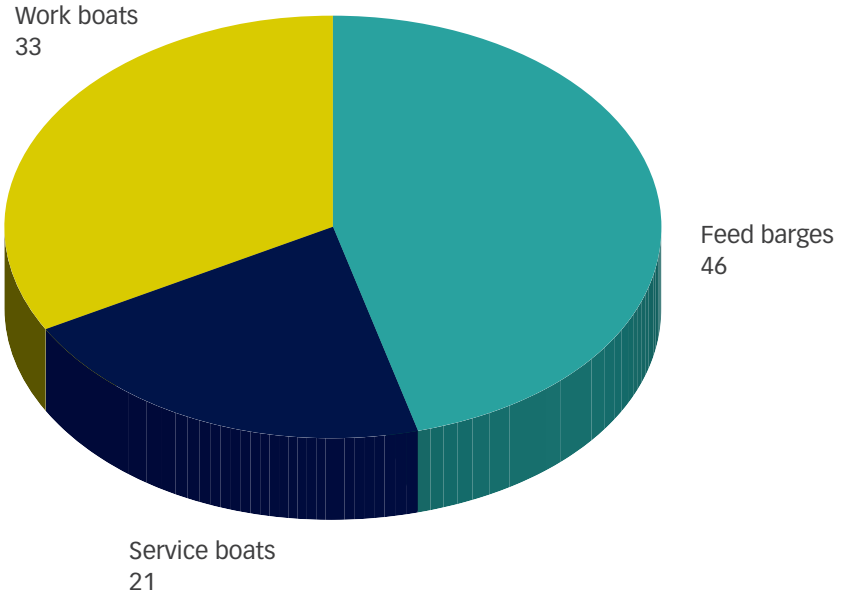
In most farming areas, feed barges are used to feed the farmed fish in the pens, and today there are 15 barges in use in Iceland. Based on the present plans of the fish farming companies, the number of feed barges will increase in the next years. The feed barges are placed by the marine pens and from there, feed tubes are extended into each pen. Feeding is controlled from a feed plant on land or out in the feed barge, and the quantity of feeding depends on the size and age of the fish. The barges are usually removed from the farming area when the feeding session ends and the area is at rest. The feed barges have 2-3 diesel engines that produce electricity that is used to blow feed into the pens, power lights, equipment and surveillance systems.

Energy demand and energy sources

Each generation of fish is farmed for about 18-30 months and a farming cycle often takes about 36 months, including rest periods. When the fish has reached the age of 10 months it is considered that the energy use of the feed barge has reached its maximum, and will remain somewhat stable until the time when the fish is slaughtered. More energy

■ Fish farm in the West Fjords

[5] radarinn.is/fiskeldi



■ Percentage of CO_2 emission from enclosure fish farming plants

ENERGY REQUIREMENTS OF A FEED BARGE	
Energy use per year (diesel)	120,000
Annual energy use of the barge (kWh)	1,200,000
Annual energy use based on 36% efficiency of the diesel generator (kWh)	432,000

■ Average energy requirement of feed barges in Iceland

is required to feed the fish when it is at the peak of its growth cycle Feeding is also done for longer periods in the summer (feeding takes place in daylight conditions). On average, the oil requirement of each feed barge in Iceland is about 120,000 liters per year.

All feed barges in Iceland use diesel oil as their source of energy but there are other options that are greener in nature, such as land-based current connection and battery-diesel engine *hybrids*. These solutions are already being applied in Norway and the Faroe Islands. If they were to be introduced in Iceland, it would significantly reduce the emission of greenhouse gas emission that results from sea cage aquaculture. It is worth noting that Laxar in the East Fjords has worked towards installing a land-based current connection and those efforts are well underway. Arctic Fish is also working on installing a land-based current connection for one of the company's feed barges.

In 2018, a report compiled by ABB and Bellona, on opportunities for electrification in Norwegian fish farming, was issued. Therein it is stated that 48% of oil used in sea cage aquaculture is for powering feed barges, and it may be assumed that this percentage is similar in Iceland.[6]

[6] A green shift in Aquaculture ABB and Bellona

■ A feed barge

Land-connected feed barges

Land-based connections for feed barges is the solution that results in the greatest reduction in the use of fossil fuel. The feed barge is then entirely powered by land-based electricity which is fed to the barge from an electricity distribution network on land through a submarine cable. To be able to use land-connections for feed barges it is necessary to have access to three phase electricity on land and there are restrictions regarding operating distances.

Hybrid feed barges

Most feed barges currently in use can be equipped with the so-called hybrid solution. This consists of installing batteries in the engine rooms of the prams and the diesel engines already present in the barges will supply power to charge the batteries. Diesel engines are running while feeding takes place, and are also used for charging the batteries. Between feeding sessions, the diesel engines are turned off and the batteries are used for powering lights and other systems in the barge that do not require much power. In this way it is possible to shorten the running time of the diesel engine from 24 hours to 6 hours per day, which means that it may be estimated that oil use will be reduced by up to 60%, based on the current setup. These hybrid solutions are suitable where electricity is not accessible or it is impractical to connect the feed barge due to its operating distance from the shore.

Use of electrofuel and green energy instead of diesel oil

There have been extensive developments with regard to the use of electrofuel such as hydrogen in recent years, although the use of hydrogen as a power source in marine-related industries is still at the experimental stage.

It would be interesting to examine if a fuel cell that uses hydrogen can be installed on board a feed barge. In this manner it would be possible to eliminate completely the emission of CO_2 from feed barges that cannot be connected to a land-based current.

Also worth examining is the feasibility of using wind-powered electric power stations or solar cells on feed barges, which would reduce the use of diesel oil.

Carbon footprint of feed barges

As aforesaid, all feed barges in Iceland are powered by diesel oil, and on board each feed barge there are 2-3 diesel engines that generate electricity. It is estimated that each feed barge uses 120,000 liters of diesel oil per year, which means that 15 feed barges will use about 1,800,000 liters of oil. These energy requirement estimates are based on data from the fish farming companies, given in average figures. By connecting feed barges to land-based current where possible, and using battery solutions in areas where it is not possible to connect to land-based current, the emission of CO_2 can be greatly reduced.

CARBON FOOTPRINT OF DIESEL FEED BARGES	CARBON FOOTPRINT OF HYBRID FEED BARGES	CARBON FOOTPRINT OF LAND-CONNECTED FEED BARGES
Annual CO_2 emission for one barge (kg)	Annual CO_2 emission for one barge (kg)	Annual CO_2 emission for one barge (kg)
324,000	129,600[7]	16,200[8]

Carbon footprint of feed barges

[7] Based on a 60% reduction in oil use

[8] Based on a 95% reduction in oil use

Cost of electrification and present operations

It is estimated that the cost of electrification can be between 30-50 million, which is offset by the lower energy cost which could be reduced by as much as 70% through the use of land-connected feed barges. Maintenance and renewal of diesel engines is a large part of the maintenance costs of feed barges, as engines are replaced or rebuilt at regular intervals. This cost is reduced or even eliminated completely if the feed barge is connected to a land-based current.

The cost of the so-called hybrid solution could be between ISK 30-40 million. That solution results in less use of oil and may lower energy costs by 40-60%. It also entails less need for maintenance of diesel engines aboard feed barges.

Profitability of electrification

It is clear that considerable initial costs are involved with the electrification of feed barges, irrespective of whether land-based current of battery solutions are implemented. This investment will be offset by the lower energy cost and less need for maintenance, and the authors' calculations indicate that investment in land-based current connections can break even in 7-8 years and that the internal rate of return (*IRR*) of the investment is 4-5%.

Present actions to encourage energy transition in feed barges

The Energy Fund

Applications can be submitted to the Energy Fund for grants to be spent on connecting feed barges to land-based current or implement battery solutions. The maximum possible amount of grants is 33% of the estimated initial cost of purchasing devices and equipment, and several fish farming companies have already applied for and received support for establishing land-based current connections for feed barges.

Accelerated depreciation

In accordance with the Income Tax Act no. 90/2003 it is permitted to calculate a specific 15% depreciation surcharge for the cost value of assets that meet certain conditions, and it is likely that this provision will apply to investment in green energy solutions for feed barges.

Further actions to encourage energy transition in feed barges

Infrastructure and technical knowledge

It is vital to have sufficiently strong and reliable infrastructure for the fish farming companies to be able to make the transition to land-based current connections. The electricity distribution system must be sufficiently strong to meet the demand that is created when the use of electricity increases, and the service reliability must be somewhat stable. An important part of energy transition in feed barges is the availability of the knowledge and capacity that is required to tend to the installation, connection and maintenance of submarine cables, as well as sufficient technical expertise to operate equipment and comply with safety requirements.

Rebate on fees to the Environmental Fund based on production

The government collects 20 SDR12 for each ton of authorized production, and 10 SDR for rainbow trout and sterile salmon, which goes to the Sea Cage Aquaculture Environmental Fund.

One option would be to grant a temporary rebate on the fee for salmon that is produced using electrified feed barges. For example, an enclosure fish farming company could be granted a 50% rebate for salmon that is produced using a feed barge that is connected to a land-based current, and a 20% rebate for production where battery solutions are used.

In that manner, a direct financial incentive would be created for investing in green energy such land-based electric connections or battery solutions.

Rebate on resource fee based on production

The government collects a resource fee for enclosure fish farming production. The amount of the fee is based on the international market price of salmon, and payment is per each kilo of fish slaughtered. Potentially, a temporary rebate could be granted on the resource fee for farmed fish that is reared in farming areas where green energy such as land-based current, battery solutions or other green energy methods are used.

Rebate on fees to the Environmental Fund based on investments

It might also be feasible to permit companies to subtract a certain percentage of investment in land-based current or battery solutions from the fee payable to the Sea Cage Aquaculture Environmental Fund. For a ISK 50 million investment in land-based current installations it would be possible to request a rebate of ISK 20 million on the fee to the Environmental Fund, and if 50 million were invested in battery solutions a request could be submitted for a rebate of ISK 10 million on the fee.

Government policy-making in cooperation with the industry

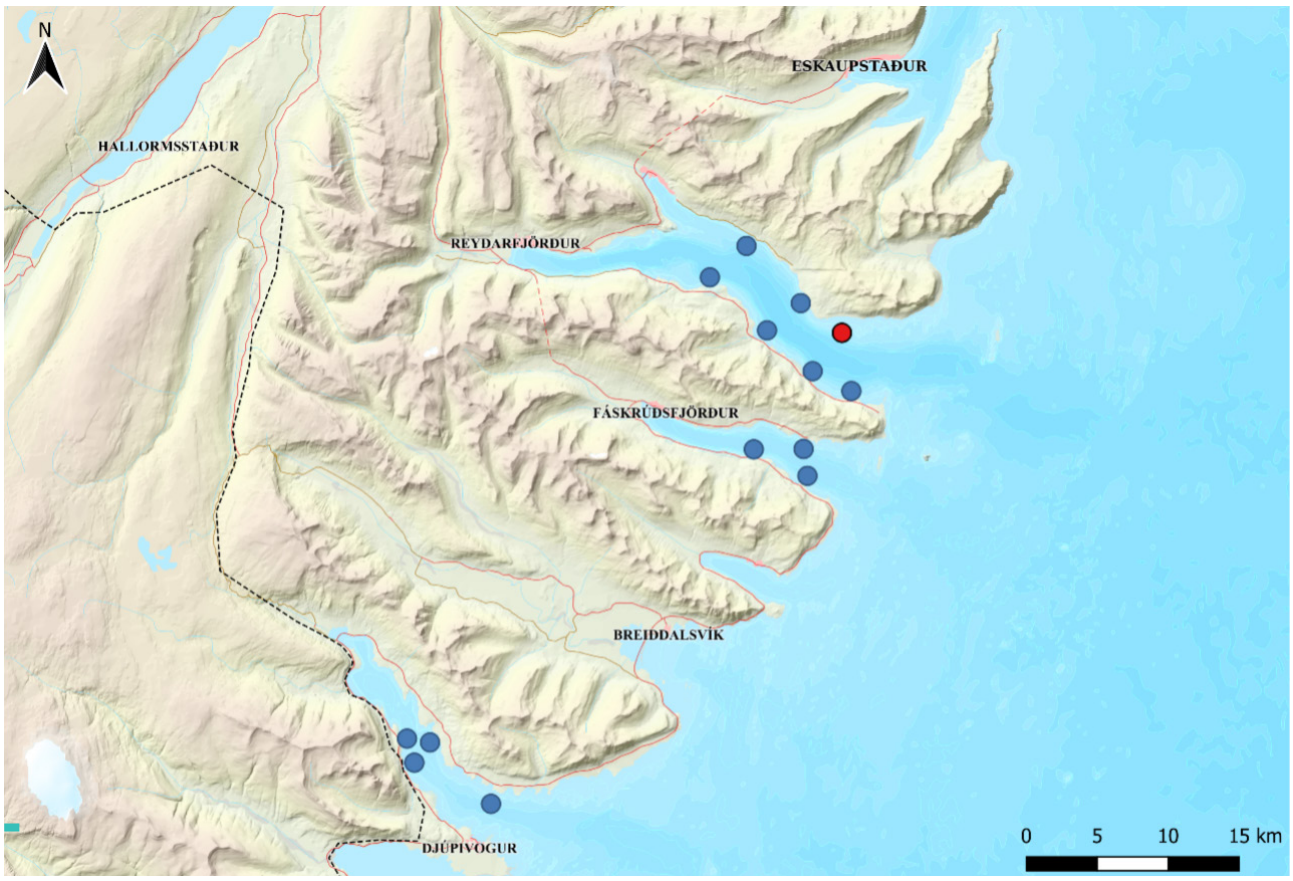
In July of 2021 a report was issued under the title Green steps in fisheries, which was compiled by a team appointed by the Minister of Finance and Economic Affairs. This report includes a review of ways in which emissions from ships and boats can be reduced, and proposals for measures are discussed.[9] One option is that the next steps would be to define specific goals regarding the fish farming industry and determine how such goals could be supported and encouraged. The government could also take on a leading role in forming policy in cooperation with the fish farming companies, municipalities and other interested parties to work towards mutual goals regarding reduction in emissions from fish farming activities.

[9] Green steps in fisheries. The Ministry of Finance and Economic Affairs

Conclusion

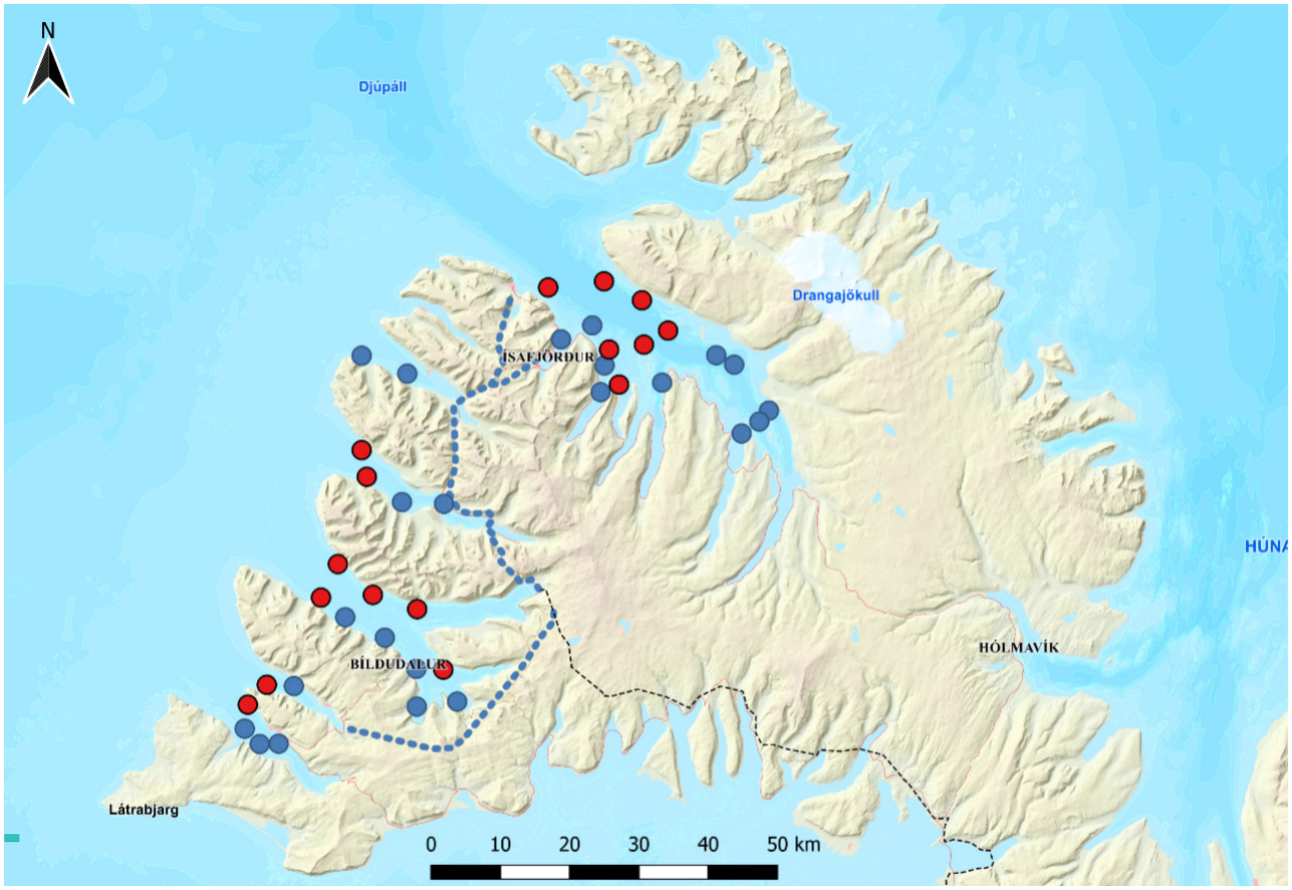
As aforesaid, sea cage aquaculture is a growing industry in Iceland and it is likely that it will continue to grow in the next years. In 2020 the Marine and Freshwater Research Institute issued an updated risk assessment[10] which authorizes a maximum biomass of 106,000 tons of fertile salmon in the East Fjords and West Fjords, and the production in that same year was 34.000 tons. It may be assumed that it is feasible to connect 50-60% of all fish farming areas to land-based current, which means there is much potential for reducing the use of fossil fuel in the nest years.

It is clear that the fish farming companies are interested in using green energy solutions. Certain companies are already working on establishing land-based electric current installations for connection to feed barges, as well as taking steps towards using batteries to reduce the use of fossil fuel. The chief obstacles to these companies in their efforts to electrify feed barges are the cost, uncertainty regarding licensing and technological impediments regarding connections, servicing and maintenance of marine cables.



■ Overview of fish farming areas in the East Fjords. A blue dot represents an area where connections might be feasible, and red areas represent locations where it is unlikely that land-based connections would be implemented

[10] Risk assessment with regard to genetic mixing



■ Overview of fish farming areas in the West Fjords. A blue dot represents an area where connections might be feasible, and red areas represent locations where it is unlikely that land-based connections would be implemented

Suppliers of electricity are also keen to provide the electric power, and even prepared to invest in the infrastructure required for its delivery. However, if this is to happen it is a prerequisite that the future organisation of fish farming areas is established, and also required is the availability of the expertise and ability to provide the installation and maintenance of connections. The representatives of the fish farming companies and the electricity suppliers all agreed that incentives such as temporary rebates on fees were very likely to lead to increased investment in greener solutions.

It is clear that the government can play an important part in accelerating energy transition in feed barges through incentives and clear policy-making. If the proper incentives are provided it would be feasible to connect 50-60% of feed barges in Iceland to land-based electric current, and to implement battery solutions in the barges that cannot be connected in that manner. In that way it is possible to reduce CO_2 emissions from feed barges by 50-80% in the next 4-6 years.

In Norway, the state-operated fund Enova SF has made targeted efforts to support financing of green solutions, and in 2020 support was provided to 13,000 energy and climate-related projects to the total amount of NOK 3.3 billion. This Fund has provided support to many fish farming companies in their work relating to the installation of land-based connections for feed barges, and today about 70% of feed barges are connected to land-based electric current.

In light of the fact that fish farming is a growing industry, the authors propose that the Ministry of Higher Education, Science and Innovation, the Ministry of Finance and Economic Affairs, as well as the Ministry of the Environment, Energy and Climate take on a leading role in exploring ways in which it would be possible to encourage energy transition in feed barges and thereby advance Iceland's ambitions towards reducing CO_2emission.

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Blámi is a collaborative project of Landsvirkjun, Orkubú Vestfjarða and Vestfjarðastofa.

The primary objective of Blámi is to support and promote innovation and development of energy transition projects by expanding the role of environmentally friendly fuel, hydrogen and electrofuel in transportation and industry. Blámi wishes to encourage energy and climate related innovation, support entrepreneurs and improve the innovation environment in the West Fjords.

The purpose of Blámi is to bring together individuals and companies that can work together towards obtaining international financing for experimentation, research and development in energy and climate-friendly solutions. By increasing cooperation between companies and government bodies it is possible to support projects and opportunities, while increasing the creation of value and competitiveness.

Blámi will make use of local strengths, human resources and companies to create a fertile soil for innovation and increased creation of value.