EXPANSION SCHEDULE

Summary

2023

umhvørvisstovan

SEV

Expansion Schedule

Main Report

Model Calculations

Summary

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1. Introduction

This summary recaps the analyses, results, and recommendations from two reports, *Expansion Schedule: Main Report* and *Expansion Schedule: Model Calculations*.

Both reports and this summary were submitted to the Minister for Energy in October 2023.

The agreement from March 2022 between the then Minister for Energy, Magnus Rasmussen, and the negotiation group representing the municipal sector and SEV stipulates that the energy authority and SEV, the grid operator, must set up and agree on a timeline for tendering renewable energy power plants. Tendering and expansion of the electricity system (grid, etc.) must go hand in hand, i.e., the electricity grid in an area where power plants are to be placed must be sufficiently expanded to receive the additional energy.

A working group formed in June 2022 began organising the work. In short, its task is forecasting energy consumption and, based on this, drawing up proposals for a renewable energy expansion timeline for the next five years.

1.1 A BRIEF OVERVIEW OF THE WORKING GROUP'S PROCESS

The working group used the digital simulation tool Balmorel as its primary tool.

The simulation process is discussed in the report *Expansion Schedule: Model Calculations.*

To achieve the best results, precise figures for electricity consumption in the Faroes and data on the expected growth in the coming years were required. Information on the kinds of green production technologies that can be used in the Faroe Islands was also needed.

First, a model of the current Faroese electricity system was made, including existing investment opportunities and limitations, such as CO_2 emissions. Then, Balmorel calculated the most efficient production possible with minimal investment and operating costs. Based on these results, specific projects that are feasible in practice were identified. Once this was done, Balmorel was set to recalculate, now with fixed investments, only production being optimised. With these results, it is, for example, possible to determine if output in 2030 will be 100% green and if the optimised production is economically viable.

2. Energy consumption forecast

This section deals with electricity consumption up to 2040. Two forecasts have been made: one considering likely consumption, called the *Probable consumption forecast*, and one based on a more rapid transition in heating and land transport, called the *High consumption forecast*.

2.1 TOTAL ENERGY CONSUMPTION FORECAST 2022-2040

- Excluding energy transitions in existing land-based industries and at sea

Figure 1 shows growth in electricity consumption up to 2040 in the probable consumption forecast. The figure shows that demand in 2030 is estimated to be around 675 GWh and around 935 GWh in 2040.

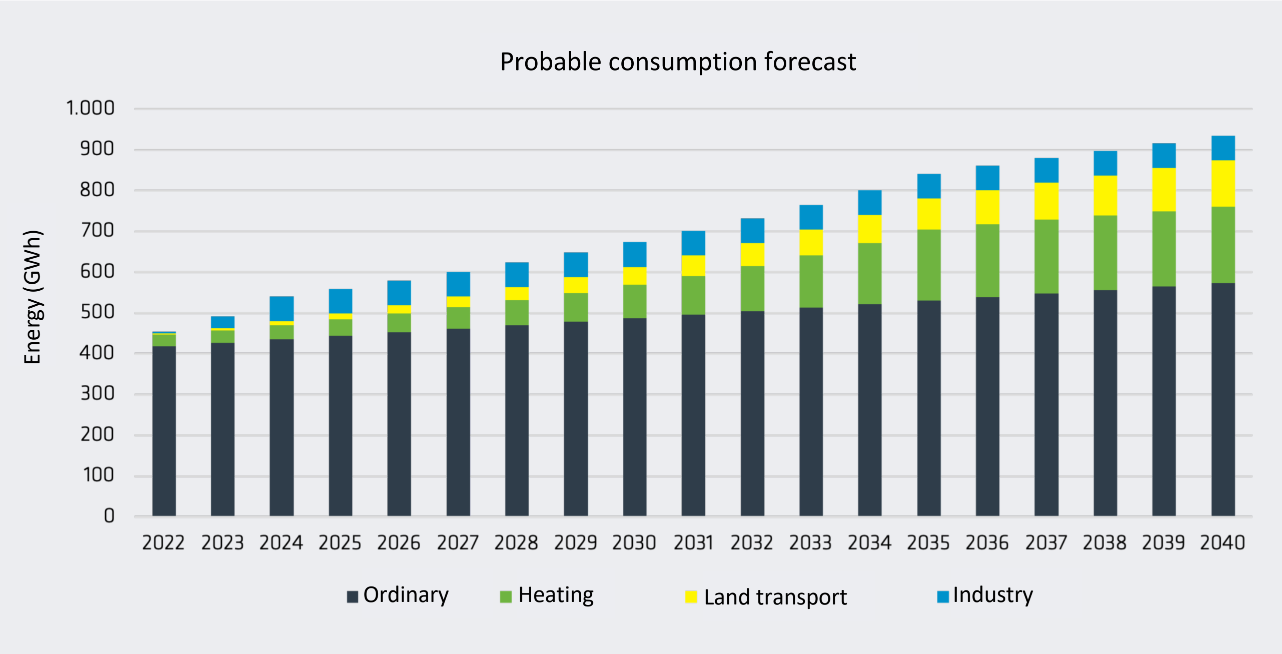

***Figure 1** Probable consumption forecast*

Figure 2 shows the growth in electricity consumption up to 2040 in the high consumption forecast. It shows that electricity demand in 2030 is estimated to be around 845 GWh and around 1,125 GWh in 2040.

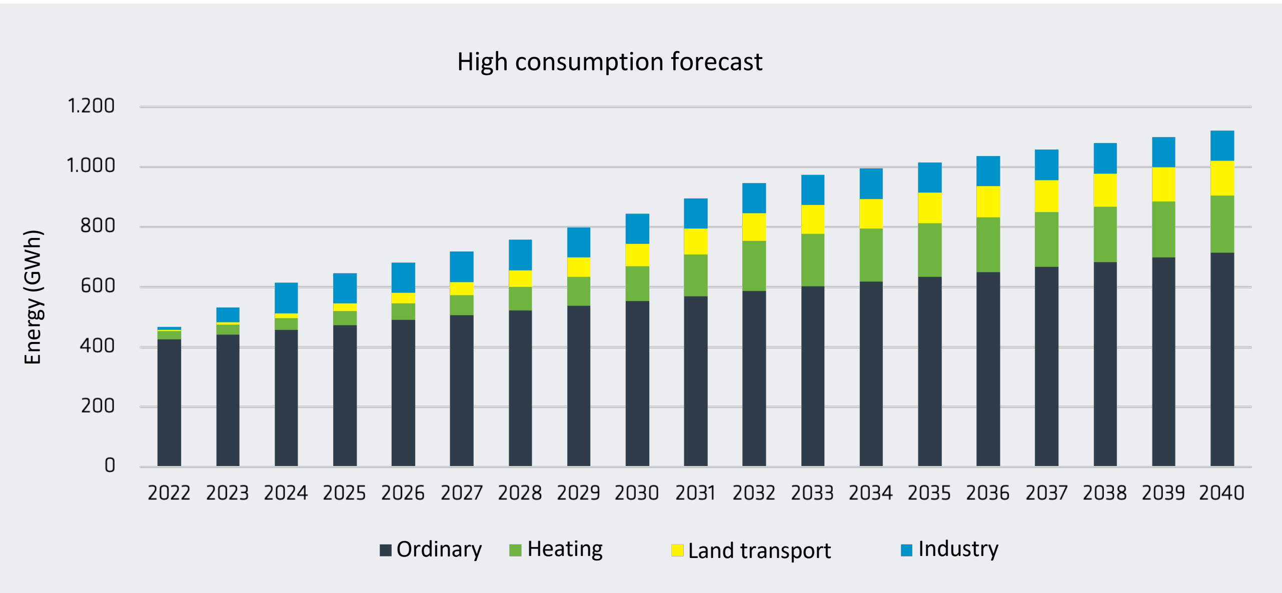

***Figure 2** High consumption forecast*

The two consumption forecasts, see Figures 1 and 2, take into account ordinary electricity consumption, heating and land transport as well as industrial development and expansion. They are used as the basis for the expansion plan up to 2040.

2.2 ENERGY CONSUMPTION FORECAST

- including energy transitions in existing land-based industries and at sea

Considering the transition from oil to electricity in existing land-based industries and at sea, assuming that half of seaborn vessels will use ammonia by 2040, a significant increase in energy demand is evident, mainly due to the energy transition at sea.

Figure 3 shows how significant the electricity demand can become if existing land-based industries are electrified and half of the oil consumption at sea is replaced with green fuel produced in the Faroe Islands.

High consumption forecast

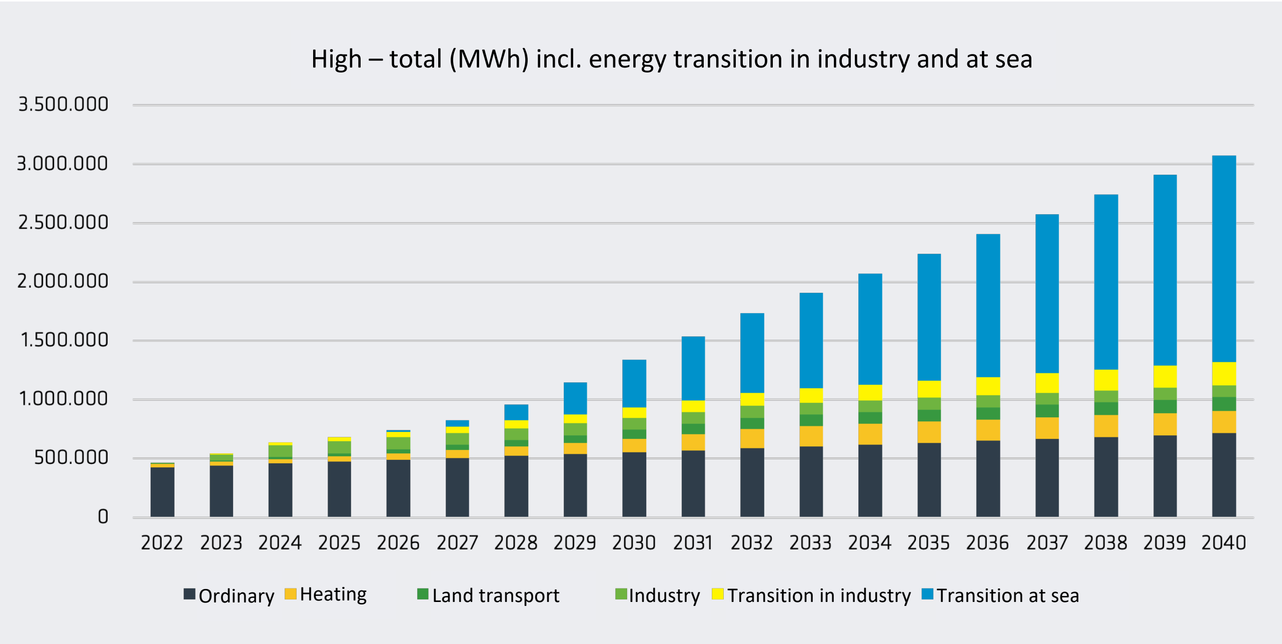

Figure 3 *High consumption forecast, including energy transitions in industry and at sea*

Figure 3 shows the consumption forecast with the highest energy demand. This consumption forecast estimates that the energy demand will be around 1,320 GWh in 2030 and increase to around 3,100 GWh in 2040. It should be noted that energy demand at sea accounts for a good half of the total energy demand, even though only half of seaborn vessels have transitioned by 2040.

If all energy consumption at sea is converted to ammonia produced in the Faroe Islands by 2040, the electricity demand will be around 4,600 GWh annually.

3. Expansion schedule

The analysis leads to an expansion schedule that indicates what type of power plants will produce electricity in the coming years. Figure 4 shows the types of power plants producing energy from 2023 to 2030.

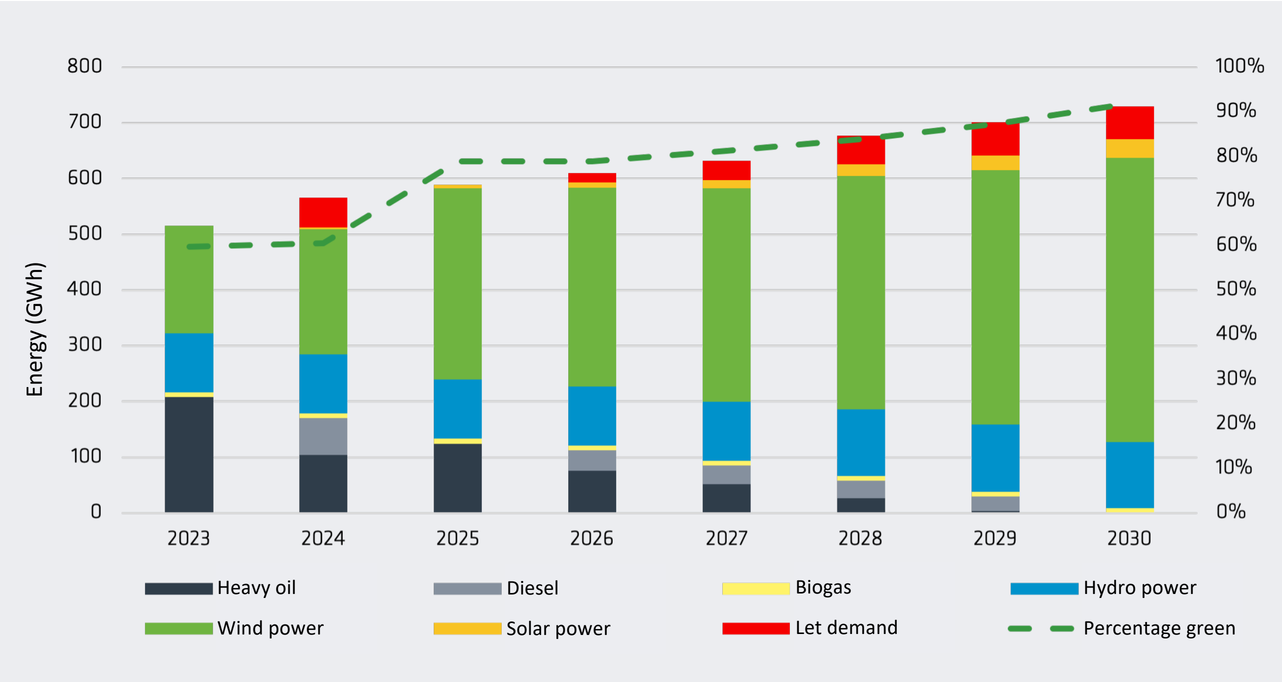

Figure 4 *Power generation categories in the expansion schedule*

The figure shows, among other things, that green energy accounts for 92% of the production in 2030. It also shows a shortfall of green energy ("let demand") during some years if the requirement to linearly reduce CO_2 emissions from electricity production to zero by 2030 is to be met. In 2030, there is an energy shortfall of approximately 59 GWh, corresponding to an 8% shortfall in becoming 100% green. If these 59 GWh in 2030 can be produced with a CO_2-neutral fuel, e.g., at the Sund power plant, then the total production can become 100% green in 2030.

3.1 FINANCING THE EXPANSION PLAN

The expansion plan proposes production tools and operations changes with evident financial implications for investments and operations.

Figure 5 shows investments and operational costs from 2023 to 2030. The costs shown are annual: for example, the investment cost for a wind farm in one year corresponds to the total investment cost for the wind farm divided by its lifespan.

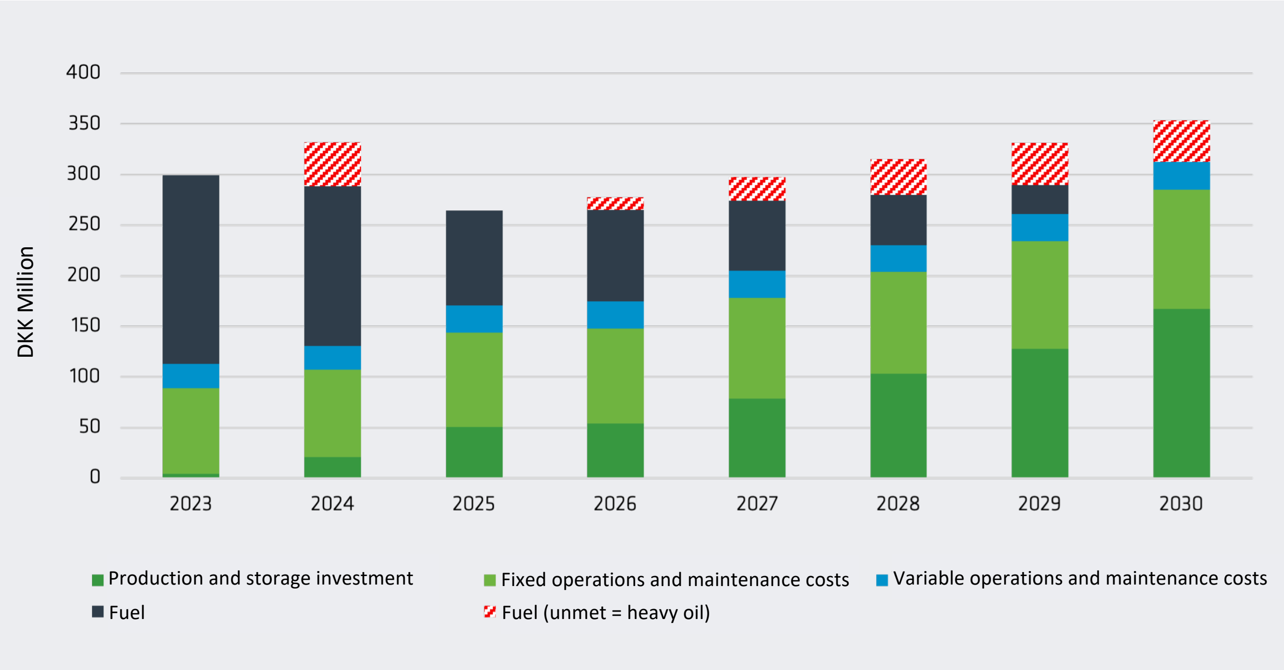

Figure 5 *Investment and operational costs in the expansion plan from 2023 to 2030*

Investments in green production tools and battery storage total DKK 607 million. Fuel expenditure (heavy oil) totals DKK 675 million but decreases to zero in 2030.

Since the expansion plan, as mentioned, provides only 92% green production, other fuel types are needed to meet the remainder of the output. It is assumed that the unmet demand will be produced with heavy oil. The total cost for this output will be approximately DKK 200 million.

3.2 CO_2 REDUCTION IN ELECTRICITY GENERATION

Figure 6 shows how CO2 emissions from electricity production will decrease towards 2030 as renewable energy production is expanded.

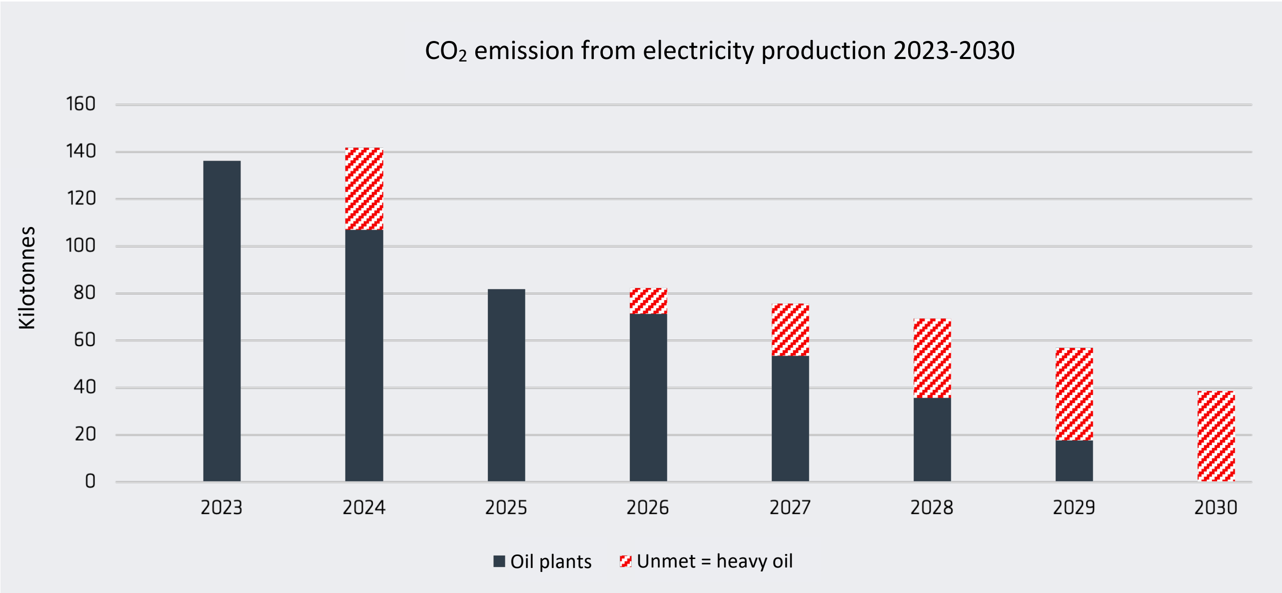

Figure 6 *CO_2 emissions from electricity production with heavy oil between 2023 and 2030*

Again, a shortfall of green energy ("unmet demand") is evident during some years if the requirement for a linear reduction in CO_2 emissions that reaches zero by 2030 is to be met.

Assuming that this remaining energy is produced with oil at the Sund power plant, CO_2 emissions will be approximately 27,000 tonnes in 2030. If the remaining energy is instead produced with green fuel, CO_2 emissions will be almost zero.

As mentioned above, two forecasts have been made, one with *probable* and one with *high* consumption. Table 1 shows a rough estimate of the reduction in oil consumption in the probable forecast for the various consumption groups.

In 2030, emissions from 172,100 tonnes of oil will be approximately 550,000 tonnes of CO_2. This is **45%** lower than in 2010.

If SEV's fuel is CO_2 neutral, emissions will be 40,000 tonnes lower, or 510,000 tonnes, which is **49%** lower than in 2010.

	2022 (tonnes)	**2030 (tonnes)**
Consumption Category	**Oil Consumption**	**Probable Oil Consumption**
Land transport	35,000	17,850
Heating buildings	45,000	15,750
Land-based industry*	25,760	16,000
Maritime industry*	144,200	110,000
SEV	43,588	12,500
Total	295,000	**172,100**

**Not included in the simulations*

Table 1 *Oil consumption divided into consumption categories*

3.3 WIND POWER

The expansion plan recommends building wind farms in specific locations around the Faroe Islands.

Table 2 shows where and when these farms should be set up and what their output should be.

Placement	Island	Output (MW)	Tender	Operation
Porkeri	Suðuroy	6	2024	Q3*/2025
Klivaløkshagi	Sandoy	20–30	2023–24	Q3/2025
Glyvrafjall	Eysturoy	25	2025	Q3/2027
Junkarahagi	Streymoy	21	2028	Q3/2029
Vestfelli	Sandoy	50	2029	Q3/2030
Total output		132–142		

***3rd quarter**

Table 2 *Expansion plan for wind energy in the period from 2023 to 2030*

Other locations not included in the above table are also of interest. For example, Eiði, where a tender for 18 MW has been temporarily halted, and Kirkjubøreyn, one of the best-suited areas in the Faroe Islands.

The working group recommends that efforts be made to make Kirkjubøreyn available for wind energy production.

It also recommends looking more closely at various ways to tender wind energy that can increase interest in participating in tenders and operating wind farms, e.g., by tendering a series of wind farms at a time with conditions on when and where the wind farms should be set up.

3.4 SOLAR POWER

Solar energy plays an important role in the future energy system because the majority of generation is in the summer half of the year when there is less generation from wind and water.

Year	Norðurstreymoy and Vágar	Norðureysturoy and Sundalagið	Norðoyggjar	Suðureysturoy, Suðurstreymoy, Hestur and Nólsoy	Sandoy	Suðuroy	Total
2024	-	-	1	2	1	1	5
2025	-	-	1	2	1	1	5
2026	-	-	1	2	1	1	5
2027	-	1	3	3	1	2	10
2028	-	-	3	3	2	2	10
2029	8	2	-	-	-	-	10
2030	5	3	-	2	-	-	10

Table 3 *Expansion plan for solar energy from 2023 to 2030. All figures are in MW*

Table 3 shows examples of where solar energy systems can be set up nationwide. This can be done through organised tenders but also by accelerating the installation of larger and smaller systems on rooftops and large buildings.

In total, it is recommended that 55 MW be installed, which can produce approximately 40 GWh of green electricity.

One way to tender solar energy could be to make a public tender for 5 MW in 2024 without requiring a specific size or location. Interested parties can then submit bids, which the grid company and the authority review jointly in terms of location, connection, and economy. This type of tendering provides flexibility regarding location, which can be on suitable land, large industrial buildings, or possibly as floating solar farms on lakes.

Since this is the first tender of its kind in the Faroe Islands, such a tender method should be reviewed after the first tender, and necessary adjustments made before the next tender. The working group recommends that the first 5 MW of solar energy be tendered in 2024.

The working group recommends looking more closely at various ways to tender solar energy that can increase interest in participating in tenders and operating solar energy plants.

3.5 ELECTRIC BATTERIES AND A PUMP SYSTEM

SEV has concrete plans for expanding battery systems in the coming years. The primary purpose of these battery systems is to ensure stability in the electricity system when it is expanded with intermittent energy sources.

Table 4 shows when and where batteries should be installed and how large they should be.

Year	Placement	Output (MW)	Energy storage (MWh)
2023	Sund	12	12
2024	Skálabotnur	25	25
2025	Sandoy	15	15

Table 4 *Battery systems*

Batteries are particularly important in stabilising electricity from wind farms and solar energy systems and in storing energy for periods shorter than an hour. This is why they are decentralised throughout the electricity grid and why they will be installed soon. The need for batteries as energy storage will be somewhat reduced when the pump system in Vestmanna is operational. The pump system has some of the same characteristics as batteries and can store far more energy.

3.6 SURPLUS ENERGY

In an electricity system with many unstable production units, there will be periods when production exceeds consumption. This is the case even if batteries and pump systems are part of the system. Therefore, there will always be electricity that cannot be fed into the grid when available, which is called surplus energy.

Figure 7 shows the forecast of potential surplus energy up to 2030 by year.

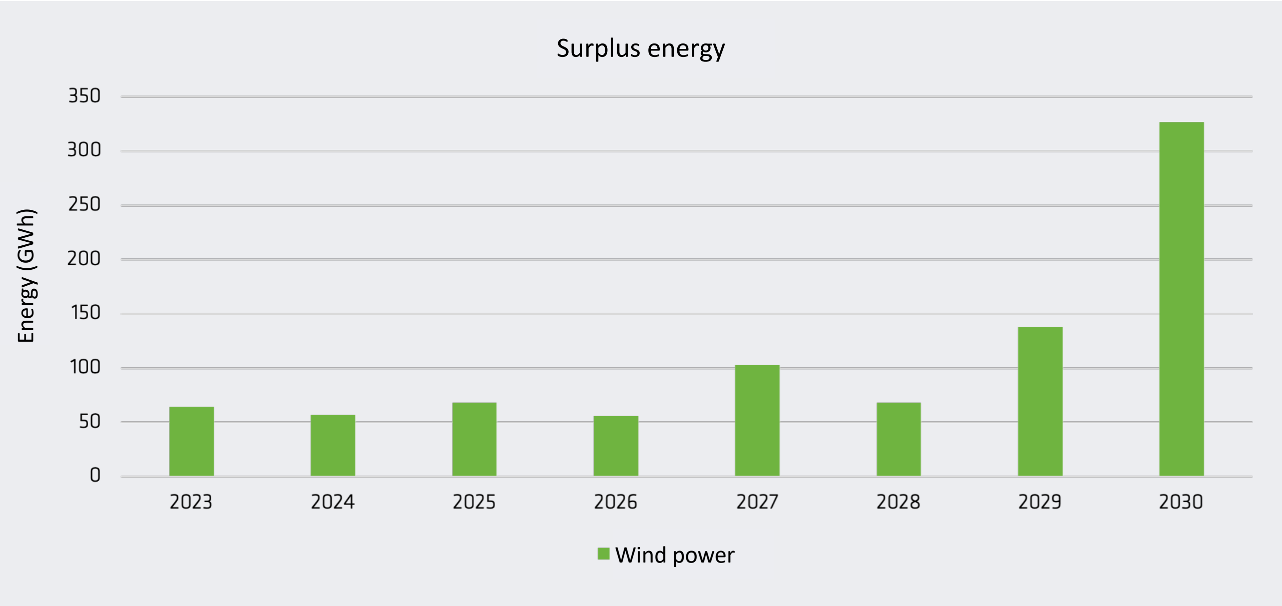

Figure 7 *Potential surplus energy, 2023–2030*

The challenge with surplus energy is the uncertainty of when it will be available. From a socio-economic perspective, surplus energy should be utilised as far as possible for some useful purpose, where the energy demand is flexible and can be staggered somewhat over time. It is also conceivable that surplus energy can be stored, e.g., as heat, hydrogen, or in another way.

One option could be to utilise surplus energy, with its limitations, in industrial activities that run on oil today. An example could be process heat, which today is produced from oil. Here, surplus energy could be used directly or stored in heat stores, thus reducing oil consumption.

3.7 OFFSHORE WIND TURBINES

Based on the probable consumption forecast, simulations show a need for approximately 40 MW of offshore wind energy by 2030, which will increase to approximately 200 MW by 2040. The high consumption forecast indicates a need for approximately 80 MW already in 2030, which will increase to approximately 460 MW by 2040. If the exceedingly demanding energy transition at sea is included, the need for offshore wind turbines will be significantly greater.

Figure 8 shows the need for offshore energy.

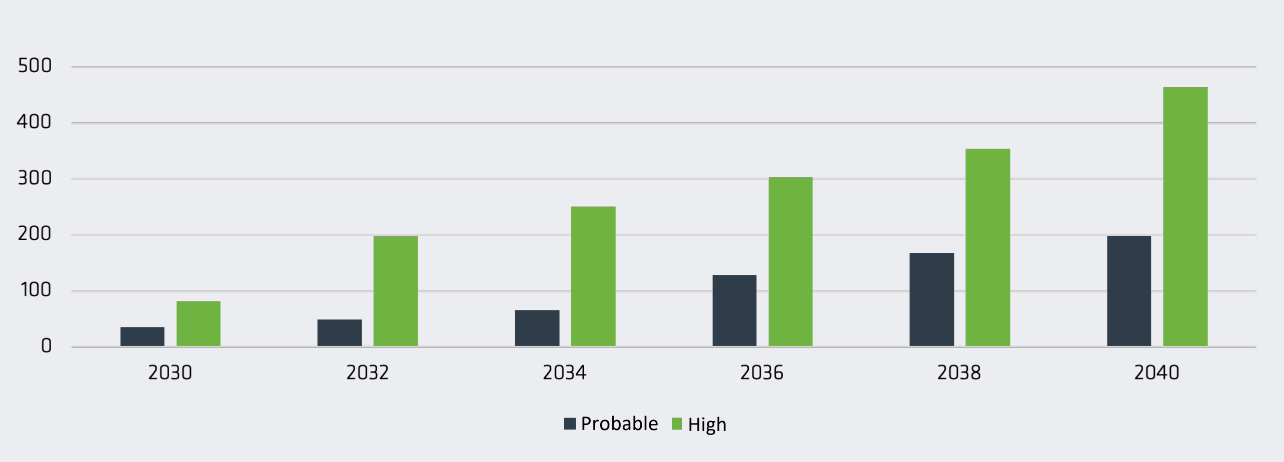

Figure 8 *Offshore wind power, potential expansion up to 2040, applying probable and high consumption forecasts*

Offshore wind turbines may need to produce vast volumes of energy. Experiences elsewhere show that preparing areas at sea for energy purposes is time-consuming, the permit process being particularly protracted.

The working group recommends that the authorities in the Faroe Islands start organising this work as soon as possible and conduct the necessary studies so that offshore wind energy tenders can be carried out when needed.

3.8 GREEN FUEL (P2X)

There is little doubt that hydrogen, produced from renewable energy, will play an important role in achieving the energy transition at sea.

The production of hydrogen by electrolysis of water is a technology that is developing rapidly worldwide. Hydrogen can be used directly or be the basis for P2X production of liquid fuels, which can replace fossil oil, especially in the transport and fishing industries.

Figure 9 illustrates one type of P2X: ammonia production from water and air using electricity from wind turbines and solar energy.

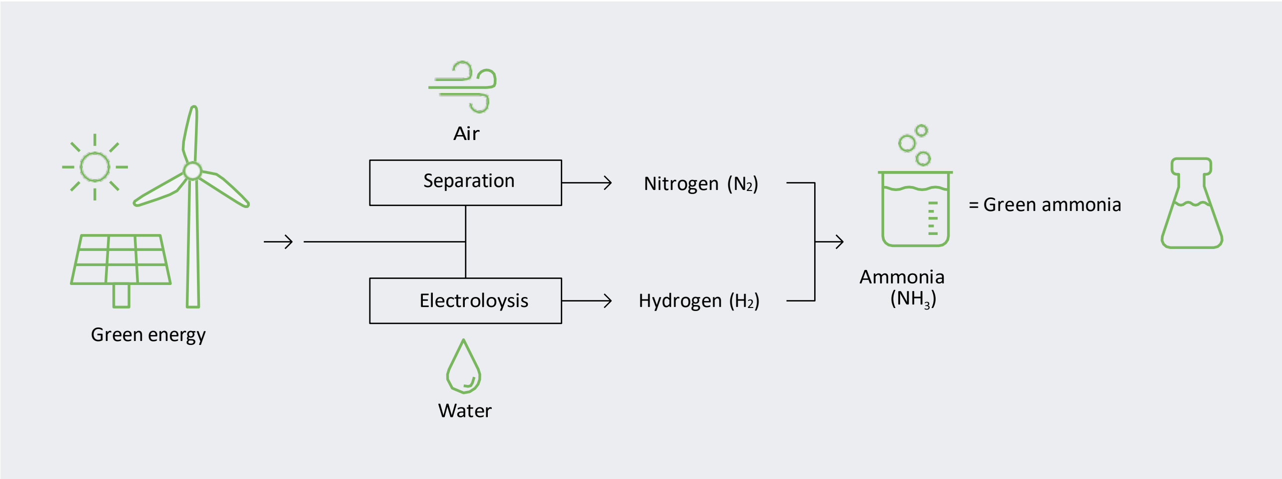

Figure 9 *Production of ammonia, simple description*

In the Faroe Islands, the first steps in this direction will be taken over the next two years through a joint electrolysis project involving the Faroese Environment Agency, SEV, and the Technical University of Denmark (DTU).

3.9 DISPATCHABLE POWER

The concept of dispatchable power includes power plants that can always feed the electricity grid with power, regardless of season, weather, and wind. Today, only oil-fired plants can provide dispatchable power. This is likely to change when new power plants can burn green fuels such as ammonia or methanol.

The need for dispatchable power grows as electricity consumption increases. Figure 10 shows how the need for dispatchable power is expected to grow in line with increased electricity consumption in Suðuroy and the central area.

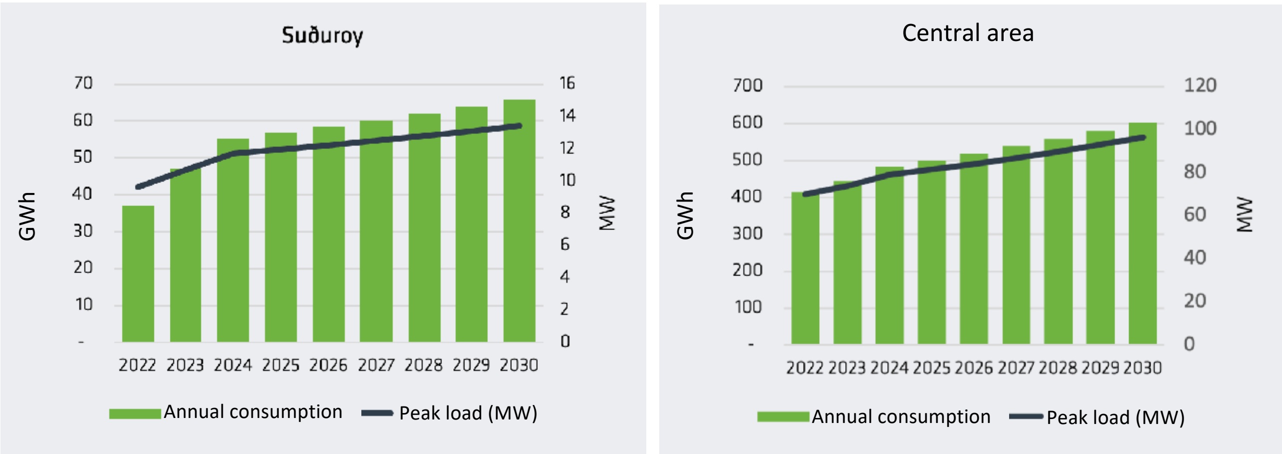

Figure 10 *Forecasted electricity consumption and peak load (probable forecast) in Suðuroy and the central area*

In forecasts of the peak load on the grid, no account is taken of an increase in the potential need for the production of green fuel for the maritime industry nor for the electrification of existing land-based sectors, both of which will undoubtedly increase the load on the grid significantly. However, it is conceivable that the production of green fuels and industrial consumption can be controlled to some extent to limit the need to expand dispatchable power.

The working group recommends that work be initiated immediately to analyse how to ensure a stable and reliable electricity supply, both in terms of meeting the energy demand (GWh) and ensuring that there is always enough power available (MW).

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