Comprehensive Plan for Electric Energy in the Faroe Islands

Vinnumálaráðið / Ministry of Trade and Industry

2011

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1. Terms of Reference & Introduction

1.1 Terms of Reference

On 7 April 2011, the Ministry of Trade and Industry sent out a press release which stated, *inter alia*, the following:

"Triple E -- Energy, Environment, Economy -- is well known, indicating that energy, the environment and the economy go hand in hand. Many reports, white papers and prospective plans have been prepared in the past, but now the times require the preparation of a comprehensive plan for electric energy and that it be detailed enough to provide the basis for political decision making, initiatives and possible amendments to legislation this coming autumn.

Electrification within Faroese society in the coming years is certain. Electrification is necessary for both financial and environmental reasons and it has become technologically more and more practicable. Electrification will mean greater electricity usage within society and this will in turn place greater demands on our electricity production and our electricity grid. If electric power continues in the main to be produced, as today, from oil, nothing is gained. The environmental goals will not be attained, we remain bound to imported oil, and our economy will be restrained by high oil prices and diminished potential.

Terms of reference:
It is desired that a comprehensive plan for electric energy in the Faroe Islands be ready to submit on 1 July 2011 so that steps may be taken to launch initiatives and changes in the autumn of 2011.

The comprehensive plan shall be comprised of detailed analyses, conclusions and recommendations within five main areas, which are:

1. Electrification
2. Electricity production
3. Grid elements and grid management
4. Economy
5. Relevant legislation and organization

The comprehensive plan shall encompass a timeframe from now to 2020 and shall provide commentary that envisions future issues in 2050."

The Comprehensive Plan is hereby submitted to the Minister of Trade and Industry.

Tórshavn, the 11th of August 2011

1.2 Introduction

For many years now, concerns about the environment and energy have gained wide attention. Climate change prompted by changes in the environment is a sensitive, highly-charged issue, which has attracted much attention. This, coupled with a steadily increasing need for energy and decreasing reserves of fossil fuel, makes it imperative that the major focus in the future should be on renewable energy resources.

The current situation in the Faroes is thus:

- The greater portion of heating and more than half of our electricity production is from oil
- Industry is extremely dependent on oil
- Transport to and from the Faroes and on land is dependent on oil
- There is considerable wind and strong tides available for renewable energy production
- There is ample hydropower, which might also be exploited as a source of energy storage

Most advanced countries have taken steps to minimize their dependency on fossil fuel. However, it must be acknowledged that this cannot be achieved overnight, and that all of the necessary technology is not available today.

We must stay abreast of what is occurring outside the Faroes, and we must adopt what is suitable for our circumstances. Moreover, we should investigate whether it is practicable to link the Faroese grid to that of other countries (the European continent and Iceland), and what advantages and risks could exist with such a cable connection.

This will cost a great deal. Cost, however, is not a major threat, for energy costs will no doubt grow over time. Our energy policy must also be been viewed in the context of or as part of a total industrial policy. These two policies are inextricably joined, because competitiveness and continuous energy production are prerequisites for business development.

The Ministry of Trade and Industry and the Faroese Earth and Energy Directorate (Jarðfeingi) have resolved, within the context of energy policy, to initially analyze electricity production on land and in this connection to determine whether existing technology, organizational structure and plans are sufficient to meet the challenges that lie ahead. The challenges are great, but much depends on whether the solutions are coherent and interconnected – so that energy, the environment and economic development can truly go hand-in-hand. Advances in technology will enhance the potential of beneficially exploiting renewable energy sources, reducing CO_2 emissions and creating new economic development.

This report is organized into seven sections.

Following this introduction, the report's conclusions and recommendations are gathered together in a separate section. The analysis section follows. This particular section discusses how electric energy is organized in the Faroes and the legislative framework. Also some relevant questions are addressed regarding possible changes in the organizational structure and existing legislation. The fourth part discusses the economic conditions present in the Faroese energy sector. Various technical issues within the electric energy sector are explored in the last three sections. The fifth section provides estimates regarding our energy needs in the coming years. The sixth section discusses the shift from energy production by fossil fuels to renewable sources. The seventh and last part reviews some possible sources for electric energy production.

1.3 Definitions

Below are the definitions for some of the terms used in this comprehensive plan:

Effect is energy per unit of time and is measured in Watt (W), kilowatt (1 kW = 1,000 W) or megawatt (1 MW = 1,000 kW).

Electric energy is measured in kilowatts per hour (kWh), megawatts per hour (1 MWh = 1,000 kWh) or gigawatts per hour (1 GWh = 1,000 MWh). One gigawatt-hour is 1,000,000 kWh.

Electrification is the process of shifting energy supplies from, e.g., fossil fuel sources to electric energy. An example of electrification is to shift from using oil for the heating of homes to the use of electricity, and to use vehicles powered by electric motors rather than petrol or diesel.

HVDC (high voltage direct current) cable is used to transmit large amounts of energy great distances with minimal energy loss.

Pumped Storage (PTS) is a method of storing surplus energy that is produced over a period of low demand to be used later during peak periods of consumption. In the Faroes, the current discussion is to use unstable excess wind energy to pump water from a lower to a higher reservoir and in this way store wind energy as hydropower that could be used when there was a need.

Smart Grid (or intelligent net) is an electricity grid that can manage production and the use of electric energy via a centralized, intelligent system. For example, a fluctuating renewable energy source could be used to advantage in a system that also has a high level of production security and is financially sustainable.

2. Conclusions and recommendations

To provide an easily accessible overview, the Plan's conclusions and recommendations are gathered together in this section.

1.

Conclusion

Transparency is lacking in the system.
Prerequisites for new electricity production are inadequate under current legislation.
Nearly impossible to create real competition.

Recommendation

Legal requirement that all new production facilities based on hydro- or windpower or other renewable energy should be let out to tender.

2.

Conclusion

Possibility for a new producer to initiate Pumped Storage is limited under current system.

Recommendation

Secure definitive legislative authority permitting a third-party to establish a Pumped Storage enterprise that links into the hydroelectric facility of SEV.

Possibly secure the legislative authority for the government to establish a new electricity production facility associated with Pumped Storage.

3.

Conclusion

Municipal interests may come into conflict with the interests of SEV as an electricity utility.
Current organizational structure of SEV can be a barrier to rapid development of renewable energy resources.

Recommendation

Place the SEV grid infrastructure under independent management.
Transfer property/facilities matters from the municipalities to the central government.
Restructure the activities of SEV into corporate entities – grid-related in one, production in another.

4.

Conclusion

Production costs of electricity are proportionally higher in the Faroes than in, e.g., Denmark.
In the Faroes, there is no duty or fee without MVG.
In Denmark, there are a series of fees that are, among other things, designed to advance the adoption of renewable energy resources, which means that the price the end-user pays is higher in Denmark than in the Faroes.

Recommendation

A system designed to encourage the adoption of advanced technology and ideas should be considered, e.g. lower electricity prices for households heating with heat pumps.
Also other environmental levies or fees should be considered that could be directed to accelerate the adoption of renewable energy sources.

5.

Conclusion

The international price of oil has a major impact on the price of electricity production in the Faroes, and the cost per kWh of electricity production is higher from oil than from hydro or windpower. The investment costs of hydropower expansion are proportionally greater, while the investment costs of expansion in windpower or Pumped Storage are proportionally lower and result in a proportionally lower production cost per kWh.

Recommendation

Expansion of windpower and Pumped Storage should be allocated the highest priority in the augmenting of electricity production.

6.

Conclusion

Electrification for purposes of home heating and transport on land demands a significant increase in electricity production.

Recommendation

Accelerate the electrification of home heating and land transport.
Implement effective campaigns/initiatives designed to reduce energy consumption.
Increase the amount of electricity produced from renewable energy sources.

7.

Conclusion

There is a limit to how much hydropower can be expanded to meet an increasing demand for electricity.

Recommendation

Initiate a precise study on which energy resources could be linked together in a future Faroese electric energy grid.

8.

Conclusion

Oil-fired power plants, which today are the foundation of our electricity production, are too expensive to operate and produce too much CO_2 emissions.

Recommendation

A reorganization should be carried out within electricity production such that wind becomes the foundation underpinning production, hydropower shall be used to balance load and store wind energy, and oil- and gas-fired power plants should be available to supplement as needed.

9.

Conclusion

Electrification and the expansion of renewable energy resources require major changes in the electricity production system.

Recommendation

All expansion of the electricity grid should be undertaken with the goal of realizing as quickly as possible a comprehensive electrification of the country and the transformation of the current electricity grid to a Smart Grid.

10.

Conclusion

Wind energy will become a reliable source of energy in the future.

Recommendation

14 MW of wind energy should be a reality in 2012. A study laying out the way forward to utilizing wind for extensive power production should be ready by 2012.

11.

Conclusion

There is no technical hindrance to lay a cable to Iceland or Scotland to purchase or sell electric energy.

Recommendation

More detailed studies should be undertaken to explore the potential of selling electric energy to Europe.

12.

Conclusion

Important limitations exist in the current system that impede the exploitation of wind energy. Pumped Storage is a decisive and necessary part of a future electricity system.

Recommendation

A comprehensive study of the electricity system shall be undertaken immediately and be completed by the summer of 2012.

3. Legislative framework and structure of the electric energy sector

In the main, the electricity production sector is governed by this legislation:

- Parliamentary Act No. 59, dated 7 June 2007 on the production, transmission and supply of electricity (Electricity Production Act);
- Parliamentary Act No. 134, dated 10 June 1993 on high voltage installation.

In addition, the electric utility SEV has the sole right to use hydropower pursuant to Directive No. 76, dated 5 October 1963 on the license grant to SEV to use hydropower.

The electric utility SEV is owned by the Faroese municipalities, whose purpose is to produce, transmit and supply electricity to Faroese customers.

SEV is a vertically integrated corporation, i.e. SEV has all the elements of the value chain related to the provision of electricity under its control: electricity production, transmission and supply. In addition, SEV has system-wide responsibility regarding production security, load balancing, and quality assurance. System-wide responsibility is generally the task of governmental authorities, but given the special circumstances in the Faroes, this oversight is placed with SEV.

In principle, pursuant to the Electricity Production Act, market competition in the production of electricity is possible. However, the situation at present is that SEV controls around 97% of the electricity production, while Sp/f Røkt accounts for around 3%. SEV holds the monopoly on the transmission and supply of electricity via the electric grid.

Given the control within the market afforded SEV as electricity producer and holder of the monopoly to transmit and supply electricity, as well as its oversight responsibility for the system, the question arises as to how best to ensure:

- true competition
- necessary transparency
- treatment of current and future competitors
- that unreasonable supply demands and not placed on competitors
- that operations are carried out effectively.

To a certain degree, the Electricity Production Act addresses these issues by requiring a license for the production and supply of electricity that stipulates specific conditions. Moreover, the Act requires that special accounts be maintained covering activities related to the grid.

Even though the Electricity Production Act is from 2007 and thus does not have many years behind it, it has been shown that the legislation does not work in all areas as intended (confer below). With regard to the main goal of the enabling legislation, which was to provide government institutions with the authority to manage the vital conditions governing the production, transmission and supply of electric energy, changes in the Act must be adopted. The amendments should ensure that the national government gains better and more flexible authority to carry out its overarching responsibility within the electricity sector, including, among others, to stimulate to a greater degree the use of renewable energy resources.

In the main, our close neighbours have liberalized and privatized the electricity sector, much like what occurred in the telecommunications sector. This has been a natural process in other and larger countries. The question is then to what degree this should be done in the Faroes.

It is doubtful whether it is just for a liberalized industrial sector – the production of electric energy – to be in open, direct competition with a company owned by the municipalities.

Given that SEV is 1) the leading provider of electricity, 2) holds the monopoly for the transmission and supply of electricity, and 3) has responsibility for the overall system, the guiding principal of SEV, which is to maintain a "break-even" status quo, could prove troublesome with regard to tendering an offer for a license to produce electricity from windpower, because SEV could not realize any profit from it. Even though a profit is incorporated into a tender from SEV that is comparable to the amount reasonably calculated by a private owner of windmills, the private company submitting a tender cannot equally compete against SEV.

3.1 Electricity sector organization in Denmark

In Denmark, Energinet.dk (which is 100% owned by the Danish state) has responsibility for the electricity system and owns the high-voltage transmission lines, as well as electricity cables to Norway, Sweden and Germany. Energinet.dk is governed by a comprehensive regulatory framework that is administered by the Danish Energy Regulatory Authority and the Danish Energy Agency.

A fee for the transmission of electricity via the main grid and for expenses related to the management of the electricity system is levied by Energinet.dk. The fee is based on the "break-even" principle and is paid by electricity producers and electricity distribution companies.

In Denmark, there is a distinct division between the production and transmission of electricity to end-users on the one hand and the tasks of the system manager and access to the main grid on the other. The split is not only based on a division in ownership, but also the responsibility for the electricity system and the transmission of electricity via the main grid is allocated to the State and managed by the State.

Open competition is relegated to the production of electricity, while small electric grids, which provide electricity to end-users, operate as local monopolies under conditions stipulated by detailed regulations. This is done to hinder favouritism and unequal treatment.

3.2 Suggestions for changes in the enabling legislation and organizational structure

There is no possibility to implement a solution in the Faroes similar to that in Denmark, as it would be to too cumbersome and expensive to administer. On the other hand, a structural regime needs to be in place that enables true competition, transparency, and the fair treatment of current and future competitors of SEV.

To a certain extent, these are provided for in the Electricity Production Act, and the question is how the current regime can be made even better. The suggestions below hopefully might contribute to the resolution of the above-mentioned questions.

True competition:

- Legal requirement that all new production facilities based on hydro/windpower or other renewable energy should be let out to tender.
- Regulation stipulating that a production license for a new production plant could only be granted to SEV when the Minister of Trade and Industry has granted SEV special permission to let out a tender for a new production facility.
- Provide specific authority for a third-party to establish Pumped Storage in association with a hydropower plant of SEV.

Transparency:

- Divest the grid, system responsibility and ownership from the municipalities and transfer these to the central government.
- Place system responsibility and grid-related activities in an independent corporate entity.

Suitable authority to punish violations of electricity license conditions or of the Electricity Production Act should be promulgated.

Said authority could be clearly articulated in § 4, paragraph 5 in the Electricity Production Act, which states in pertinent part:

"The Minister may, in connection with the grant of a license or afterward, stipulate that the licensees cooperate within the supply and storage sector. If the licensees cannot come to an agreement, the Minister may take a decision in this regard."

This is done with the direct and immediate intent of authorizing third party access to initiate, among others, a Pumped Storage project in association with a hydropower plant of SEV.

3.3 Division between the grid and production

Given the current organizational structure of SEV in which grid and production operations are under the same management, unfortunate circumstances could arise when SEV takes a decision as grid operator that concerns production. At the very least, this is a relevant concern with regard to companies that are competing against the production arm of SEV and are forced to operate under stiff conditions stipulated by the grid operations arm of SEV, which in reality are set by the same entity (management team) against which the companies are competing.

Seen from the perspective of a government oversight authority, tangled complications could arise making it difficult to ascertain with which entity the authority is actually in dialogue – SEV Grid or SEV Production.

The above-referenced circumstances will remain in effect regardless of whether SEV is taken over by the central government or continues on as now owned by the municipalities.

Below, a concrete example is set forth as to how a separation of grid and production operations could be carried out.

Besides the Electricity Production Act directly stipulating a separation of accounts, § 12, paragraph 4 of the Act also grants the Minister of Trade and Industry the authority to prescribe changes in the organizational structure by which aspects of the enterprise's operations, such as named above, could be placed under independent management, or that grid operations as a whole could be placed under an independent company.

One interesting structure could be to divide the company into two separate main divisions – grid and production – wherein each division managed its own accounts, finances and technical functions.

Administration and human resource management could be under one and the same department (staff functions) and initially one manager could remain as the manager for the entire SEV concern.

From the perspective of both competitors and government oversight, there needs to be a clear and impenetrable division between grid operations and production operations. The question remains whether it is at all practicable to permit a purely cosmetic division between these two areas under one and same management, as it is today.

If such a possible division as outlined above were to be implemented in the company, it is imperative that "cross-support" not occur between departments / sections, and that all financial transactions between sections be undertaken pursuant to arm's-length, market conditions.

At what point the possible becomes the necessary with regard to implementing a restructuring that creates two, independent companies – SEV Grid and SEV Production – will over time become a more and more interesting question.

The decisions regarding the above-referenced questions / comments are political, but regardless of which solution is chosen, or if the decision is to do nothing, those decisions will have major import with regard to how in future the principal goals of the Electricity Production Act can be achieved, to wit:

- increase the use of renewable energy,
- production security,
- competition and
- appropriate electricity prices, etc.

Conclusion

Transparency is lacking in the system. Prerequisites for new electricity production are inadequate under current legislation. Nearly impossible to create real competition.

Recommendation

Legal requirement that all new production facilities based on hydro- or windpower or other renewable energy should be let out to tender.

Conclusion

Possibility for a new producer to initiate Pumped Storage is limited under current system.

Recommendation

Secure definitive legislative authority permitting a third-party to establish a Pumped Storage enterprise that links into the hydroelectric facility of SEV.

Possibly secure the legislative authority for the government to establish a new electricity production facility associated with Pumped Storage.

3.4 Advantages of the central government taking control of SEV

Effective 1 January 2009, SEV was reorganized as a joint municipal public enterprise with delimited responsibility. At the same time, the Board of Representatives was altered to an Annual General Meeting. Municipal representatives convene at the Annual General Meeting. There is one representative for every 1,000 residents in a municipality. The regular Annual General Meeting is held once a year, with Extraordinary General Meetings called as needed.

The Annual General Meeting elects the Board of Directors, which is comprised of one member and one alternate member for each region in the country. The fiduciary guarantee or surety provided by the municipalities for the debt of SEV ended on 1 January 2009, while the fiduciary surety for civil servants remained in effect.

With this reorganization, SEV, to a greater degree than before, came to resemble and operate like a private corporation.

Despite these changes, the current ownership structure, by its very nature, could create problems, in that local municipal interests could come into conflict with the interests of SEV as a corporate electric utility.

If the central government took over SEV from the owners, which today are all the municipalities, the representative would be a single person, namely the Minister with the energy sector mandate.

The energy sector Minister functions within a mandate prescribed by the Parliament. Given that SEV operates throughout the country providing a resource that society as a whole cannot live without, this in and of itself should mandate that, in the end, the Parliament and not the municipalities should watch over and take responsibility for SEV.

An enterprise engaged in partial competition, which is the case for SEV in the production area, could moreover gain certain advantages by being reorganized as a private corporation and thus operating under normal commercial parameters within the framework of the Companies Act.

Another advantage with the central government taking over SEV is the potential for reduced financing costs.

Conclusion

Municipal interests may come into conflict with the interests of SEV as an electricity utility.
Current organizational structure of SEV can be a barrier to rapid development of renewable energy resources.

Recommendation

Place the SEV grid infrastructure under independent management.
Transfer property/facilities matters from the municipalities to the central government.
Restructure the activities of SEV into corporate entities – grid-related in one, production in another.

3.5 If the central government takes over SEV

Below is an evaluation of which issues should be addressed in connection with the possible takeover or purchase of SEV by the central government.

The analysis begins with a review of the conditions / framework under which SEV operates today (i.e. the Electricity Production Act and the licenses for production and the grid, which are provided by the company). The analysis takes the point of view of a possible private purchaser.

A further assumption of the analysis, so long as there is no real competition, is that after a possible acquisition SEV would continue to operate fundamentally on a break-even basis for both production and the grid.

There is no objective, correct price for a company nor is there an objective, correct method to calculate the value of a company. In the main, a valuation is based on what the buyer and the seller expect from the sale and the anticipated future profit of the company. Because the profit derived with the break-even principle is zero, the value of the company in principle is also zero, viewed from the perspective of derived profit.

A valuation of SEV should also take into account the financial / fixed assets of the company. Moreover, one shall keep in mind that the price for SEV shall not only be viewed within a commercial context, but also within the realm of politics, which in the end can be quite determinant regarding SEV’s ultimate acquisition price.

Background

In the Faroes, the electricity sector can be divided into the production facilities, which generate electricity from oil, hydro- or windpower, and the grid, which involves the transmission and supply of electricity from the producer to the end-user.

SEV owns and operates the Faroese electricity grid, holds the monopoly right to grid-related activities, and is responsible for the generation of around 97% of the electricity used in the Faroes. The remaining 3% is produced by three windmills owned by Sp/f Røkt.

The owners of SEV, which are the local Faroese municipalities, placed an initial equity infusion into the company of DKK 4,139.875. According to the company's 2010 accounts, the booked value of the share equity is DKK 889,131,031.

The growth of the share equity in SEV operating under the "break-even" concept is derived from the regulated price of electricity. A consequence of this "break-even" principle is that the share equity of the company cannot be considered as set-aside profit or as a dividend to the owners, based on the otherwise low initial investment of DKK 4 million, because the "break-even" principle does not allow for surplus profit.

On the contrary, the share capital – apart from the initial investment – is considered as necessary reserve capital for company operations and, based on the "break-even" principle, can be considered as an asset of the end-users.

SEV cannot transfer or assign the company with permission from the central government / Electricity Authority.

Given the special market conditions within the electricity sector and the monopoly status regarding the grid (and essentially for production as well), a possible assignment of the licenses held by SEV would be difficult to approve, and a sale of the company to an entity other than the central government must be considered as hypothetical. On the other hand, it is rather impossible to force the municipalities to transfer SEV to the central government. SEV will refer to the usual and customary rights of ownership, as well as the operational rights granted under the licenses for production and the grid, and the license SEV has to tap for its use the rivers and streams on Vágar, Eysturoy, Streymoy and Suðuroy until 5 October 2013.

Examples of methods to valuate companies

The most usual methods to value a company are:

- Price/earnings (P/E) – a method by which the revenue serves as the basis.
- Discounted cash flow (DCF) – a method whereby future cash flow is discounted by the average cost of capital,
- Normalized earnings – a method based on a projection of a company's earnings over a specific period, e.g., 5 years.

Regardless of which method is selected, it is necessary to consider as well:

- the actual sale value of a company under the given circumstances
- initial share equity investment of the owners
- value of the company under an alternative ownership structure, and
- owner interest in transferring the company

The three referenced methods to value a company are all based on the ability of the company to generate income. Because the net income of the company over time, as a consequence of the "break-even" principle, will be zero, thus the value of the company using these methods will always be zero.

The company has a sales value. However, this sales value should not accrue to the benefit of the owners, because the municipalities have no right, in principle, to accumulate profit by increasing the share equity beyond that needed to ensure the necessary operational capital. This structural principle means that, in essence, the end-users and not the owners have the right to the sales value of the company.

On the other hand, the owners without any doubt have the right to demand their investment back, possibly with requisite interest. A supplement to address operational risk is a non-issue, as the "break-even" principle removes any operational risk of the company.

The owners of SEV should not anticipate that private investors might be interested in paying a good price for the company. The reason is that the transfer or assignment of the company to private investors requires the approval of government authorities, which no doubt will be difficult to grant, given the special circumstances currently in effect in the sector.

It should also be borne in mind that if the company were sold under normal market conditions, this would mean that end-users would again pay for the assets of the company, which were previously purchased through user fees.

The interest of the municipalities to sell SEV for their initial investment plus interest based on a zero valuation will never be great. The value of the company for the municipalities also stems from the power and influence that devolves to the municipalities by virtue of their operating and managing the supply of electricity in the Faroes.

The municipalities could be expected to insist – in the same manner as occurred in Denmark – that the share equity that cannot be directly shown to be the initial investment equity, is an asset of the respective individual owners and thus shall be deemed to be an asset of the municipality held on behalf of the people (however, separated out and not to be used for anti-competition purposes). Insufficient compensation for this part of the share equity will be in conflict with the constitutionally-protected right of ownership and could be construed as an expropriation of assets.

It is therefore very important to determine specifically who owns this money:

- Is it the end-users of electricity, and, if so, how can it be refunded to them?
- Is it the joint owners (the municipalities) and, if so, could/should the municipalities use the money to supply electricity?
- What might be the adverse consequences for future competition within the electricity sector?
- Does the central government own the money because it represents electricity end-users – both old and new – where the money comes from?
- Is it possible via a parliamentary act to legislate what shall be done with the money (that part not derived from the original investment)?

It will be necessary to have this matter more thoroughly researched and clarified before engaging in conclusive discussions regarding the valuation of SEV.

A comprehensive study and evaluation of the valuation of SEV is in reality quite complex, because SEV will no doubt seek a political payment as part of the transfer of the company. A determination of the size of such a payment demand will require detailed analysis, and many issues must be addressed that will have future implications for both the buyer and the sell.

As in other cases of company valuation, the establishment of a value for SEV when an agreement is finally reached will reflect the price that the buyer and the seller have agreed upon. However, in light of the above-mentioned views and perspectives, the aggregate conclusion is that SEV, from a purely economic perspective, can be acquired for the original investment. However, the municipalities will never be interested in transferring the company under this scenario. Thus, the question is what compensation the buyer and seller could possibly agree to based on the above-referenced assumptions. To a large degree, the compensation package will play a prominent role in the argument presented by both the buyer and the seller.

The discussion above should not be construed as a final and definitive determination of the valuation of SEV, but rather as an attempt to clarify the structural issues and the framework that will be crucial in determining a price for the company.

4. Economics of the electricity sector

If it were a goal that the production of electricity could respond to usage, rather than usage remaining delimited by production, as is now the case, and if it were possible at the same time to accomplish "Triple E", meaning that the Economy, Energy and the Environment go hand-in-hand, it would indeed become possible to continuously exploit the potential of green energy at a comparatively lower price for electricity.

According to the Electricity Production Act, a key goal is that the price of electricity shall not be higher than necessary. In addition, the provision of electricity in the Faroes shall be so managed as to ensure due regard for supply security, the economy of the country, and the environment. At the same time, the use of renewable energy resources shall be encouraged, however, with due regard to supply security.

In order to achieve the above-referenced goals, the implementation of an advanced Smart Grid system is critical, see also Section 7.2.

The Smart Grid concept requires a crucial paradigm shift from the passive use of electricity to an active and intelligent use.

The Smart Grid system affords the possibility, among other things, of an effective interplay between:

- Wind energy production
- Pumped Storage systems
- Long distance (district) heating systems
- Electric vehicles
- Heat pumps for private households.

The Smart Grid enables the effective integration of all the stakeholders, those that only produce electricity, those that only use electricity, and those that do both, in order to supply electricity in a more sustainable, economical, and secure manner. A study undertaken by Energinet.dk demonstrates that significant savings can be realized by deploying a Smart Grid system, from both an economic and environmental perspective.

The electric utility SEV is a major player in the Faroese electricity market. SEV is alone in the distribution of electricity to Faroese customers. SEV owns the grid and has responsibility for it. Moreover, until recently, SEV was the only producer of electricity in the Faroes. SEV has developed and expanded the grid as well as its production capacity to such a degree that today some 40% of the energy produced by SEV comes from renewable energy resources.

SEV is a leading company, stimulating and creating meaningful employment through a variety of initiatives, funded by investments over the past 15 years of between DKK 35-75 million (€4-10 million) annually. Annual net sales of the company are today around DKK 280 million (€37.6 million), income that is derived from Faroese electricity consumers.

A normal household in the Faroes uses around 6% of its income for electricity. By comparison, a household uses 8% of its income for telecommunications, and 30% for housing, etc. The price of electricity, along with the price of telecommunications, as well as expenses for housing and transport, thus all have considerable importance for a household's economy and thereby also its standard of living as a whole.

Common to many of these expense areas is the lack of economies of scale, which is difficult to achieve in such a small country as the Faroes, compared to larger countries. Thus, the electricity sector must be even more well managed, with regard not only to production, but also sales and services.

At the same time, it is critically important to recognize that the solutions adopted in our neighbouring countries are not always the correct solutions within a Faroese context. Among others, it could be noted that liberalization and open competition – which is often the usual prescription in other countries – will not necessarily give the best result in all cases in a small society such as ours where the market forces do not always operate adequately nor effectively.

4.1 Competition and innovation in electricity production

The conditions for the effective exploitation of renewable energy are better in the Faroes than in most other countries. Water and wind are abundant, but challenges exist in that collection areas are small for reservoirs and the wind is not stable.

Increased electricity consumption, which took off in the 1970s especially, is in the main covered by the new, oil-fired production facility at Sund in southern Streymoy. A stable and secure supply is the top priority, and for the most part SEV has been able to provide the electricity energy that a modern society demands. However, a growing awareness in recent years of the environmental impact of present energy production methods, coupled with higher oil prices, has necessitated a re-thinking of priorities and a totally new agenda.

With these issues in mind, a new electricity production law went into effect in 2007 and among the several goals of the law is the mandate for sustainable development in the sector for the benefit of the entire country. A partial liberalization of production, which should enhance greater innovation and lend support to alternative solutions, was a goal of the new legislation and an electricity oversight authority was established.

It is possible today to state that, despite we in Faroes having excellent conditions for renewable energy, relatively little has occurred in the area, apart from the hydropower expansion initiative carried out by SEV.

4.2 Electricity prices in the Faroes compared to Denmark

In 2010, the price of electricity for Faroese households was DKK 1.50 per kWh, including a grid surcharge of around 20 øre per kWh and VAT of 25%. By comparison, the price consumers should pay in Denmark in 2010 was around DKK 2.00 per kWh (including all surcharges and taxes).

There is a considerable difference in the total surcharges levied in Denmark and in the Faroes. In the Faroes, VAT is applied to all surcharges. In Denmark, a surcharge is levied for, among others:

- the government mandate to supply electricity
- other requirements, such as balancing
- various costs related to the grid
- VAT and other duties

In Denmark in 2010, the base price for electricity was between 30 and 40 øre per kWh. This price can be compared to the price for households in the Faroes of DKK 1.20 per kWh, excluding VAT.

The chart below shows the price of electricity for households in the Faroes between 1983 and 2011. The price paid by certain industry sectors is somewhat lower than the figures presented here.

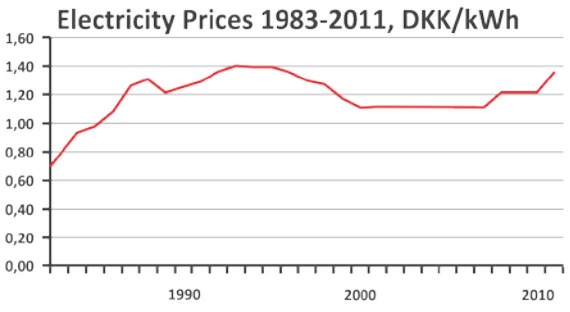


Figure 4.1: Price for electricity for Faroese households 1983-2011, excluding VAT. Source: SEV.

The surcharges in Denmark should dampen electricity consumption and the income from the surcharges is used, among other purposes, to finance expansion of renewable energy resources and to enhance supply security.

Consideration should be given to establishing a system that could stimulate innovation and the deployment of new technology, e.g., a lower electricity price for the use of heat pumps for household heating. Further, consideration should be given to levying other environment-related surcharges that could be used to accelerate the expansion of renewable energy sources.

4.3 Oil prices and prospects for the future

Island communities and isolated districts around the world, like the Faroe Islands, have what is called a Stand Alone power system. A unique problem with these systems is that any excess energy cannot be sold on and any lack in power cannot be imported. Thus, a flexible production system is required that is able to meet demand around the clock. In this case, oil-, coal- or gas-fired power plants, together with hydropower turbines, are the securest and easiest solution.

Island communities without a cable connection to other electricity grids, such as, e.g., the Shetland Islands, the Grand Canaries and the Azores, face the same challenges as we do in the Faroes.

Motor-driven power plants are not considered the most suitable alternative upon which to build a future electricity production system.

The environmental impact of current energy systems and the conventions calling for lower CO_2 emissions have import. We know, however, that, in many cases, money speaks with a stronger voice than idealism. From an environmental perspective, it is quite advantageous that the price of oil has risen as high as it is today.

Figure 4.2 below shows the trend in oil prices over the last few decades.

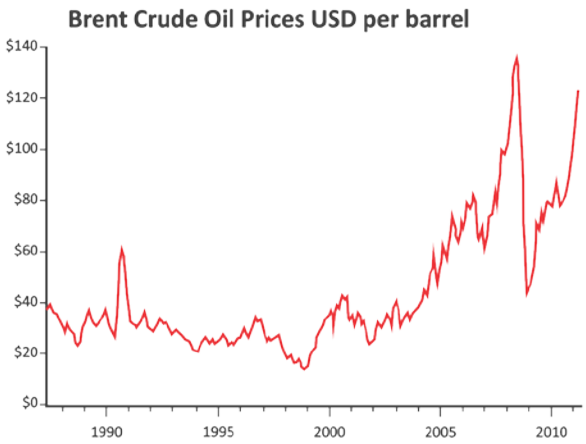


Figure 4.2: Oil prices from 1987 to 2010 (USD). Source: Danish Energy Agency

In the Faroes as in other places, the price of oil hits us through the price of electricity, which as consumers we have to pay. Around 1 litre of oil is used to produce 4 kWh.

4.4 Electricity consumption per person in some selected countries

The consumption of electricity per inhabitant in Denmark and the Faroes is at approximately the same level, some 6-7,000 kWh per person, while consumption in Norway is around 24,000 kWh per person. Figures for Finland and Sweden lie between 15,000 and 20,000 kWh per person.

The reason for the high electricity consumption in Norway is partially that Norway has electricity-intensive industry and that electricity is used to heat homes.

With increased electrification, the consumption per person in the Faroes will increase substantially.

4.5 Future investment in the electricity energy sector – some examples

Table 4.1 presents the cost of investing in various selected electricity production options and what the consumer price for electricity might be under each option. The data references total investment, operational cost factors, depreciation, interest, MW produced, etc. and concludes with an indication of the cost per kWh for the various production options. Costs per kWh are closely aligned with how quickly the investment must be paid back and the rate of interest, which also has a major impact on overall cost of the investment.

The depreciation period for hydroelectric plants is 50 years, but the repayment period of the investment would no doubt be less than 50 years. If a repayment period could be, e.g., 30 years, then the projected data indicates that an investment in a hydroelectric facility at Víkarvatn could be competitive compared to current thermal energy production facilities. In this example, the value of this option does not take into consideration the possibly reduced beauty of the area set aside for hydropower, nor the impact such an installation would have on the environment.

Table 1 shows that the construction of a hydroelectric power plant requires considerable investment. At the same time, the production price per kWh is relatively higher. On the other hand, wind energy and Pumped Storage requires much less investment and also yields a lower price per kWh. Electricity production using oil results in the highest price per kWh.

It should be noted that these figures are estimates only and any changes in the various parameters could greatly impact the resultant data, e.g., changes in the repayment period for the investment, the rate of interest charged, and annual electricity production.

By comparison, Table 4.2 shows that in 2010 the price per kWh was DKK 1.21 and the sales price for consumers was on average (both for households and industry) DKK 1.00 per kWh produced.

Costs for electricity production	Hydroelectric	Wind power	PTS Heygadal	Thermal á Sundi	Biogas	Nuclear
Available effect, MW	14	3	10	10	5	50
Annual production in kWh	37.000.000	10.000.000	32.800.000	20.000.000	8.000.000	150.000.000
Total investment (DKK)	624.000.000	27.000.000	255.000.000	100.000.000	50.000.000	200.000.000
Interest per annum	5%	5%	5%	5%	5%	5%
Projected repayment of investment (years) example only	30	20	20	30	20	30
Depreciation (years)	50	15	40	30	20	30
Projected operations, maintenance, raw materials as % of total investment	0.50%	3.00%	1.00%	20.00%	6.00%	1.50%
Projected operations, maintenance, raw materials in DKK	3.120.000	900.000	2.550.000	20.000.000	3.000.000	30.000.000
Interest and deductions / set-asides (annuity loan) in DKK	40.592.095	2.166.500	20.461.860	6.505.144	4.012.129	13.010.287
Annual cash flow needs in DKK	43.712.095	3.066.550	23.011.860	26.505.144	7.012.129	43.010.287
Cost for each kWh in DKK	1.18	0.31	0.70	1.33	0.88	0.29

Table 4.1: Cost of electricity production by various sources. Source: Editors' own calculations.

Electricity production and prices in 2010	
SEV	273.991 kWh
Sp/f Røkt	6.375 kWh
Total	280.366 kWh
Average production cost per kWh	Kr. 1.21
Average sales price per kWh	Kr. 1.00

Table 4.2: Electricity production and prices in 2010. Source: Editors' own calculations.

4.6 Production methods and pricing

Figure 4.3 shows gigawatt-hours along the x-axis, and price/cost for each type of production on the y-axis. It is possible to read the quantity and the ratio between the amount produced by water, wind and oil. However, what is important to note is the size of the block representing oil costs and how much it is impacted by the price of oil.

Hydroelectric plants are partially depreciated and can therefore operate more cheaply. However new hydroelectric construction is expensive, which impacts the size of the lower block in the hydroelectric column. Windpower lies in the middle and today it costs DKK 0.40 to produce one kWh with the latest windmills, based on a 15 year life cycle. The risk however is that the grid cannot tolerate large fluctuations in production. This limits the width of the wind energy column.

Figure 4.4 below shows how various production methods can impact the total price paid by the consumer.

Figure 4.4 shows that the production prices for each individual power plant, e.g., the power plant in Vestmanna and Eiði, are calculated using a weighted average, and are thus a part of the price, P_e, which consumers pay for each kWh.

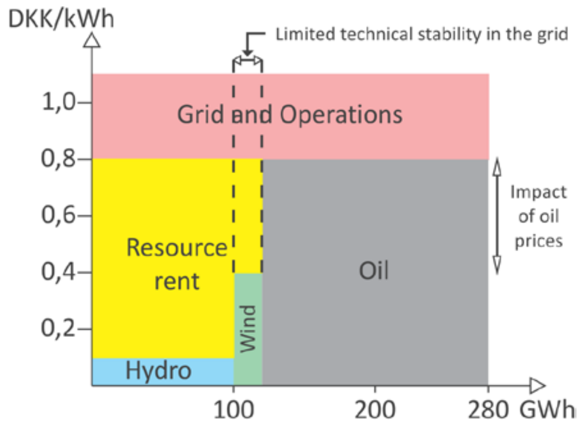
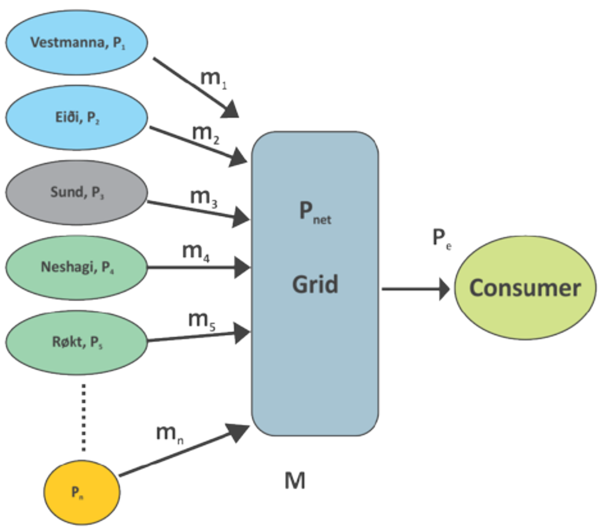


Table 4.3: Production and costs for various production methods.
Source: Editors' own calculations.



$$P_e = \frac{P_1 \times m_1 + P_2 \times m_2 + P_3 \times m_3 + \ldots P_n \times m_n}{M} + P_{net}$$

Table 4.4: Connection between various production methods and the price of electricity.
M and m are production, P and p are prices.
Source: Editors' own calculations.

4.7 Advantages and disadvantages of the various protection methods

On the whole, we can say that the advantages and disadvantages of the various production methods are, in the main:

Hydroelectric

Advantage: Long-term investment, which is rather inexpensive, given the long depreciation period (> 50 years), and, based on the projected numbers above, is competitive in pricing compared to thermal energy (especially given current projections for increasing oil prices).

Disadvantages: Large and capital-intensive investment, significant risk, major impact on the environment, destroyed natural beauty.

Windpower

Advantages: Proportionally little investment and thus cheap energy that is quite competitive compared to thermal energy. Little impact on the environment, relatively easy to repair the surrounding environment damaged during installation, easy to remove an old windmill and restore the site to its original natural condition.

Disadvantages: Unstable power.

Pumped Storage

Advantages: Relatively little additional impact on the environment (in those cases where the dams are already in place), long-term investment, given the long depreciation period (> 20-30 years), and, given the projected numbers calculated by the Faroese Earth and Energy Directorate, is price competitive compared to thermal energy. Unstable, but inexpensive, wind power can be transformed into stable hydropower.

Disadvantages: Proportionally large investment (however much lower than a new hydroelectric plant), untried technology with windmills connected to a pump.

Other production methods, which in the future could become a reality, are, e.g., tidal energy, international electric cable, biogas energy and nuclear energy.

With regard to the national economy, it is important to bear in mind that investment in the expansion of hydroelectric power for the most part remains in the country, generates income, and is cheaper to operate than other energy sources. On the other hand, oil-fired power plants must first import the motors and subsequently import oil.

There are major development opportunities within the electricity production sector, if done correctly.

To install a windmill in the Faroes, costs relatively little more than to install it elsewhere, while experience and wind measurements show that the production generated by each windmill in the Faroe Islands is almost twice that produced on the continent of Europe.

Hydropower is costly to construct. In addition, reservoirs in the Faroes are rather small and it has been noted that the annual production for each MW installed is much less than, e.g., in Norway.

Conclusion

Production costs of electricity are proportionally higher in the Faroes than in, e.g., Denmark.
In the Faroes, there is no duty or fee without MVG.
In Denmark, there are a series of fees that are, among other things, designed to advance the adoption of renewable energy resources, which means that the price the end-user pays is higher in Denmark than in the Faroes.

Recommendation

A system designed to encourage the adoption of advanced technology and ideas should be considered, e.g. lower electricity prices for households heating with heat pumps.
Also other environmental levies or fees should be considered that could be directed to accelerate the adoption of renewable energy sources.

Conclusion

The international price of oil has a major impact on the price of electricity production in the Faroes, and the cost per kWh of electricity production is higher from oil than from hydro or windpower.
The investment costs of hydropower expansion are proportionally greater, while the investment costs of expansion in windpower or Pumped Storage are proportionally lower and result in a proportionally lower production cost per kWh.

Recommendation

Expansion of windpower and Pumped Storage should be allocated the highest priority in the augmenting of electricity production.

5. Demand for electricity

This section discusses the demand for electricity and what changes are anticipated in the coming years. This section ends with a conclusion and recommendation.

5.1 Climate change policy in the Faroes

In 2009, the Parliament unanimously approved the Climate Change Policy for the Faroe Islands, which in tangible way bound the Faroese community to reduce oil consumption by 2020 by at least 20%, compared to oil consumption in 2005. The principal goals of this policy are to make the Faroes less dependent on oil and to considerably increase energy production from renewable energy resources. This shall be achieved by reducing energy consumption where possible, and the use of new, environmentally- friendly technology.

5.2 Electrification is necessary

Electrification implies a reorientation from energy consumption directly from fossil fuels to electric energy. An example of this is the use of electricity to heat homes rather than the use of oil and transport on land relying on electricity instead of oil. If electricity can be derived from renewable energy resources, electrification is one way to be less dependent on oil and to facilitate the exploitation of our renewable energy sources. Electrification is necessary, if we are to achieve the goals set forth in the Climate Change Policy.

5.3 Concrete initiatives on the way

In this session of the Parliament, the central government intends to submit a construction bill mandating the establishment of energy requirements for all buildings. Previously this year, the Parliament heard a bill on geothermal heating, which is expected to be approved in the autumn. A directive on geothermal heating will so organize the sector that geothermal installations will be required to meet all modern-day requirements on quality and environmental impact.

We are already experiencing a trend toward the electrification of home heating, in that more and more households are choosing to use heat pumps instead of oil furnaces.

5.4 Emissions and oil consumption

The Climate Change Policy has confirmed that the Faroe Islands, as a part of the world community, must bear some of the responsibility for climate change resulting from the emission of greenhouse gases.

Nearly all of the Faroese emissions stem from the consumption of oil by all sectors of society. To reduce the emission of greenhouse gases is therefore to reduce oil consumption.

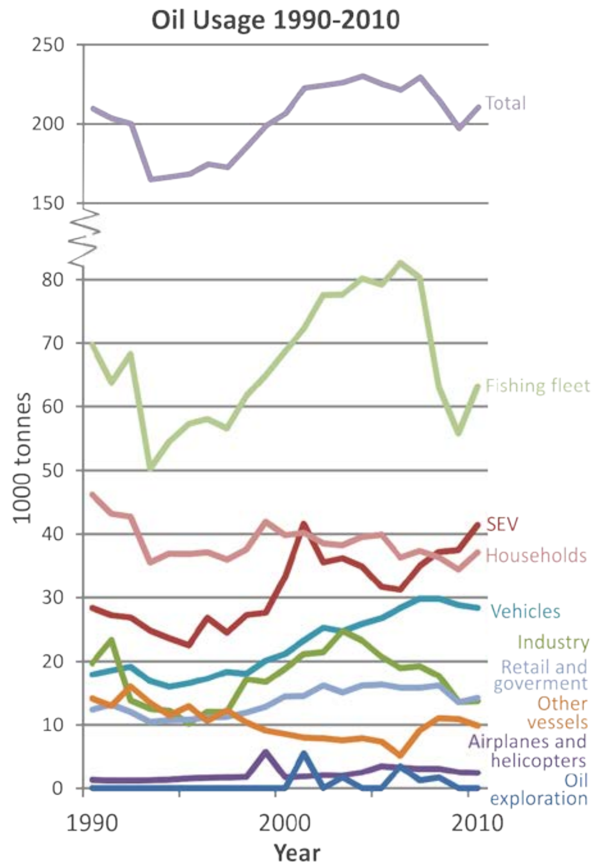


Figure 5.1: Faroese oil consumption 1990-2010. Source: Environment Agency.

Table 5.1 shows that oil consumption is much less in 2008 and 2009, as a result of factors impacting the fishing industry. In 2010, total oil consumption again grew considerably. Part of this was due oil for electricity growing from 37,000 metric tonnes in 2009 to 42,000 metric tonnes in 2010.

Thus, there is nothing to indicate that oil consumption will decline dramatically in the near future. Therefore, effective measures need be implemented to reduce current oil consumption by at least 40,000 metric tonnes per year, if the goal of the Climate Change Policy is to be achieved. In the main, the Climate Change Policy mandates that this reduction shall be achieved by reducing oil consumption for heating, land transport and electricity production.

5.5 Projections of electricity demand

It is necessary to electrify energy consumption and to increase the amount of electricity derived from renewable energy resources, if the country as a whole is to become less dependent on the import of oil, more self-reliant in the production of energy, and if the goals of the climate change policy are to be achieved.

It is difficult to predict how great the growth in electricity consumption will be in the coming years. Growth is, of course, closely aligned to trends in society in general and how much emphasis is placed on electrification. We have chosen to assume that the community will continue to develop as it has over the last 50 years and that considerable electrification will occur.

Goal	Oil consumption (tonnes)	Electricity (GWh)
Half of industrial oil consumpton on land	10.026	27
All heating of homes and buildings	53.233	142
All land transport in 2009	30.000	94
Total	93.259	263

Table 5.1: Electrification of electricity demand. Source: Editors' own calculations.

Table 5.1 shows how large the increased demand for electricity will be when and if the energy demand of half of the industrial sector, all of the energy demand for the heating of homes and buildings, and all the energy demand for transport on land is met through electrification. When calculating the need for electricity for heating, all oil furnaces used for heating were assumed to be replaced with heat pumps operating at a use factor of 3.0.

5.6 Trends in the electrification

The figure below gives some insight into how electrification will occur. At the same time, it is assumed that the energy demand of society will grow.

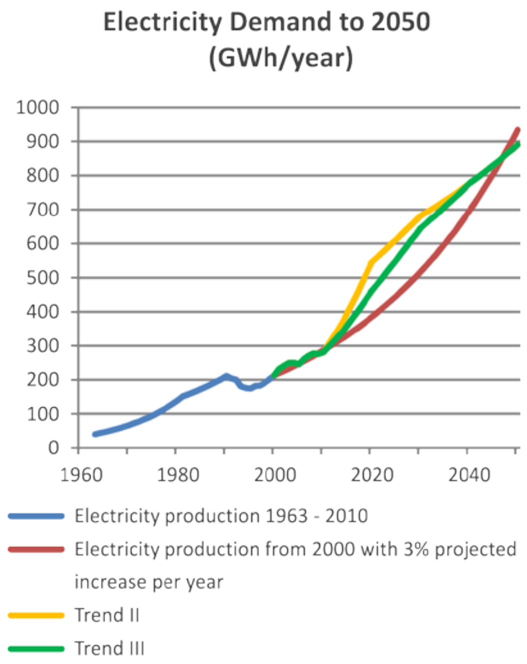


Figure 5.2: Estimates of electricity demand to 2050. Source: Editors' own calculations.

In Figure 5.2 above, the Trend II example is a rapid electrification. Assumptions: Home heating shifts to electricity steadily from 2011 – 2020, subsequently 0% growth to 2050, based on insulation and other energy saving initiatives. Land transport steadily shifts to electricity from 2015 – 2030, subsequently 0% growth to 2050, based on efficient motors and other energy saving initiatives.

Trend III is an example of slow electrification. Assumptions: Heating shifts to electricity steadily from 2011 – 2030, subsequently 0% growth to 2050, based on insulation and other energy-saving initiatives. Land transport steadily shifts to electricity 2011 – 2040, subsequently 0% growth to 2050, based on efficient motors and other energy-saving initiatives.

For the last 10 years the growth in electricity consumption has been around 3% per year. The red line in Figure 5.2 above, indicates consumption if this trend continues until 2050. The yellow and green lines indicate the electrification trends. In both of these cases, the prerequisite assumptions are: Half of the industrial sector steadily shifts to electricity from 2011 – 2020, subsequently 1% growth per year to 2050. In addition, a 2% growth per year in electricity consumption not related to electrification is factored in from 2010 at 2050.

All three trends show a significant growth in electricity consumption which is, of course, closely related to the selected assumptions. In 2020 electricity consumption will be between 350 and 550 GWh per year. Compared to today, this reflects an increase of between 80 and 280 GWh per year. For the most part, current energy demand is met by oil-fired electricity production – around 160 GWh per year. The challenge ahead to 2020 is, therefore, to produce between 240 and 440 GWh per year from renewable energy resources. The challenge in 2050 is to produce around 800 GWh per year from green energy.

Just as we have seen an electrification of heating in homes, it is quite likely also that transport on land will gradually be electrified. Therefore, the pressure on electricity production will, no doubt, be greater and greater, which is also reflected in the trends indicated above.

One good opportunity to reduce considerably the consumption of oil in society is to expand our renewable energy resources. On the other hand, by choosing the maintain the status quo and to select limited expansion of renewable energy resources, and continue with an expansion of oil-fired electricity production, society will continue to be extremely dependent on imported oil and will never be able to achieve the goals mandated in the Climate Change Policy.

Conclusion

Electrification and the expansion of renewable energy resources require major changes in the electricity production system.

Recommendation

All expansion of the electricity grid should be undertaken with the goal of realizing as quickly as possible a comprehensive electrification of the country and the transformation of the current electricity grid to a Smart Grid.

6. Electricity production

This section discusses how electricity production by hydropower and oil-fired power plants has developed in the Faroes. Moreover, alternative electricity generation sources are explored, as well as how electricity production could be organized in the future.

6.1 Electricity generation today

The history of Faroese electric power is well over 100 years old. In 1907, the year after the first telephone line was laid between Tórshavn and Vestmanna, an experiment was undertaken to use hydropower in Vestmanna, but it did not succeed.

The first hydroelectric power plant in Vágur and Klaksvík came online in 1921 and 1931, respectively. Vágur and Klaksvík were able to gain considerable commercial success as centres of power production, as the land around them was quite suitable for hydropower. In Tórshavn, Tvøroyri and Runavík, there is very little potential for hydropower.

After the Second World War several municipalities in the north of the Faroe Islands took the initiative to establish SEV and to expand the hydroelectric plant in Vestmanna. Later, SEV was enlarged to encompass the entire country and the hydroelectric plant, coupled with a few oil-fired power plants, was providing reliable energy in the early 1970s. When consumption began to grow considerably, the decision was made to construct an oil-fired power plant at Sund. This was before the first oil crisis when oil was cheap. The facility was completed and continues to this day to be the dynamo of electricity production in the Faroes. In the 1980s, a hydropower facility was constructed in the northern part of Eysturoy with the power plant located at Eiði. Today, the grid encompasses the entire country, with the exception of Suðuroy and five, small outlying islands.

What is characteristic of that first period of electricity production was its fumbling beginning where inspired activists led the way. Just as in most other countries where small steps were taken, the municipality was the main stakeholder. What they had in common was that in the beginning it was doubtful whether the project could hang together financially – something which is not unknown for new businesses. Even though the initial hydroelectric facilities were located in the most suitable areas, the investment was large and it took a long time for consumption to rise to the projected levels. Thus, there was considerable overcapacity in those early years. In such a case, operations were onerous or impossible with short-term and expensive financing.

6.2 Expansion possibilities

Today, oil-fired power plants are the foundation of electricity production. Hydropower is exploited as much as possible, while wind power is only used marginally and often there are problems with the system. Therefore, it is advisable to determine how electricity production shall be expanded in order to meet increasing demand and a reorientation toward using electricity for other power needs. We have the technical skill to use these power sources: water, wind, tides, coal, oil, gas, biogas, incineration of trash, and nuclear energy. These sources are discussed below.

Water: The first electricity power plant in the Faroes was a hydropower facility and the most suitable areas in the country were for good reason developed. In February 2000, together with the engineering consultants, Landsbyggifelag (Faroes) and Norconsult (Norway), SEV evaluated the possibility of building out several areas in the country for hydropower production, see Table 6.1 below. It was deemed feasible to produce some 100 GWh annually, but the costs are very high. These plans are reviewed and updated periodically.

Area	Watershed Km^2	Annual production Mil. kWh	Construction cost Mil. kr.	Construction cost/kWh DKK/kWh/year
Strond	7.2	8.61	255	29.61
Árnafjørður	6.5	9.21	242	26.28
North Streymoy Saksun valley	22.7	36.55	699	19.12
Víkarvatn, expansion	21.2	41.29	533	12.91
Týggjará with collecting tunnel	12.3	11.79	242	20.53
Vágur	18.3	23.17	477	20.59
Fámjin	15.3	5.55	267	48.11
Botni	1.9	1.22	13	10.41

Table 6.1: Potential hydroelectric sites in the Faroes. Source: SEV and P/F Landsbyggifelag.

The areas listed in Table 6.1 cover in total over 100 km^2, and current hydropower production utilizes about the same area. However, one factor that needs to be considered is that proper and necessary rainfall measurements have not been carried out for all 1400 km^2 of the Faroes. There is a wide disparity in the amount of rainfall. In Mykines, it rains some 800 mm annually, while in Hvalvík and in Hellu it rains some 3200 mm or four times as much. Moreover, it rains more at higher elevations than at sea level. Therefore it would be advisable to study smaller potential hydropower sites, such as areas in Kunoy, Borðoy and Viðoy. The last tender offers for construction projects in the Faroes have shown that there are often significant differences in the bids and that over time these have been well under actual projected costs, e.g., the latest expansion of the airport. This is because new technology and more effective tools have come onto the market. Therefore, it is perhaps advisable to take another look at these hydropower sites that have been recommended for future expansion.

Wind: Wind energy is a well-known and proven technology and appears at present to be the only alternative to oil and hydropower. However, given the fluctuations in wind energy production, there is a limit to how much wind energy the grid can tolerate today. It is, however, fair to say that with more advanced windmills and technological improvements to the grid will make it possible to bring more wind energy into the system. See also Section 7.3.

Oil: For the last several years, oil-fired power plants have represented some 60% of all electricity production in the Faroes. The majority is produced by the power plants in Sund and Vágur, which were built at a time when oil was relatively inexpensive. Oil-fired plants are cheap to construct and easy to operate and maintain, and it is easy to regulate production to match demand. Therefore, operationally, it is very easy to stabilize the power fluctuations experienced from hydropower turbines in the Faroes, most especially during the summer when there is very little rain and, as a consequence, there is little or no hydropower produced. For example, in July 2011 hydropower accounted for only 11% of electricity production, while total hydropower production for the first seven months of 2011 equalled some 36.5% of total electricity production.

However, the price of oil fluctuates and as a consequence so does the cost of production. An increase in the price of oil or in the dollar is directly reflected in an increase in production cost.

Coal: Coal is the most abundant fossil fuel. Estimates indicate that known deposits of coal worldwide could be exploited for the next 200 years. To a large degree, coal is used for electricity production around the world. In the early 1970s when the power plant at Sund was first being considered, there was some discussion to use coal – both imported and from the coal mines in Suðuroy. It should be noted that the last estimate indicated that there were some 10 – 15 million tonnes of coal on Suðuroy. Faroese coal is not of the highest quality and it would take 3 – 4 tonnes of coal to equal 1 tonne of oil. Thus, if electricity production at Sund were converted to coal, some 150,000 tonnes would be needed per year; thus the deposits in Suðuroy would last a century. At should be noted that the coal is easy to obtain.

Large, coal-fired power plants are inexpensive to operate, compared to oil-fired plants. However, one of the disadvantages of a coal-fired plant is that they can only be used to provide a base load and are not easily regulated up or down. Moreover, it is necessary to release the excess heat and there is considerable pollution associated with these plants. The conclusion, therefore, is that such power plants are not advisable for the Faroes.

Nuclear energy: The nuclear energy power plants with which we are most familiar are normally large installations designed for countries many times larger than the Faroe Islands. In the Nordic region, only Sweden and Finland have nuclear energy power plants. At present, there is very little new construction in this sector. However, small nuclear energy power plants do exist, e.g., onboard submarines and icebreakers.

This spring, representatives from the Ministry of Trade and Industry and the Faroese Earth and Energy Directorate visited TOSHIBA in London, where such a system was presented, which could yield between 20 and 50 MW of electricity, and is expected to be available within 6 to 10 years. Exact costs are not known, but there are indications that the production price of electricity would be between 50 – 60 øre/kWh. This type of power plant is designed for remote areas and, e.g., mining operations in uninhabited areas. Moreover, there are special security requirements governing such power plants. It is highly unlikely that such a power plant would actually be built in the Faroe Islands in the foreseeable future.

Tides: Current pilot tests and ongoing technological development indicate that within in very few years it will be commercially feasible to produce electricity from a tidal energy power plant. There is little doubt that such a power plant could be built in the Faroe Islands, where conditions in the fjords and sounds are quite suitable.

Researchers at the University of the Faroe Islands have conducted an evaluation of the possibility for a tidal energy power plant, and in connection with this study have looked at the potential of the sounds near Vestmanna, Skopun, Hest and Leirvík. The conclusion was that there was sufficient production potential for both our own use and export of excess energy. But this type of power plant has the same shortcomings as wind energy, because production fluctuates and is not regular. Therefore, it is necessary to have a storage system to balance the fluctuation in electricity generation.

Gas energy: Natural gas (LNG) is an interesting source of fuel for Faroese electricity production.

Engines exist that can run on diesel and/or natural gas. Therefore, it would be advisable to research the possibilities of importing LNG from, e.g., Norway, rather than, as now, to use heavy oil for the generation of electricity. Another good reason to switch to LNG for electricity production is that total CO_2 emissions are less than with heavy oil. In connection with any possible enlargement or renovation of existing power plants, it would be advisable to research if there were any advantages in using LNG for electricity generation rather than oil. Moreover, rate calculations indicate that oil prices are higher than gas, and therefore it would be anticipated that the price of oil would be more expensive than gas long-term.

Bio-gas: Recently, research was undertaken to study whether it was commercially feasible to produce bio-gas in the Faroes from biodegradable refuse, such as fish entrails, manure, etc. One proposed scheme was to produce electric energy and heat from these sources, in addition to drying manure.

Incinerators: The waste heat from the incinerator at *á Hjalla* near Tórshavn is used to heat homes and other buildings close by, and is distributed by the District Heating Company. The heat from the incinerator at Hagaleit is used to dry fish products at a nearby factory. It is also possible to produce electricity on-site at an incinerator, but that would mean less heat available for home heating. The Faroese Earth and Energy Directorate has estimated that if, e.g., all the refuse in the Faroes were collected and burned at one specific facility, one steam turbine could produce around 28 GWh of electricity, which is the equivalent of 5,000 tonnes of oil.

Conclusion

There is a limit to how much hydropower can be expanded to meet an increasing demand for electricity.

Recommendation

Initiate a precise study on which energy resources could be linked together in a future Faroese electric energy grid.

6.3 Future electricity generation in the Faroes

Today, oil-fired power plants are the foundation of our electricity production. This is not sustainable, both because oil-fired facilities are expensive to operate, and the will no doubt continue to be more and more expensive as the price of oil rises. Moreover, a steadily increasing demand for electricity from these oil-fired power plants will result in continuously increasing CO_2 emissions. Hydropower has been exploited as much as possible, while wind energy has only been used marginally and at present there are difficulties with the system.

This situation must be turned around. Wind and subsequently tidal currents need to be the foundation underpinning our electricity generation. Hydropower shall be used incrementally to balance the load and for storage of potential energy and oil should be available as a back-up. A system should be set up so that electricity production responds to demand.

- Strive toward having 10—14 MW of windpower available in the system by 2012. In the near future, SEV will set up 3 MW windmills and from the very first day they will provide 3-7 MW.
- The study of entire electricity system, which is expected to be completed in the spring of 2012, shall confirm:

- how water can best be used together with wind (wind/water pump system)
- how the grid, engines, turbines, and hydropower reservoirs can be supplemented so that all production is managed with the goal of utilizing as much windpower as possible.
- how electricity production can be responsive to demand via a Smart Grid system
- if the expansion of hydropower around the country is commercially reasonable under a new electricity management regime
- which renewable energy resources could be linked into a future

- In 2020, electricity generation continues to be based on oil/gas. However, efforts continue to ensure that all electricity production is derived from renewable energy sources before 2050.

We in the Faroes should strive to use windpower as much as possible. Confer Figure 6.1 below.

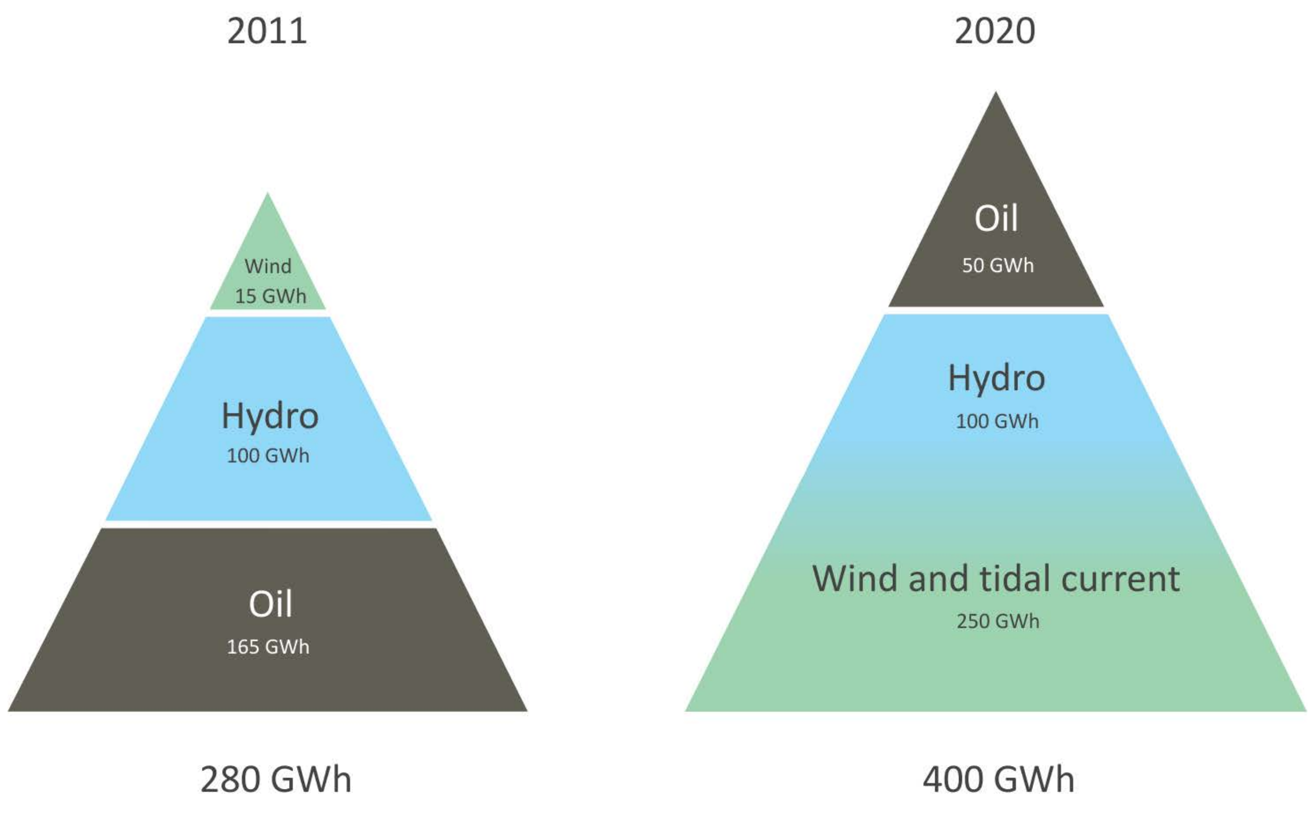


Figure 6.1: Changes in electricity production to meet higher demand by using renewable energy resources. Source: Editors' own calculations.

Conclusion

Oil-fired power plants, which today are the foundation of our electricity production, are too expensive to operate and produce too much CO_2 emissions.

Recommendation

A reorganization should be carried out within electricity production such that wind becomes the foundation underpinning production, hydropower shall be used balance load and store wind energy, and oil- and gas-fired power plants should be available to supplement as needed.

7. The electricity grid and sources for electricity generation.

This section discusses the existing electricity grid. Further, some possibilities for electricity production from renewable energy resources that could be relevant within a Faroese context are discussed. A conclusion and recommendation are provided.

7.1 The electricity grid and control system

The Faroese electricity grid is in reality comprised of several independent grids. The largest is in the central region (90 MW nominal effect). In addition there is the grid on Suðuroy (11 MW) and five small grids (30 kW–200 kW) on the small islands. The nominal effect is comprised of 31 MW from 9 (1–6.7 MW) hydropower turbines, 4 MW from 7 (0.15–0.66 MW) windpower turbines and 67 MW from more than 10 (1–12.4 MW) oil-fired motors. A series of cables, transformers and transmission lines making up the grid ensure that electricity from the power plants is conveyed out to each and every consumer.

7.2 Smart Grid in the Faroes

If a major electrification of energy demand is to be promoted, and at the same time it is decided to dramatically increase electricity production from fluctuating renewable energy resources, then major changes to the grid and its monitoring system must be implemented.

In the existing system, electricity runs one-way from the power plant to the grid. The system operator is able to control how much energy is released into the grid, but can only partially control the interplay between the various sources of power. It is not possible at present to control the demand for electricity. By 2020, the anticipated pattern of consumption shown in Figure 7.3 below will make it quite difficult to incorporate into production to any significant degree fluctuating power sources. Therefore, it is extremely critical to find methods to control and manage production and demand.

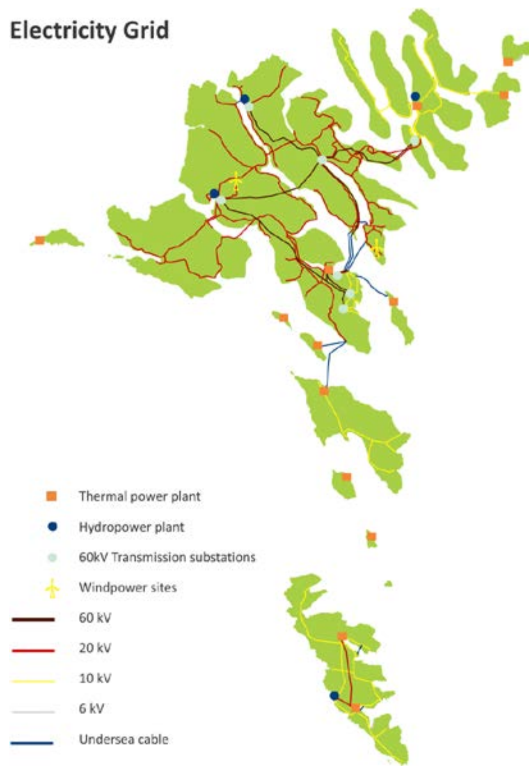


Figure 7.1: Faroese electricity grid. Source: SEV.

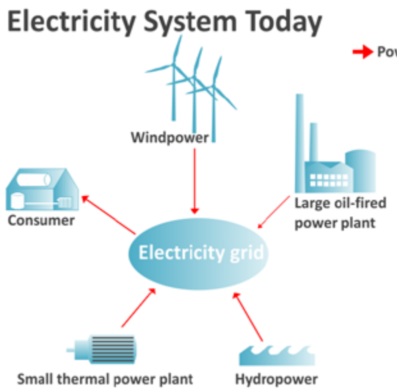


Figure 7.2: Model showing how the electricity system operates today. Source: SEV.

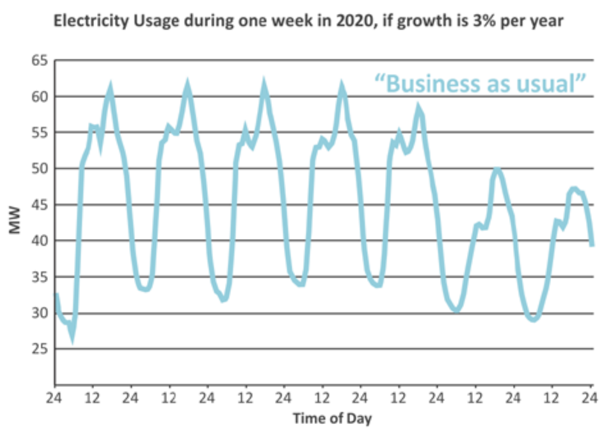


Figure 7.3: Electricity consumption without a Smart Grid. Source: SEV.

The solution is the so-called "Smart Grid", by which the system controller can not only manage electricity production, but also electricity demand to such a high degree that the demand pattern is fundamentally altered from large daytime fluctuations in consumption, like we have today, to a nearly even consumption over a 24-hour period.

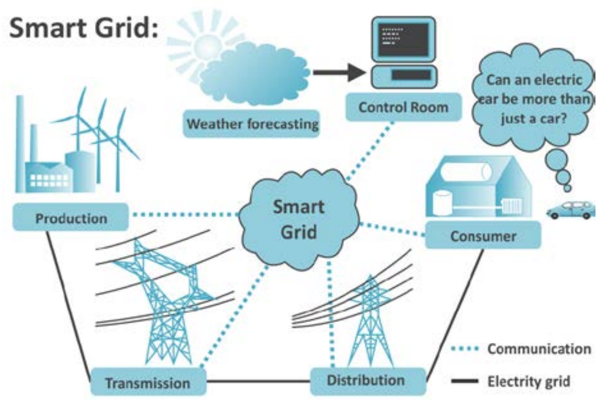


Figure 7.4: Model of how an electricity system operates with a Smart Grid. Source: SEV.

This system cannot be implemented in one day and is a major challenge, both technically and financially. Production-related equipment, such as motors, turbines, etc. must be upgraded with new technology and control systems must be installed, so that the system operator can always have as much renewable energy in production as possible.

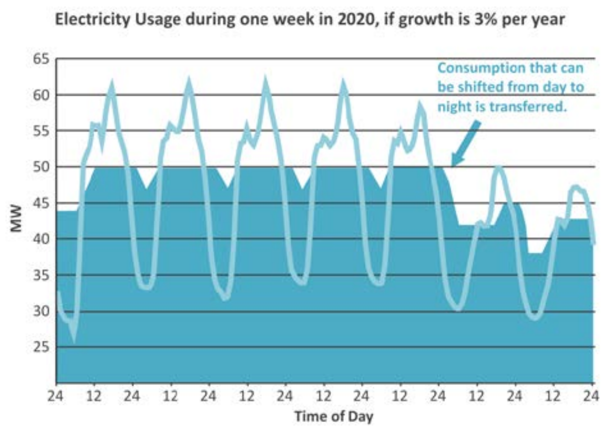


Figure 7.5: Electricity consumption with a Smart Grid. Kelda: SEV.

On the consumption side, it will be necessary to connect large and small consumers of energy into the system based on demand. An example of a large energy consumer is a pump in a "Pumped Storage" system and heating elements – e.g., in the District Heating System. An example of a small energy consumer is a household with a heat pump or heating elements or electric car.

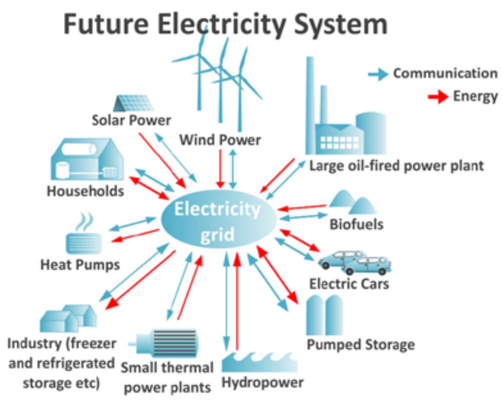


Figure 7.6: Model of a future electricity system. Source: SEV.

In a Smart Grid, intelligent electricity meters located at each individual consumer are crucial. Via these meters, the system operator can control when various equipment must have electricity or can transmit electricity (e.g., electric cars, small hydropower turbines, small windmills, solar cells) and can also differentiate electricity pricing – all the possibilities that are needed to balance energy consumption throughout the entire day. See Figure 7.5.

Conclusion

Electrification and the expansion of renewable energy resources require major changes in the electricity production system.

Recommendation

All expansion of the electricity grid should be undertaken with the goal of realizing as quickly as possible a comprehensive electrification of the country and the transformation of the current electricity grid to a Smart Grid.

7.3 Wind energy is the future foundation of energy production

Figure 7.7 shows the anticipated demand for electricity in the years ahead. The graph shows that, measured against anticipated demand, the potential to be gained from expanded hydropower will be comparatively very little.

The first column “Electricity Demand” shows a total electricity production in 2020 of around 500 GWh/year and in 2050 around 900 GWh/year. Production today from renewable energy sources is over 100 GWh.

The next column “More than in 2010” shows how much room there is for renewable energy in 2020 and 2050. The graph indicates that there is room for around 400 GWh/year in 2020 and around 800 GWh/year in 2050 of renewable energy.

These numbers can be compared with the potential to be derived from expanding the hydropower system in the Faroes. According to SEV (April 2008), approximately 135 GWh/year will be gained for an investment of DKK 2.7 billion.

The third column “New hydropower” shows the amount of additional hydropower that will be available after the planned Eiði II and Víkarvatn projects are completed.

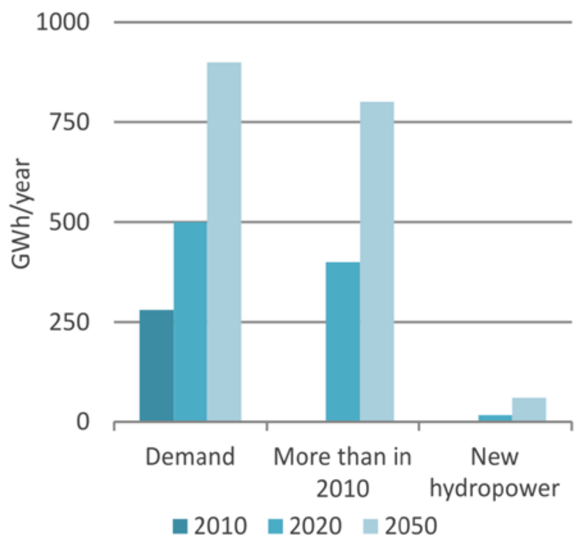


Figure 7.7: Anticipated electricity demand 2020 and 2050. Source: Editors' own calculations.

Thus, it is necessary to consider other alternatives than hydropower to exploit renewable energy resources for electricity production.

The wind energy trials over the last 10 years in the Faroes has shown that windmills on land produce double the amount of land-based windmills in Denmark, and the same amount as windmills located in good windfarm areas offshore of Denmark.

The generation of, e.g., 400 GWh/year of electricity from wind energy can be produced by around 40 2.3 MW windmills. This is possible in a system where all the hydropower – current and expanded – is used to balance and store wind energy. In addition, this scenario assumes that electricity is used for household heat pumps, the district heating system, direct heating via heating elements, land transport, and possibly small boats. As mentioned elsewhere in this report, the study shall show how a comprehensive system would look like that included a Pump Storage system, large dam infrastructure, etc.

The report *Indpasning af vindkraft på Færøerne* [Integration of Wind Power in the Faroe Islands], prepared by the consulting firm, Risø, in 2009 indicated that the current system could accommodate considerably more windpower, however with certain limitations. The plan is that in 2012, 14 MW of wind energy will be introduced into the system. Thus, by next year electricity generation from windpower could be between 50 and 60 GWh/year. The Risø report noted, however, that initially it might be difficult to store all the power produced and much of the hydro- and windpower will be lost. Calculations based on the Risø report show that if only 55% of the wind energy were utilized, around 12 GWh/year of hydropower and 25 GWh/year of windpower would be lost. Calculations based on the Risø report show that if only 55% of the wind energy was utilized, around 30 GWh/year of hydropower and windpower would be lost. The calculations also show that even with this large loss the price of energy production would be no greater than today, assuming that the price of that portion of the power generated by wind energy is stored and utilized (around 55%) is around DKK 0.60 per kWh.

If the 30 GWh – or a portion thereof – derived from hydro- and windpower that is expected to be lost could, instead, be used in the place of oil, a major financial and environmental advantage would result.

SEV has a plan to establish a windfarm (with batteries) in Hoyvíkshaga, a suitable expanse of land north of Tórshavn (see Figure 7.8 below), which is expected to cost around DKK 200 million and generate some 45 GWh/year. The production price should be around DKK 0.50 per kWh.

Figure 7.8: The photo shows how SEV envisions a windfarm on Húsahaganum. Source: SEV.

The photo above shows how SEV envisions installing 13 1-MW windmills in the Húsahaga area above Hoyvík outside Tórshavn that should generate more than 40 GWh/year. An innovative element in this plan is the combination of wind energy and batteries, which together will give the potential of controlling the energy production from wind. According to the plan, this installation could begin generating electricity in 2013.

Conclusion

Wind energy will become a reliable source of energy in the future.

Recommendation

14 MW of wind energy should be a reality in 2012. A study laying out the way forward to utilizing wind for extensive power production should be ready by 2012.

7.4 Electricity cable to other countries

Wind energy can not only be used for an environmentally-friendly generation of electricity for the Faroese market, but also with the installation of large windfarms it would be possible to produce electricity for export. It should be borne in mind that the weather in the Faroe Islands makes it much more commercially viable to produce electricity from wind energy in the Faroes than, e.g., on the European continent.

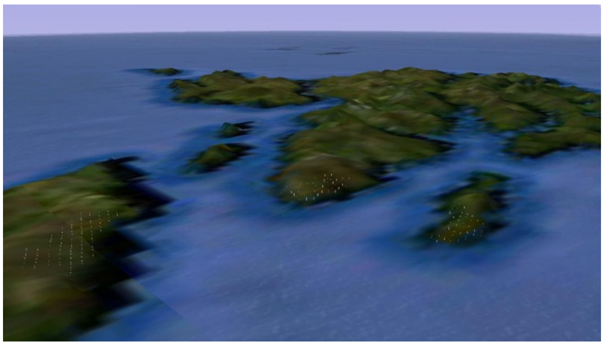


Figure 7.9: Possible locations of windfarms on southern Streymoy, Sandoy and Nólsoy. Source: Editors' own calculations.

Several locations in the Faroes are quite suitable for windfarms. Figure 7.9 above shows the areas located in southern Streymoy, the southern part of Nólsoy and on Sandoy.

The idea is to locate several, well-suited areas for large windfarms, e.g., three windfarms producing 200 MW of wind energy each. The windmills would produce electricity that would be delivered by an undersea power cable to the European mainland (via Scotland).

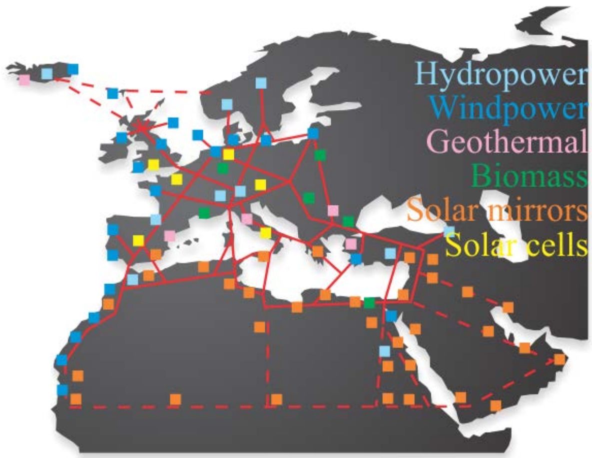


Figure 7.10: Countries in Europe, Africa and the Middle East could supply energy into a common grid. Source: Editors' own calculations.

Recent years have seen a major advance in the type of equipment designed to make it possible to transmit large amounts of electricity great distances, both on land and under the sea between countries. Today, HVDC cables exist or are being laid on the ocean floor which are hundreds of kilometres long, joining the countries in northern Europe into an extensive and sustainable scheme.

In the Faroes, such a cable system could address two goals. The first is to buy renewable energy from, e.g., Iceland; the second is to sell electricity generated from renewable resources, such as windmills or tidal current systems, to the European continent via, e.g., the Shetlands or Scotland.

In 2007, a work group with representatives from the Faroese Earth and Energy Directorate, SEV and the Icelandic energy authority prepared a study on the possibility of laying a 100 MW HVDC cable between Iceland and the Faroes. It would be possible to transmit up to 700 GWh of electricity per year through the cable. This is enough energy to meet all normal electricity demand, plus home heating and land transport.

If such a plan were to become a reality, it would, of course, have sweeping consequences for the entire energy supply system in the Faroes. One would no longer have to consider an expansion of renewable energy resources, but rather on the strengthening of the electricity supply and security system to ensure the provision of electrical energy whenever the cable was not in operation.

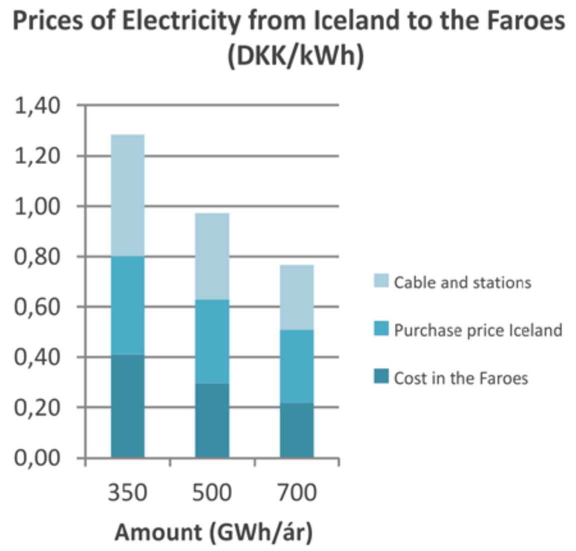


Figure 7.11: Cost of electricity in the Faroes with a cable from Iceland. Source: Editors' own calculations.

The project could only be commercially viable if a large amount of energy were to be transmitted via the cable. As an example, the second column in Figure 7.11 shows that the price paid by consumers would be around DKK 1.00 per kWh at a consumption rate of 500 GWh per year. These figures are based on an assumed DKK 2 billion for the cable, DKK 700 million to strengthen the grid and reserve capacity in the Faroes, a 15% loss of energy throughout the entire system and a 30- year depreciated lifespan for the cable.

It is also possible to envision the Faroes as an exporter of sustainable energy into a large European energy grid. Windmills in the Faroes could produce nearly twice the electricity as windmills on the continent, and energy from tidal currents can be extracted in large quantities.

An undersea cable would also make it possible to purchase large quantities of electricity for the Faroes in periods when there is little wind.

The export of energy requires that a cable be laid from the Faroes to, e.g., Scotland or Norway, and that a major expansion of wind energy and later tidal energy takes place in the Faroes.

The new energy plan for the EU, which is expected this autumn, will no doubt confirm the continued push for the use of renewable energy resources. This will be significant for wind energy from northern Europe and solar energy from southern Europe, see Figure 7.10 above. Large projects will not be financed by an individual country, but by all countries jointly. This could mean that a cable to the Faroes that connected to large windfarms and tidal current facilities could prove very interesting.

The cost of such a project is quite large – over DKK 10 billion – and requires foreign investment. A 600 MW windfarm requires some 15 km² of land and can generate around 2000 GWh of electricity, which can be sold for around DKK 1 billion. The first steps that need to be taken are:

- Find a suitable area to set up windmills and measure the wind
- Lock-in buyers of the electricity
- Find interested investors.

Conclusion

There is no technical hindrance to laying a cable to Iceland/Scotland to purchase/sell electricity.

Recommendation

Detailed studies should be undertaken to explore the potential of selling electricity to Europe.

7.5 Limitations, risk and solutions

The present electricity grid and control system is consistent with the production and consumption found in today's society in the Faroes. The main control principle is the production must always be adjusted as closely as possible to actual consumption. This means, among other things, that no special protocol is in place designed to optimize the control and management of the grid in order for it to accept as much wind energy as possible.

Risø noted in its 2009 report, *Indpasning af vindkraft på Færøerne* [Integration of Wind Power in the Faroe Islands], that even though it could recommend increasing wind energy production from the current 4 MW up to at least 12 MW using the existing system, there are significant limitations in the system that would inhibit a greater exploitation of windpower. Noted were:

- current motor installations cannot be adjusted to compensate for fluctuating wind energy;
- most of the hydropower turbines have old control systems that are not suitable for operation in a dynamic mode;
- the system is not designed to adjust to fluctuating energy from increased windpower production. This means that considerable wind energy will over time be wasted;
- the current control system is not sufficiently reliable to compensate for windpower.

The current system thus has built-in limitations and risks relative to major renewable energy expansion that must be resolved in line with any ongoing development. In addition, we must face all the natural limitations that are present because the entire grid is limited in size and has little inertia both from the perspective of production and consumption. These limitations could be considerably reduced by increased electrification and by intelligent control of consumption and production.

At a conference held in the Nordic house in the autumn of 2010 on the storage of energy in hydropower reservoirs, there were clear indications that a "Pumped Storage" system is an important element in a future electricity system. See the comments in the three boxes below.

PTS can:

- *Use surplus windpower for pumping rather than waste it*
- *Considerably increase supply capacity of the reservoir*
- *Increase the reserve capacity of hydropower turbines thus affording the possibility to shut down the diesel motors rather than idling.*

Tom Cronin, Risø DTU (National Laboratory for Sustainable Energy)

Aside from its importance in energy storage, a Pumped Storage facility in small electricity grids also has major importance because:

- *it acts as a power reserve;*
- *both in pump and turbine operation, it can transfer power to the grid and in this way assist in controlling grid stability;*
- *it could help limit the required investment in the electricity system to compensate for unstable renewable energy sources.*

Øyvind Holm, Voith Hydro

Pumped Storage (PTS):

- *Increases electricity production from existing reservoirs;*
- *Increases the supply security of the hydropower plant;*
- *Recycle the water in reservoirs and reduce the need for additional hydropower plants*
- *the energy cost for one 10 MW plant in Vestmanna is DKK 0.65 per kWh;*
- *stabilize other fluctuating energy sources such as tidal and wave energy;*
- *PTS or other energy storage systems are necessary, if we are to meet the goal of having 75% of electricity production be derived from renewable energy resources.*

Terji Durhuus
Faroese Earth and Energy Directorate

Conclusion

Important limitations exist in the current system that impede the exploitation of wind energy. Pumped Storage is a decisive and necessary part of a future electricity system.

Recommendation

A comprehensive study of the electricity system shall be undertaken immediately and be completed by the summer of 2012.