/ NORDIC WEST OFFICE

# STRONGER TOGETHER:

## THE FUTURE OF THE NORDIC ENERGY MARKETS

**A report by Nordic West Office with input from industry representatives**

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# FOREWORD

**Climate change is one of the major challenges of our time and for better or for worse, energy plays a key role in it. In 2013, 72% of global greenhouse gas emissions were caused by the energy sector, including energy used for electricity and heating, manufacturing, construction and transportation[1].**

**However, a large-scale energy transition is taking place. The world is reducing its dependence on fossil-fuel based energy resources, such as oil and coal, and moving towards low-carbon solutions, harnessing renewable energy sources such as solar and wind power, bio energy and hydropower.**

Enabled by the advancement of technology and the associated decline in costs, this transition is progressing rapidly. According to the International Renewable Energy Agency (IRENA), one-third of the world's power capacity in 2018 was from renewable sources, and nearly two-thirds of the capacity added in 2018 was of renewable origin[2]. In the European Union, renewable energy increased by two-thirds in the decade between 2007 and 2017[3].

The Nordic countries are widely recognised as frontrunners in the energy transition. Already in 2017, Denmark, Sweden and Finland had renewable energy shares that exceeded their EU 2020 targets.[4]As early as 2016, the proportion of renewable energy in Norway's gross final energy consumption was 69.4%[5]. The relative share of renewable energy in Sweden's transport fuel consumption in 2017 was 38.6%, and in Finland 18.8% – both well above the common EU target of 10%[6].

It is clear that the Nordics can – and should – serve as an example, not only within the European Union but for the rest of the world. However, in order to achieve this and to remain forerunners also in the future, the Nordic countries must do more.

While an energy sector transition is vital from the climate perspective and provides possibilities for economic benefits, the transformation also brings

[1] *https://www.c2es.org/content/international-emissions/*

[2] *https://www.irena.org/newsroom/pressreleases/2019/Apr/Renewable-Energy-Now-Accounts-for-a-Third-of-Global-Power-Capacity*

[3] *https://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics#Renewable_energy_produced_in_the_EU_increased_by_two_thirds_in_2007-2017*

[4] *https://ec.europa.eu/commission/sites/beta-political/files/fourth-report-state-of-energy-union-april2019_en_0.pdf*

[5] *https://ec.europa.eu/energy/sites/ener/files/no-en-4th_res_report_norway.pdf*

[6] *Figures calculated according to the related EU directive. https://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics#Renewable_energy_produced_in_the_EU_increased_by_two_thirds_in_2007-2017*

about challenges that need to be addressed. For example, while wind and solar energy become increasingly available, their integration into the power system introduces complexities as they do not provide a constant source of power. This report delves into some of these issues and proposes tangible solutions to them.

Our report builds on "Nordic Energy Co-operation: Strong today – stronger tomorrow", a review commissioned by the Nordic Council of Ministers and written by Jorma Ollila in 2017. It is also a response to the Nordic Energy Ministers' request[7] for input on how to strengthen Nordic exports and innovation in the field of energy. Cases that showcase Nordic innovation are featured throughout the report, and further examples are provided in the annex.

Our report brings together the valuable insights of energy producers, technology providers, service providers and energy users. I would like to thank all of the contributors. Participating companies include Danfoss, Fortum, Gasum, Stora Enso, SSAB, Statkraft, Virta and Wärtsilä. In addition, the report has benefitted from the expertise of Pöyry and Climate Leadership Coalition. Academic insight has been provided by Johannes Urpelainen, the Prince Sultan bin Abdulaziz Professor of Energy, Resources and Environment at the Johns Hopkins School of Advanced International Studies. Special thanks go to Maria Wetterstrand, CEO of Miltton Purpose, who took a leading role in drafting the report.

At Nordic West Office, we strongly believe that the business sector is a crucial part of Nordic societies and plays a key role in addressing some of the key problems of our time – not least the urgent global challenge of climate change. We hope that this report provides both useful insights and concrete proposals for Nordic decision makers to drive progress towards a sustainable energy transition.

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[7] *https://www.norden.org/en/news/ministers-want-businesses-boost-export-nordic-energy-technology*

# EXECUTIVE SUMMARY

# This report on the future of the Nordic energy markets explores concrete ways to create the world's smartest energy system and to find the most energy and cost-efficient solutions in moving towards a low-carbon green economy.

The Nordic countries have already achieved a great deal, and at many fronts. The Nordics are leaders when it comes to moving towards a low-carbon green economy; however, the region must keep moving forward to stay ahead. If not, plenty of valuable opportunities will be lost. While the Nordics make up the 12th largest economy in the world when seen as a whole, the physical and regulatory border barriers hinder the market from functioning as one.

An energy transition is on its way. Some of the key signs from the Nordic perspective are the following:

- Awareness on climate change is rising.
- More and more affordable capacity of weather-variable renewables, such as wind and solar power, are being built.
- Electricity demand is rising within certain sectors, as part of the development of efficient low-carbon solutions for industry, heating and transport.
- A growing bioeconomy is increasingly seen as part of the solution, while fossil fuels are being phased out.
- There is a need for more flexibility on both the demand and production sides to respond to more variable and distributed power generation.
- The use of the grid is changing, prompting the need for development and investments.
- Green transport solutions are in demand, and corresponding solutions can be found within the fields of electrification, biofuels or other low-carbon energy sources.

To create the smartest low-carbon energy system in the world, there is a need to take a broad perspective on energy – not only looking at electricity, but also at the integration of different parts of the energy systems. Changes and challenges that are forecast in the medium and long-term perspective, specifically in the period from 2030–2050, ought to be managed by taking action now.

This report identifies three basic pillars that are needed to support the vision of the world's smartest low-carbon energy system: affordability, sustainability through de-carbonisation, and security of supply.

In addition, this publication explores four themes that must be addressed to support development:

1. Power supply and flexibility;
2. Advanced fuels and transport;
3. Efficient integrated energy systems; and
4. EU Energy Union and Nordic solutions.

Creating a well-functioning market for energy-related solutions and smart systems integration will strengthen the export of Nordic solutions and enable the region to influence the EU by setting a good example.

To conclude, this report provides concrete recommendations regarding the next steps to take to reach the vision of creating the world's smartest low-carbon energy system:

## THEME 1: POWER SUPPLY AND FLEXIBILITY

1. Recognise the value of hydropower as a balancer for other renewable energy sources through its potential for flexible operations, and take this into account when considering measures that might restrict its use. At the same time, recognise that new smart demand response[8] solutions are providing new options to balance the system.

2. Build a system where flexibility is rewarded, break down regulatory barriers between the countries to provide a pan-Nordic market for flexibility and flexibility solutions. Specifically, enable new distributed solutions as energy resources will increasingly be located in people's homes.

3. Commit to maintain an energy-only market also in the future, and enable the market to provide the right price signals; and in this way, find the most cost-efficient solutions to flexibility challenges.

4. Set up a vision for a common Nordic organisation that prioritises grid investments from a Nordic systems perspective, rather than from a national perspective. As a step on the way, increase the common budget and give the national grid organisations a stronger mandate to cooperate.

5. Aim at decreasing the number of price areas in the electricity market.

*8"Demand response" means that instead of increasing or decreasing the supply of electricity as a response to changing demand, measures can be taken to adjust demand to supply; for example by decreasing the use of electricity at peak times or to use more of it at times of high supply.*

# THEME 2: ADVANCED FUELS AND TRANSPORT

1. Increase practical implementation and research cooperation on charging infrastructure for electric vehicles (EVs) and vessels to manage its effect on utilisation of the grid and its functionality in contributing to flexibility in the power system.

2. Adapt and change relevant regulations to help EVs and other distributed solutions to be part of the electricity system. This requires stronger cooperation and harmonisation of rules.

3. Initiate a roundtable discussion between decision makers, the shipping industry, harbours and technology providers to create a joint vision and a roadmap for the transition to a low-carbon Nordic and Baltic shipping sector concerning, for instance, ensuring shore supply of electricity across the region and harmonising the regulatory environment related to liquified natural gas and biogas (LNG/LBG.)

4. Assess potential regulatory barriers to the production or introduction of low-carbon fuels between Nordic countries and take measures to remove them. For instance, the political efforts to decarbonise aviation should be coordinated.

5. A regional biogas certificate or guarantee of origin could foster increased biogas production and efficient cross-border trade, inspired by the green certificate market for electricity in Norway and Sweden.

1. Review today's varying taxation of energy and energy-related resources in the light of increasing integration between different parts of the energy system. Taxation should guide the use of resources so that they are used where they most benefit the vision of a cost-efficient, smart, low-carbon energy system.

2. Create test beds and demonstration projects to develop promising areas with efficient integrated energy systems, as well as more long-term solutions like power-to-X technology development.

3. Bring together stakeholders and develop a common future vision of how buildings can contribute to an integrated energy system, including possibilities for energy efficiency measures, energy storage, electricity production, EV charging, providing of flexibility to the grid, and efficient heating solutions such as the use of waste heat from industry.

4. Investigate energy integration with a systems-level approach to evaluate the potential and the impact of different solutions as means to decarbonise the Nordics, with the aim to assess where resources can be used most efficiently.

# THEME 3: EFFICIENT INTEGRATED ENERGY SYSTEMS

# THEME 4: EU ENERGY UNION AND NORDIC SOLUTIONS

1. Showcase the Nordic electricity market as the market model for the EU, emphasising the energy-only approach.

2. Use the energy and climate plans to coordinate a Nordic approach to the implementation of national or EU climate targets, identify hot topics for cooperation and analyse how energy-related national decisions make an impact on the Nordic level.

3. Give well-functioning low-carbon energy technology a Nordic passport, so to speak, by harmonising and coordinating regulations and removing border barriers between the Nordic countries.

4. Set up an online service where companies in the Nordics can report border barriers that hinder the spread of low-carbon energy-related technologies.

5. Cooperate on the international arena to promote Nordic, rather than national, solutions to global challenges and brand the Nordics as the place where new solutions are developed, tested, commercialised and implemented.

# INTRODUCTION

## The aim of this report is to explore concrete ways to create the world's smartest energy system and to find the most energy and cost-efficient solutions in moving towards a low-carbon green economy[9].

The report focuses on the Nordic region[10], an area that has unique potential to act as a frontrunner in the energy transition. Nordic countries are less dependent on fossil fuels than many others, with good conditions for renewables like hydro power, wind and biomass and investments in the fossil free nuclear energy that are all playing an increasingly pivotal role in the Nordic energy system. In the long run, the Nordics might have the best conditions in the world to showcase an authentically low-carbon energy system – and achieve this cost-efficiently. If the Nordics do not move ahead, who will?

In addition, the Nordic countries are at the forefront when it comes to cooperation, not least through the implementation of a common electricity market. Overall, when it comes to creating the world's smartest energy system, the Nordic countries are well-positioned – not only in terms of geographical conditions such as their topography and land use, but also economically and technologically.

However, the transition to a cost-efficient low-carbon energy system presents challenges. The need for a stable and affordable power supply, and for flexibility on both the supply and the demand sides, the necessity to transition to a low-carbon transport sector, and to fulfil the full potential of energy efficiency measures, as well as the question of how to create favourable conditions for investments and innovation are just a few of the issues that need to be solved.

Since the challenges are quite similar worldwide, if the Nordics manage them correctly, they will be able to provide solutions of potentially global value. If, on the other hand, the Nordics do not succeed in this, it will be harmful both economically, ecologically and socially. Worthwhile prospects will be lost.

Therefore, this report does not only provide an important perspective on these issues from the business sector; it is also a call to action for relevant actors to seize the full potential of the Nordic energy markets.

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*[9] Low-carbon in this context means a development that decreases greenhouse gas emissions in line with the UNFCCC Paris Agreement on climate change.*

*[10] The Nordic countries or "the Nordics" are a geographical and cultural region in Northern Europe and the North Atlantic, where they are most commonly known as Norden (literally "the North").The term includes Denmark, Finland, Iceland, Norway, and Sweden, as well as Greenland and the Faroe Islands—which are both part of the Kingdom of Denmark—and the Åland Islands and Svalbard and Jan Mayen archipelagos that belong to Finland and Norway respectively. (from Wikipedia)*

This report assesses the future of the energy system from a medium to long-term perspective (2030–2050) while recommending important steps that, if taken urgently, could put the region on track towards the desired future.

The scope extends beyond just electricity, since all parts of the energy system interact and must therefore be taken into account in the transition. Cooperation in research and development is thoroughly discussed in Ollila's report; therefore, it is only examined partially here.

"The Nordics" is used as a term in this report although the actions, analyses and conclusions provided are not always applicable to all areas of the Nordic region.[11] In the future, the Baltic region might also be more closely integrated with the Nordics.

## THREE BASIC PILLARS

This report states that a Nordic vision of a smart, low-carbon energy system needs to stand upon the following three basic pillars:

1. ***Affordability.*** Consumers and businesses need affordable energy. Energy poverty is not acceptable in well-developed welfare states like the Nordics. Competitiveness is vital for the economy, jobs and innovation. Moreover, a low-carbon Nordic energy mix means that goods and services produced in the Nordics could have a smaller carbon footprint than in almost any other part of the world, as long as the energy production is efficient enough.

2. ***Sustainability (decarbonisation)***. The Nordics should be at the forefront in fighting global climate change and in working towards the targets set in the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement. The climate targets set by the individual Nordic governments and the European Union[12] provide a direction and a framework for the development of the energy sector and energy markets.

3. ***Security of supply***. Secure and trustworthy power systems have been crucial to the economic growth and industrial success of the Nordics. A smart combination of flexibility and generation adequacy is vital to meet the demands of a future-proof energy system. The issue of security of supply must also be examined from a broader perspective than just electricity.

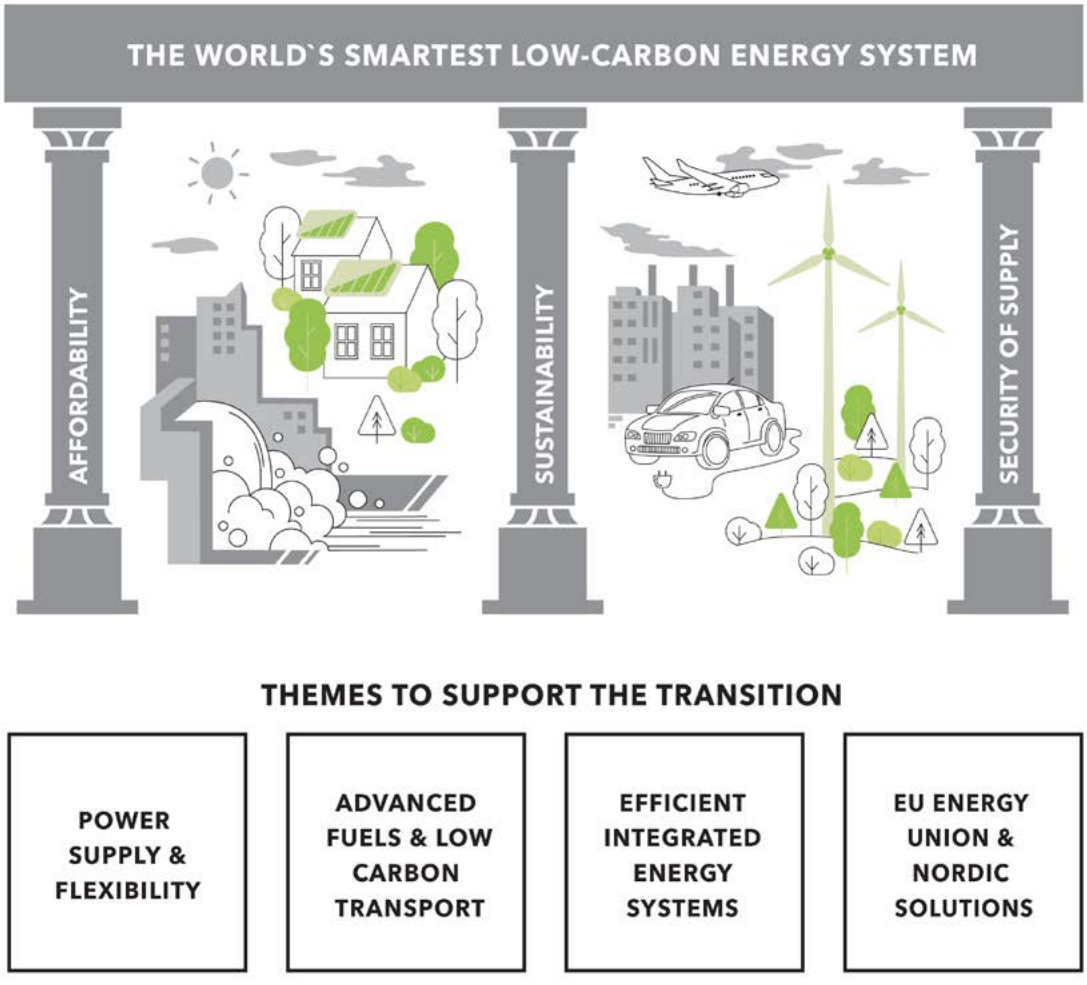
*[11] For example, depending on whether the areas are integrated parts of the electricity market. Similarly, the discussion related to a common grid organisation is not relevant in all areas, such as Iceland or Greenland.*

*[12] For example, the European Union has set the following targets by 2020: 20% cut in greenhouse gas emissions (from 1990 levels); 20% of EU energy comes from renewables; 20% improvement in energy efficiency. Read more: https://ec.europa.eu/clima/policies/strategies/2020_en*

# KEY THEMES

To support the transition towards this vision, we have identified four themes that should be addressed;

1. Power supply and flexibility,
2. Advanced fuels and low-carbon transport,
3. Efficient integrated energy systems, and
4. EU Energy Union and Nordic solutions.




These themes are discussed in detail below. As inspiration, the beginning of each section provides quotes from Ollila's report.

# THEME 1: POWER SUPPLY AND FLEXIBILITY

"A suggested starting point could be to give political guidance to the TSOs[13] on their future role and mandate for even closer co-operation between them. The focus should be on maximising benefit for the entire region. It would be relevant for the politicians debating this to discuss the need for a vision of an independent Nordic system operator."

"Historically, securing market balance has mainly occurred on the supply side, but the demand side will need to take a more active role."

*-Jorma Ollila, Nordic Energy Co-operation – Strong today, stronger tomorrow*

# WHERE WE ARE NOW – STRENGTHS AND CHALLENGES

In 2017, Denmark set a world record for wind power when 43% of the power consumption was covered by wind. However, wind varies with the weather, and because production and consumption of electricity must always be in balance, Denmark exports as well as imports electricity. Its main sources for balancing are Norwegian and Swedish hydropower, whose production is flexible and can be adjusted relatively quickly to meet demand. This is much more cost-efficient than investing in separate Danish back-up capacity that would only be used when the wind is not blowing. The integration of the power system in this manner makes it possible to use more wind in Denmark.

The growth of intermittent renewables like wind power is economically viable and is expected to continue, to the benefit of affordability and sustainability. This means, however, that electricity production will be less stable than before. This variation in production poses challenges.

The Nordic energy market is mainly what is called an energy-only market, as opposed to a capacity market. In an energy-only market, a price is paid for energy produced rather than for keeping capacity ready, although some complementary mechanisms exist to guarantee a balance between supply and demand. This has worked well.

When large amounts of cheap but variable, intermittent, renewable energy enter the market, prices may become less stable, which may then prompt political measures to be taken to support back-up capacity as a means to stabilise production and prices. This could mean, however, that the most cost-efficient solutions to the flexibility challenge may not be chosen, ultimately leading to higher total costs. For example, different types of demand response[14] could provide a cheaper way to balance intermittent production than investing in new back-up production capacity. Maintaining an energy-only market would provide the correct price signals to guarantee a cost-efficient range of solutions.

With Nordic hydropower as a key component for medium-term and seasonal[15] energy balance, the system within the region is well equipped. Nevertheless, a need for further development remains. The truly quick-response flexibility solutions, which will be even more vital in the future, might well be found elsewhere at a lower cost. In addition, demand for balance in the power system in general will increase as renewable energy is introduced ever more rapidly within the Nordics and beyond.

In relation to the above, new environmental regulations might restrict the use of hydropower as a power system balancer. These restrictions might be reasonable from a local environmental perspective; however, it must be taken into consideration that they may negatively impact the possibility to introduce more renewables in a cost-efficient manner and thus reduce the pace at which the impact of climate change is mitigated.

[13] *TSO = Transmission System Operator*

[14] *"Demand response" means that instead of increasing or decreasing supply of electricity as a response to changing demand, measures can be taken to adjust demand to supply. It might be to decrease the use of electricity at peak times or to use more of it at times of high supply.*

[15] *Medium term and seasonal balance = days to seasons. Short term = hours and minutes*

Aggregated, distributed demand response – as in the case of many electric vehicle batteries connected in a common digitalised system – may be a cost-efficient way to balance the system in the future as described in the next chapter. In practice, present-day regulations make it difficult to provide such solutions.

The Nordic electricity market is based on a common grid, which makes it possible to transport electricity from the production site to where there is demand, or to import and export between countries. Currently there are bottlenecks limiting the transferring capacity of the grid. There may be difficulties in reaping the benefits of the energy transition if this capacity is not increased, since the need to transfer electricity could rise with more varying production from intermittent renewables. Today, investments in the grid are mainly allocated on the national rather than a pan-Nordic level.

To mirror the differences in production and demand in different areas, the Nordic electricity market is divided into "electricity areas", or "price areas" as they are commonly called. This is to encourage investments in those areas where production does not meet demand, since all transport of electricity results in losses while also requiring investments in grid capacity. For industry, however, these different price areas may affect competitiveness.

# WHERE WE ARE HEADING

The Nordic power system is in transition. The use of wind power is expected to increase rapidly due to significant economic benefits alongside abundant wind resources. Fossil fuels are being phased out and traditional thermal power plants may eventually be decommissioned – changes which are being driven by the market. While nuclear power reactors are being shut down in Sweden, new capacity is being installed in Finland. Overall, the political debate on nuclear energy differs between Nordic countries. Nevertheless, nuclear will be a part of the power system for the foreseeable future, continuing to provide fossil-free power to the grid.

It is also forecast that distributed energy at domestic or small commercial scale will emerge, enabled by smart platforms. In the future, consumers could also more and more become producers, or so called prosumers, thus changing the traditional topology of the power grid. In connection to this, investment in photovoltaics and other solar solutions is increasing.

All of the above are factors in the vision of creating the world's smartest low-carbon energy system. While the on-going transition helps build foundations for the pillars of ***affordability*** and ***sustainability,*** it might challenge the pillar of ***security*** of ***supply*** if not managed correctly. Also, energy users will need to find services that enable them to implement ways to hedge against fluctuating prices that will become increasingly common. These services need to be developed by energy companies.

While the low-cost renewables enable low-cost average market prices, more extreme pricing at peak times of high-demand and low-production are likely, and may be politically demanding. However, these conditions will also provide a necessary incentive to invest in flexibility solutions.

A likely result is a changing role for thermal electric capacity; traditional inflexible thermal generation capacity may be decommissioned gradually, but

ultra-flexible thermal generation capacity may enter the market to provide flexibility when needed. This could also lead to an increased use of natural and renewable gases, such as biogas and power-to-gas solutions[16] to generate flexible balancing power. The transition also puts pressure on the power grid. Investments are needed to increase transferring capacity, both to meet the demand when production is changing and to level out the price differences between different areas.

According to "Nordic Energy Technology Perspectives 2016", a report by the International Energy Agency (IEA), in the future "the Nordic region can both export electricity and balance European variable renewables, generating large economic revenues and facilitating the transformation of the European energy system".

# CONCLUSIONS

Due to the environmental benefits and the economic viability of renewable energy, the power system is in transition towards a more intermittent and distributed power supply. This shift demands that two aspects in particular be addressed:

1. Flexibility for balancing, especially quick response within seconds or minutes
2. Grid capacity and grid integration

The demand-side response needs to be developed and integrated, and the progress of digitalisation in the Nordics offers the region an excellent advantage as a likely frontrunner in this field. Considering the Nordic situation, with relatively low electricity prices and access to flexible hydropower, any solutions for flexibility that are economically competitive here, would presumably be cost-competitive in other countries as well.

The individual Nordic countries are small, but together they constitute a considerable market. However, varying regulations between countries act as obstacles to the realisation of this market. For example, aggregated demand response services that are proven as well-functioning in one country might not be permitted in another. At times, no Nordic market provides possibilities to test new potential solutions for demand response. Barriers such as these squander opportunities and should be identified and removed.

The energy-only market should be the basis also in the future. Price signals are the best incentives for developing the most cost-efficient solutions. Decisive factors include finding the right business models and services, and a lot of responsibility

[16] *Power-to-gas refers to a concept where, for example, an oversupply of power can be used to produce, e.g., hydrogen gas, thus storing energy as gas.*

rests on the business side. Support for research and development is valuable, but even more important is utilising market mechanisms and designed services that present incentives to both the supply and demand sides to offer the right kind of flexibility to the market.

Whatever solutions are found to address the challenges regarding balance and flexibility, the need for a strong and adequately designed grid to support the transition is obvious. Grid capacity and integration are crucial for a cost-efficient energy system. Stronger cooperation between the Nordic grid organisations, also known as transmission system operators (TSOs), has been on the agenda for several years, and there are initiatives that are going in the right direction. Nevertheless, these efforts need to be intensified.

As a vision, a common Nordic[17] grid organisation that prioritises the investments from the Nordic rather than national perspective, should be developed. A first step in the planning and prioritisation towards creating a common grid could be a larger common budget and a shared strategy for grid investments across borders. Investments in the grids are needed and might be more cost efficient if prioritised collaboratively on the Nordic level rather than on national levels. Investments in the grid should make it possible to decrease the number of price areas in the electricity market.

The local grids are also integral parts of the system, and flexibility solutions can be aggregated and offered through them. This is beneficial from a customer perspective, since the local grids can ensure that individual consumers can contribute to the solutions.

Finally, the integration of electricity to the energy system as a whole must be taken into consideration. This aspect will be discussed in more detail in Theme 3: ***Efficient integrated energy systems***.

Electrification is a strong trend in heating, industry and transport. Also, when production is at its highest, the possibility to utilise the oversupply is crucial in obtaining optimal economic benefits. The easiest solution is to export, but the development and implementation of different storage solutions such as batteries or power-to-X conversion technologies might be needed as well.

[17] *In this instance, referring to Sweden, Finland, Norway and Denmark*

CASE

# NEW INNOVATION HELPS IMPROVE AIR QUALITY BY CAPTURING $CO_2$ FROM THE AIR AND CONVERTING IT TO SYNTHETIC RENEWABLE FUEL

Soletair Power Oy, a Finland-based startup company, operates in the field of Power-to-X, which refers to conversion technologies that allow for the decoupling of power from the electricity sector for use in other sectors such as transport or chemicals. Soletair has developed a unique way to improve air quality in buildings by capturing carbon dioxide ($CO_2$) and converting it to synthetic renewable fuel that can be used in transportation or power generation. The concept represents an important step towards carbon neutral societies.

While hydrogen can be produced with electricity from renewable sources, Soletair's concept captures the $CO_2$ from the air and utilises synthesis to combine these components into synthetic renewable fuel. The technology group Wärtsilä has agreed to provide EUR 500,000 in seed funding to Soletair and will provide global support in the development and commercialisation of the technology.

Power-to-X technologies are an example of integrating the power generation and transportation sectors. Building a sustainable future for the energy industry requires maximised renewable generation, which is enabled by integrating flexible energy generating assets together with intermittent renewables and storage. In a world with 100% renewables, the majority of energy produced will be from solar photovoltaic (PV) technology, which converts sunlight into direct current electricity by using semiconductors, and wind power. The required operational flexibility will be provided by utilising excess renewables in production of synthetic fuels for transportation and by flexible gas power plants using synthetic fuels, as well as by use of other types of energy storage. Read more: https://www.soletairpower.fi/

CASE

# FORTUM SPRING, THE VIRTUAL BATTERY BUILT FROM DISTRIBUTED DEMAND-SIDE ASSETS

Fortum's internal venture, Spring, has developed a cloud service called the Virtual Battery. It enables trading with a distributed and diverse fleet of demand-side assets. The Virtual Battery is currently autonomously trading and dispatching a fleet of over 2,000 units. All individual units can be steered and measured on a one-second resolution. The service utilises machine learning to analyse real-time measurements and forecast the availability of flexibility as well as its optimal bidding tactics in Frequency Containment Reserves.

A significant part of the fleet consists of electric water heaters in single-family homes. The Spring venture sells the flexibility solution to households through multiple electricity retailers. Additionally back-up power batteries at data centres, telco sites and grid locations, as well as, increasingly, EV charging, bring additional flexibility to the Virtual Battery. The synergistic operation of different types of flexibility at high speeds is one of the major advantages of Spring's approach. Fortum is moving towards operating all flexibility with the same logic in the coming years. This will bridge the gap between high-capacity and high-energy flexibility sources, and enable the power system to be served in all time scales even with the increasing share of intermittent renewables.

# PROPOSALS

1. Recognise the value of hydropower as a balancer for other renewable energy sources through its potential for flexible operations, and take this into account when considering measures that might restrict its use. At the same time, recognise that new smart demand response solutions are providing new options to balance the system.

2. Build a system where flexibility is rewarded, break down regulatory barriers between the countries to provide a pan-Nordic market for flexibility and flexibility solutions. Specifically, enable new distributed solutions as energy resources will increasingly be located at people's homes.

3. Commit to maintain an energy-only market also in the future, and enable the market to provide the right price signals; and in this way, find the most cost-efficient solutions to flexibility challenges.

4. Set up a vision for a common Nordic organisation that prioritises grid investments from a Nordic systems perspective, rather than from a national perspective. As a step on the way, increase the common budget and give the national grid organisations a stronger mandate to cooperate.

5. Aim at decreasing the number of price areas in the electricity market.

# THEME 2: ADVANCED FUELS AND TRANSPORT

"Each Nordic country is addressing the challenge of transport at national level – and in more or less different ways. This is less than optimal, and means the Nordic Region is potentially missing out on new positions of strength. We need to ask ourselves, again, whether this is truly affordable if we want to maintain our living standards and welfare model."

"The countries therefore ought to engage in a joint effort aimed at making a commercial breakthrough in the greening of heavy transport, shipping and aviation."

"The proposals outlined above are not necessarily easy to implement, and may even seem far-fetched or unrealistic. It is hard enough to align the efforts on greening the transport sector within one country – but exponentially more difficult at regional level. However, the scale of the challenge does not diminish its necessity."

*-Jorma Ollila, Nordic Energy Co-operation – Strong today, stronger tomorrow*

# WHERE WE ARE NOW – STRENGTHS AND CHALLENGES

Transport accounts for a fifth of global energy demand and a quarter of energy-related $CO_2$ emissions. In the Nordics, the transport sector accounts for almost 40% of $CO_2$ emissions[18] and is also a major contributor to city air pollution.

The electrification of the transport sector is on its way, decreasing both climate impact and air pollution. Norway has been a global driver facilitating and speeding up this process through national measures, leading the country to the top position in the world in its sales of Electric Vehicles (EVs)[19]. In March 2019, more than half of the cars sold in Norway were EVs. Number two in the world is another Nordic country, Iceland, where 19% of cars sold in 2018 were EVs. Both Sweden and Finland also made it to the global top 5 of EVs sold in 2018. The growing EV market provides a good opportunity for the Nordics to create new business in this sector.

As a whole, the Nordic region is the third largest market for EVs by sales in the world after China and the US, with a market share of 10.6% on average in 2017[20]. More and more cities are investing in electric bus fleets.

Finland and Sweden are the top two countries in the EU when it comes to the share of renewables in the transport sector, mainly because of the high share of advanced biofuels. Both countries have reached the EU 2020 target[21] well in advance.

At the moment, a network of fuelling stations offering liquified natural gas and biogas (LNG/LBG) for the heavy-duty transport segment is built across Sweden, Norway and Finland, forming a basis for increased uptake. Hybrid or electric-powered heavy duty vehicles and off-highway vehicles such as excavators are also being developed. In addition, there are ongoing projects in the Nordics on electric roads for heavy transport as well as investments in railways.

The rapid growth of LNG's role in the global energy system improves the security of the gas supply in the region. The network of small-scale LNG terminals in the Nordics connects the region to global LNG markets and diversifies its gas supply. In addition, the Baltic connector, a new gas transmission pipeline between Estonia and Finland, will further deepen regional integration. In the future, increased biogas production in the Nordics will further enhance the security of supply.

Norway will implement a mandatory blending of bio-jet fuel into jet fuel for aviation. Furthermore, the country aims for all domestic flights to operate using electric aircraft by 2040. In Sweden, the agreement that formed the basis for the current

[18] *IEA; Nordic Energy Technology Perspectives 2016*

[19] *Electric vehicles include battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV) and fuel cell electric vehicles (FCEV) in the category of passenger light-duty vehicles (PLDVs). BEVs and PHEVs are the majority of electric cars in use today in the Nordic region.*

[20] *IEA, Nordic EV Outlook.*

[21] *The EU 2020 target for the transport sector is to reach 10% share of renewable energy in transport by 2020. Sweden reached this target in 2013, and in 2017 the figure was 38.6% calculated according to the EU directive. In Finland the same figure for 2017 was 18.8%.*

government resulted in a similar proposal on bio-jet, so far without specific targets. The Swedish aviation industry has made a roadmap pointing the way towards fossil-free domestic aviation by 2030 and fossil-free domestic and international aviation from Swedish airports by 2045.

On the Baltic Sea, there are already several ships in regular freight and passenger traffic using LNG, which is an easily accessible and cost-efficient low-carbon fuel for the maritime industry. The number of LNG-fuelled ships is expected to rise significantly over the coming years. Electrification and hybridisation of vessels are also on the agenda, as well as shore power supply for ships.

Even with the testing of innovative solutions such as electric roads, electrification or LNG/LBG for heavy-duty vehicles, LNG for ships, and bio-jet for aviation, a major challenge remains in heavy-duty vehicles, ships and aeroplanes. There is a long way to go and Nordic cooperation can help.

# WHERE WE ARE HEADING

The car fleet will gradually become more and more electrified, although biofuels will continue to be instrumental for a considerable time. According to a scenario by the IEA, the fleet of EVs in the Nordics will reach 4 million by 2030. This would save greenhouse gas emissions equivalent to 27% of those released by passenger vehicles in the Nordics in 2017, contributing to the pillar of sustainability. The ambitious climate targets in the Nordic countries will necessitate a change in the way we transport goods and people, both in the short and long term.

Four million EVs will increase electricity demand by around 9 TWh annually, which would amount to 2–3% of the expected total electricity consumption in 2030. An electrified car fleet might also in the future be an asset in the aforementioned need for flexibility in the power markets, as they can provide both demand response, charging only at times of low demand; and input to the grid, using batteries as storage solutions. As EVs are constantly moving, this requires new perspectives in terms of regulations. For example, it would be beneficial to the customer and to the whole system if the EV battery could be utilised for as many purposes as possible at different times, wherever it is located. This requires harmonisation in rules and cooperation between e-mobility operators.

The possibilities to produce advanced and sustainable bio-based fuels in the Nordics are technically good and several initiatives are ongoing. Coordination on the political level between the Nordic countries could, in a best case scenario, provide a larger market and a stronger demand that could drive investments in different solutions.

It should be remembered that the future of transport is crucial to business both directly and indirectly. Goods and people need to move. The transportation of goods must be cost-efficient, and the labour markets large enough to find the right competences. Combining competitive transport solutions with the ambitious climate targets may be the biggest challenge of all for the Nordics.

# CONCLUSIONS

The Nordic countries have, in some ways, chosen different approaches to the greening of the passenger vehicle fleet and have contributed to the development of both EVs and biofuels. There is a need for coordination, however. Learning from each other and breaking down technology barriers, for example, on the charging infrastructure as well as on projects exploring possibilities to use batteries as energy storage or chargers as sources of short-term flexibility to the power grid (see also Theme 1: Power supply and flexibility).

When it comes to aviation, shipping and heavy transport, there is a great opportunity and need for a joint Nordic approach. There is a high degree of interdependence in these sectors over national borders, and a Nordic cooperation to find both technological and political solutions to support the transition in these areas would add value. The need for innovative new solutions is immense. The Nordics are dependent on a functional transport system and it is natural that the region take a role in driving this transition in heavy-duty vehicles, shipping and aviation, just as it is doing for passenger vehicles.

To accelerate the transition of the transport sector in a cost-efficient way, there is a need for openness towards different solutions. There should not have to be a need to choose between electrification or other low-carbon fuels, or between short- and long-term alternatives. Rather, policy makers should set the targets and build a basis for fair competition based on the cost efficiency of solutions in decreasing emissions and then rely on the market do the rest.

Existing solutions for heavy-duty vehicles include LNG/LBG, biodiesel or hybrids. Biodiesel is already available, but the key is to find sustainable and cost-efficient resources for production. Increasing Nordic production of biodiesel from forest residue might be one way to enhance the growth of the bioeconomy. To protect the long-term credibility of such biofuels as a sustainable alternative, it is important that the region's forest management is both competitive and responsible, and that regulation does not favour direct combustion or any single-use of round wood for energy.

Shipping is an efficient means of transporting goods and people, but there is a need for low-carbon solutions. LNG technology is available today and there is a possibility to blend in liquified renewable gases to decrease climate impact even further. To support investments and encourage the use of biogas, a certificate system could be introduced on a Nordic level, similar to the green certificates for electricity in Norway and Sweden, where a producer of green electricity gets a certificate that can be sold to electricity suppliers, which are obliged to show a certain number of certificates corresponding to the volume of their sales.

There should be a joint Nordic approach – a cooperation between decision makers, the shipping industry and harbours – to drive this transition forward and make the Nordics and the Baltic Sea an example to the rest of the world. In this case, partnership with the Baltic States would add value. To enhance sustainability in shipping further, harbours should provide shore supply of electricity for ships to reduce their use of fossil fuels when docked.

The initiatives already taken on bio-jet fuel for aviation should be taken up for discussion in a Nordic context. The more coordination there is between the countries on these issues that concern cross-border transport, the better.

Coordination can be valuable both in implementation of regulatory frameworks and in research and development. The potential regulatory barriers that exist in these fields between the Nordic countries should be assessed, and measures taken to remove them.

The Nordics have the potential to take a key role in the electrification of the transport sector, as well as in the production and uptake of sustainable bio-based fuels. In the longer term, there is also the possibility to use power-to-fuels technology, where wind power can be a source for cheap electricity. The Nordics should coordinate efforts in research and development in these fields. This is also a question concerning the integration of the energy systems, a theme which will be explored in the next chapter.

CASE

## NORDIC TECHNOLOGY HELPS TO DECARBONISE SMALL ISLANDS IN THE CARIBBEAN

Martinique and Guadelupe are small and sunny islands in the Caribbean, where there are great opportunities to decrease the use of fossil fuels in electricity production and transportation. A local energy company, Green Technologie, has invested in new technologies such as solar panels and electronic vehicles (EVs) to decarbonise the footprint of the islands. However, the power grid is quite weak and congested. To enable solar production and the use of EVs, Green Technologie invested in Finnish company Virta's smart control system. The system enables a larger amount of solar production than before and a larger number of EV charging stations on the islands. The system takes grid capacity and solar production into account and based on that, optimises EV charging. This system helps the island to be greener and more sustainable, which also means cleaner air for locals and tourists to breathe.

CASE

# THE WORLD'S MOST ECO-FRIENDLY BULK CARRIERS ARE OPERATING ON THE BALTIC SEA

ESL Shipping's bulk carriers Viikki and Haaga started operating on the Baltic Sea in late 2018. The vessels feature a wide range of innovations, and they are pioneers in terms of eco-friendliness and transportation efficiency. The combination of the latest hull design and numerous other energy-saving measures together with the use of liquified natural gas (LNG) as fuel will reduce the $CO_2$ emissions per tonne of cargo transported by more than 50% in comparison to the present generation of vessels.

These new, ice-class 1A ships are the first LNG-fuelled large bulk carriers in the world, representing the latest in technology and innovation. They will carry out sea transports within the Baltic Sea and the North Sea.

Shipowners worldwide are turning to LNG as their primary source of fuel. LNG meets all current and planned environmental requirements. It also eliminates particles and significantly reduces $CO_2$ emissions. LNG marine fuel is widely available, and will remain economically efficient for the foreseeable future. In 2018, the Nordic's leading LNG company, Gasum, completed over 1,000 LNG bunkering operations in the Baltic Sea region.

# PROPOSALS

1. Increase practical implementation and research cooperation on charging infrastructure for EVs and vessels to manage its effect on utilisation of the grid and its functionality in contributing to flexibility in the power system.

2. Adapt and change relevant regulations to help EVs and other distributed solutions be part of the electricity system. This requires stronger cooperation and harmonisation of rules.

3. Initiate a roundtable discussion between decision makers, the shipping industry, harbours and technology providers to create a joint vision and a roadmap for the transition to a low-carbon Nordic and Baltic shipping sector concerning, for instance, ensuring shore supply of electricity across the region and harmonising the regulatory environment related to LNG/LBG.

4. Assess potential regulatory barriers to the production or introduction of low-carbon fuels between Nordic countries and take measures to remove them. For instance, the political efforts to decarbonise aviation should be coordinated.

5. A regional biogas certificate, or guarantee of origin, could foster increased biogas production and efficient cross-border trade, inspired by the green certificate market for electricity in Norway and Sweden.

# THEME 3: EFFICIENT INTEGRATED ENERGY SYSTEMS

"The energy transition is already underway – if the Nordic countries do not participate to the fullest, the jobs will be created elsewhere."

*-Jorma Ollila, Nordic Energy Co-operation – Strong today, stronger tomorrow*

# WHERE WE ARE NOW – STRENGTHS AND CHALLENGES

Without energy efficiency improvements, the world's use of energy in 2016 would have been 12% higher than it actually was, adding the equivalent of another EU to the global energy market. Energy efficiency is pointed out as a crucial factor for reaching the Paris Agreement – even more crucial than renewable energy.

Energy efficiency, defined in a traditional manner, means decreasing the use of a specific type of energy resource while still getting the same benefit out of it; for example, producing the same products using less electricity or building more fuel-efficient cars. While still important, the concept of energy efficiency is changing.

A broader use of the term can include such things as: using waste heat from a data centre to supply district heating; building low-temperature heating and cooling grids connecting facilities with different needs; taking measures to cut peaks of power demand by demand response or the use of oversupply; electrifying industrial processes or road transport to make them more efficient; or producing chemicals from recycled plastics. These examples illustrate how sector coupling between different energy sectors can be a means to increase energy efficiency in a broader sense. The idea is that once a resource is brought into the energy system, it should be used as thoroughly and for as long as possible, across sectorial borders. This also connects energy efficiency to circular economy.

The sharp line between power, heat, transport, and industrial use of fuels is blurring. This is a positive development, since it brings the possibility to use resources more efficiently. But these system integrated solutions do not just appear out of thin air. There are barriers slowing down the emerging integrated solutions. For example, taxation differs for district heating and electrical heating, or third-party access to heating systems might be hindered.

Many different sectors see biomass as a potential solution to replace fossil fuels. Biomass can provide a source of energy for industry, replace fossil fuels in chemical processes, be used in district heating, as biofuels for transport, or in building material, to name a few applications. There is still potential to use more biomass from forestry in the Nordics, but limited biomass resources should be utilised where it brings most value by enabling the move towards a low-carbon future.

Buildings could be a key to both traditional energy efficiency measures and more integrated solutions. If developed in a smart way, buildings can contribute to decreasing both the base and top consumption in the system. One positive effect of this might be that less biomass is needed in district heating, thus increasing the availability of biomass for other sectors. Using less to do more is the cheapest and fastest way to improve the availability of energy resources, heat and power. The energy we do not use is the cleanest and most secure.

# WHERE WE ARE HEADING

It is estimated that overall electricity consumption will increase. The IEA's trend analysis points out electrification as one of the most important energy trends. The electrification of transport and industry are often used as means to decarbonise in an efficient way. Also, increased production in Nordic industry facilities is expected and must be considered as a positive force in society. This emphasises the need to increase efficiency of resources where possible and economically viable. Energy efficiency does not necessarily mean that total energy consumption decreases, but that it is lower than a baseline scenario.

Electrification of industry, road transport and heating might lead to increased demand for electricity. On the other hand, large-scale electrification will also provide flexibility sources, such as the charging of cars at night using oversupply of electricity, using batteries as storage, and decreasing heat pump use in the short term to bring balance to the power system.

When the IEA sets up a scenario for Nordic transition towards a low-carbon society in 2050, one of the crucial ingredients is enhanced energy efficiency measures in new and existing buildings. Investments in energy efficiency in real estate are still below their theoretical cost-optimal potential. There are barriers other than purely economic ones; for example, incentives that are lopsided, or a lack of knowledge.

In the EU, an average of 30% decreased use of energy in buildings is possible through the use of smart technological and digital solutions. These solutions would save EU citizens and businesses EUR 67 billion on their energy bills annually in 2030 and contribute to reaching the 2030 EU energy efficiency target. They could also reduce the quantity of greenhouse gas emissions annually in 2030 by 156 Mt of $CO_2$. Even better, the average payback period for the needed investments is only two years.[22]

Buildings could also play a larger part in an integrated energy system. Solar panels on roofs, storage facilities, the use of waste heat from industry, charging of EVs and providing flexibility to the grid are just a few of the uses buildings can have in a more integrated system. The district heating system can be developed. Storage solutions and district cooling systems are increasing. Also, low temperature systems that combine district heating and cooling with heat pumps are currently being tested and developed.

As electromobility increases in passenger cars, it is important to implement fast and smart charging solutions and avoid non-controllable charging infrastructure. The demand for biofuels for heavy transport, industrial processes, chemical industry or combined production of heat and power might compete with each other, but there are also possibilities for co-production and use of waste resources.

In the future power system, some flexible, thermal power plants will provide electricity only at times when neither supply nor demand response is sufficient. A relatively small quantity of fuel supply will then be able to supply large generation capacity as time of use is limited.

In the long term, abundant renewable electricity supply will create potential for power-to-gas and other synthetic fuels and chemical products. Synthetic fuels further support transition of the transportation sector, including aviation, road and marine, to low or zero carbon.

[22] *A study by Ecofys*

# CONCLUSIONS

If the Nordic countries can display world-class energy efficiency and lead the way in low-carbon energy, electrification and an integrated approach to the energy system, the region will be in a position to gain significant future investments. This means that the region is  facing a crucial opportunity to ensure future growth and jobs.

There is great potential in energy efficient buildings that are integrated into energy systems in different ways. When decreasing the need for energy for heating or household electricity, resources that are now used to produce heat and power can be transferred to other sectors. This is specifically interesting for biomass, since many sectors declare biomass as the easiest way to replace fossil fuels.

Using more of the waste heat available from industry and other facilities in the district heating system, in combination with heat pumps, has the potential to decrease the need for other resources. Heating and cooling in integrated low temperature systems with heat pumps is another interesting possibility to develop further.

Decarbonisation is needed in all sectors, and the Nordics should focus on finding synergies and removing unnecessary barriers between different energy products as well as between users and producers. The less political involvement there is in trying to steer where different resources are used, the better efficient solutions can be developed. Taxation, for example, should support the transition towards the most beneficial solutions for reaching the overall vision of a cost-efficient and smart low-carbon energy system. Integrating the systems more closely should lead to better affordability, improved sustainability and an increased security of supply.

CASE

# ELECTRIFICATION AND SECTOR COUPLING ACHIEVE $CO_2$ GOALS AT FLEXHEAT NORDHAVN

One way to create flexibility in power consumption is through sector coupling, where excess electricity is stored in other energy systems. In the district heating supply, heat pumps with thermal storage can use power when it is plentiful and therefore inexpensive; and avoid using it in periods with peak loads in the system, for example, in the late afternoon, when most people come home from work and turn on lights and household appliances. The HOFOR (Greater Copenhagen Utility) FlexHeat project in Copenhagen's Nordhavn is a prime example of this type of sector coupling. The thermal energy storage consists of a 100 cubic metretank and corresponds to a 4 MWh virtual battery.

Copenhagen has adopted the ambitious goal of becoming a $CO_2$-neutral city by 2025, and district heating plays an important role in reaching it. The FlexHeat demonstration plant at Copenhagen's Nordhavn harbour, which supplies cruise ship terminals with district heating, shows just how much can be achieved with electrification and sector coupling. The plant emits 315 fewer tonnes of $CO_2$ annually, compared with the LPG gas-based alternative.

CASE

# COMBINED DATA AND HEAT IS A PURE WIN-WIN FOR ALL

Calefa Oy is an innovative supplier of waste heat recycling systems in Finland, offering complete turn-key solutions for reusage of industrial excess heat. Calefa has designed and built a system in Mäntsälä, Finland, where waste heat from a data centre is recovered and utilised in a district heating network.

A data centre uses plenty of energy. In Mäntsälä, operating the computers requires 7.5 MW of electrical power. All of the used electricity transforms into heat. Instead of discarding the heat as waste into the sewage or into the air, it is recovered and sold to a district heating company. By selling its waste heat, the data centre compensates 30% of its total energy expenditure.

A district heating company buys excess heat from the data centre and produces 25 GWh per year of district heating for the local network. This is made possible by carbon neutral heat pump technology: 25°C waste heat from the data centre is refined into 85°C hot water, suitable for district heating.

Earlier, district heating was generated with natural gas; now 70% of the annual district heating needs are met using the excess heat of data centre, which is carbon neutral energy generation. The $CO_2$ emissions have decreased by 5,000 tonnes per year. In addition, waste heat is an economic source of energy, which also benefits the local customers of the district heating company. Because of the utilisation of waste heat, the price of district heating has declined by 11%.

Multiple parties benefit from the creation of these types of ecosystems. In this case the winners are not only the company operating the data centre, but also the district heating company and the local people as end-users of district heating – not forgetting the environmental aspect of cutting $CO_2$ emissions.

CASE

# STORA ENSO'S ANJALANKOSKI MILL INTEGRATES A NEW ENERGY-EFFICIENT GRINDING TECHNOLOGY

Galileo, a grinding technology provided by Valmet, is an all-steel cylinder construction with small synthetic industrial diamonds attached to the metal plates on its surface. This makes Galileo more durable and more energy-efficient than traditional pulp stones used for mechanical pulp production. When the diamond coating on the metal plates wears down, plates can be replaced with new ones and the old ones can be re-used several times.

The gradual switch to cylinders has brought exciting results. The Anjalankoski mill is now using 25% less energy in the grinding and refining phase than before the first cylinder was installed. After having installed six cylinders, the savings in energy use will be about 50,000 MWh annually – that's roughly a 5,000-tonne reduction in CO2 every year.

Technologies used even in traditional applications can be improved to be more energy efficient and climate friendly. Nordic forest industry has a long history and can be utilised as a source of best available technologies among the industry.

# PROPOSALS

1. Review today's varying taxation of energy and energy-related resources in the light of increasing integration between different parts of the energy system. Taxation should guide the use of resources so that they are used where they most benefit the vision of a cost-efficient, smart, low-carbon energy system.

2. Create test beds and demonstration projects to develop promising areas with efficient integrated energy systems, as well as more long-term solutions like power-to-X technology development.

3. Bring together stakeholders and develop a common future vision of how buildings can contribute to an integrated energy system, including possibilities for energy efficiency measures, energy storage, electricity production, EV charging, providing of flexibility to the grid, and efficient heating solutions such as the use of waste heat from industry.

4. Investigate energy integration with a systems-level approach to evaluate the potential and the impact of different solutions as means to decarbonise the Nordics, with the aim to assess where resources can be used most efficiently.

# THEME 4: EU ENERGY UNION AND NORDIC SOLUTIONS

"Internationally, the Nordic countries are often considered as part of a single, larger unit, rather than as specific individual countries. – There is therefore a need for alignment in the promotion of Nordic energy solutions.

*-Jorma Ollila, Nordic Energy Co-operation – Strong today, stronger tomorrow*

# WHERE WE ARE NOW – STRENGTHS AND CHALLENGES

More and more energy-related policy making takes place within the European Union. The emissions trading scheme (EU ETS), the 2030 climate and energy targets with the demand for national energy and climate plans and different initiatives concerning the EU's Energy Union are just some examples. These affect the Nordics and will continue to do so, and vice versa – in other words, what happens in the Nordics will affect the EU.

The Nordic countries are at the forefront, generally scoring high on renewable energy and ambitions to decrease greenhouse gases, as well as competitiveness in electricity pricing. The Nordic electricity market is a model of a well-functioning regional cooperation. In addition, the Nordic countries lead the transition in specific solutions like wind power, geothermal energy, EVs, biofuels and circular economy. Still, it is possible to do more.

It is obvious that the transition of the energy system increases the need for cooperation across borders to find the most cost-efficient alternatives and spread innovation – throughout the EU and in the Nordics. If the Nordics manage to enhance cooperation, remove border barriers for energy related technology and solutions, and thus create an innovative, smart, dynamic and low-carbon energy system, the region will be able influence the EU in the best of ways – through leading by example.

The Nordic region is among the 12 largest economies in the world, if taken as a whole. Yet, there is still room for improvement when it comes to integrating both the national policies and the different parts of the Nordic energy system. If the Nordics do not continue moving, they will soon be overtaken by others.

# WHERE WE ARE HEADING

The Nordic countries have set ambitious national targets to decrease greenhouse gas emissions, both in the medium (2030) and long term (2045 or 2050). Reaching these targets will not be easy. Well-functioning markets, innovation and the commercialisation and spreading of clean energy-related technologies will be part of any success in the work to arrive at the desired future.

By showing that a cost-efficient low-carbon economy is possible, the Nordics are in a position to set a good example not only in the EU, but also globally. There is a risk, however, of becoming complacent with the good results that have already been achieved and of failing to continue developing even better solutions. The Nordic countries are well organised and governed. While this is laudable, it might sometimes lead to long decision-making processes and difficulties in adopting and integrating new technologies. The task is to brand the Nordics as the place where innovative solutions are developed, tested, commercialised and implemented.

While decision-making in the EU can be considered a slow-moving train, seeking consensus over a large region, the Nordic cooperation can move faster, go further and ultimately take a leading position. Successfully positioning the Nordics as the target model – as ***the*** well-functioning regional market that decarbonises and integrates distributed sources, renewables, and so forth – could also influence the direction of the EU.

# CONCLUSIONS

The Nordics should focus on facilitating the entry of new technologies across the region by removing entry barriers and standardising market rules. An example could be to investigate what the market barriers are within the Nordics which stop technologies, for instance, in demand side response solutions from being tested and scaled across the region from Norway to Sweden and Finland or vice-versa, before being exported to other markets. In short, well-functioning energy technologies should be given a Nordic passport, and thereby contribute to setting new global standards.

The same question concerning market barriers could be asked with regard to all the other potential solutions and necessary pieces of the low-carbon cost-efficient energy puzzle that have been mentioned throughout this report. To get a picture of the situation, the Nordic Council could set up an online service where companies can report barriers that specifically hinder the spreading of low-carbon-energy related technology across the borders in the Nordics. These border barriers could then be brought to the attention of the existing Nordic border barrier council.

Decarbonising the energy systems of the Nordic countries is a necessary contribution to fighting global climate change, where everyone must do their part. But a more thorough impact can be reached by taking part in developing and introducing low-carbon solutions and leading by good example.

In some cases, an individual country can choose to contribute by itself, such as in the case of Norway supporting the spread of EVs. Such initiatives can drive change and inspire others. This should not be hindered. In general, however, there is a lot to gain from harmonising or coordinating policy making and political initiatives on the Nordic level. The work towards the national and EU climate and energy targets should be used as a platform to promote this cause.

Another approach is to promote the fact that the Nordics, by providing a low-carbon energy system, will be able to export products with a smaller carbon footprint. If the Nordic countries are to reach their ambitious climate targets, the effort will involve a transition in the industrial sector, which could mean a competitive advantage in a world looking for solutions to decrease climate impact.

Finally, to get the most out of this transition, the Nordic countries should cooperate on the international arena to promote and spread Nordic solutions, as well as to brand the region as the place where new solutions are developed, tested, commercialised and implemented.

# PROPOSALS

1. Showcase the Nordic electricity market as the market model for the EU, emphasising the energy-only approach.

2. Use the energy and climate plans to coordinate a Nordic approach to the implementation of national or EU climate targets, identify hot topics for cooperation and analyse how energy-related national decisions make an impact on the Nordic level.

3. Give well-functioning low-carbon energy technology a Nordic passport, so to speak, by harmonising and coordinating regulations and removing border barriers between the Nordic countries.

4. Set up an online service where companies in the Nordics can report border barriers that hinder the spread of low-carbon energy-related technologies.

5. Cooperate on the international arena to promote Nordic, rather than national, solutions to global challenges and brand the Nordics as the place where new solutions are developed, tested, commercialised and implemented.

# CLOSING REMARKS

**This report has set the vision for the Nordics to create the world's smartest energy system and explored concrete ways to find the most energy- and cost-efficient solutions to facilitate progress towards a low-carbon green economy. It has also delved into some of the challenges and presented solutions on how to address them.**

Essentially, the decarbonisation of the energy system is a key to reaching climate targets. However, changes bring insecurity. This report has focused on the effects of the transition to a more sustainable society on business and industry, and on the cost competitiveness, affordability and security of supply. But there is also a need to acknowledge the importance of social sustainability, and the consumers' and people's perspective should be emphasised.

When technological solutions or new services are implemented, it is important to evaluate the impact on consumers, not least those who are socio-economically more vulnerable. It should be noted that if implementing new technologies is supported by governmental subsidies, which are, ultimately, provided by taxpayers, this means that less favoured groups of society participate in financing technology that will not be accessible to them for several years. As such, political measures can be important to drive development but might need to be balanced by other initiatives.

Equally, it is important that flexibility solutions like demand response, dependent on new digital technologies, are not only implemented for certain groups without taking other groups into consideration. When creating new business and service models within the energy industry, this must be taken into account.

However, it should be borne in mind that the consumers of the future will not simply be in the hands of the energy or technology companies. It may, in fact, also be the other way around. Consumers will more often also act as producers. Better availability of affordable storage systems, such as batteries, could eventually make some households independent from the power grid. For example, their own electricity could fuel their car. A historical case in point is how mobile phones made the old type of phone grid unnecessary, resulting in the rapid destruction of the old monopolies. Similarly, the on-going energy transition might shift the power balance in the energy sector as well as the roles of societal institutions.

All things considered, if any region in the world can handle social issues concerning the energy transition, the Nordics should be that region with their history of social welfare and inclusive societies. Technological development and new solutions are essential, but are not the only aspect that matters. Ultimately, any change must have the support of people to be sustainable in the long term.

# ANNEX: CASE CATALOGUE

**This section provides additional case examples that showcase Nordic innovation.**

# 1. VALUE OF FLEXIBILITY FOR WIND-DOMINATED PORTFOLIOS FOR NORDIC ENERGY UTILITIES

Rapid reduction in wind energy prices is making wind generation an attractive source of electricity supply for Nordic energy utilities, as well as for large energy users. Such companies can either invest in wind generation directly or through long-term power purchase agreements (PPA). However, transition to a wind-based portfolio causes utilities new risks related to variations in wind energy output, as well as market pricing during non-windy periods.

Investing or contracting with ultra-flexible thermal power plants is a way for utilities and large energy users to mitigate risks related to wind energy heavy portfolios. Such power plants act as a physical hedge, capping the maximum electricity purchase price for the utility at times when wind is not available. When the market price is low, a utility can continue to buy it from the market at a low cost. Flexible plants can also generate additional revenues from balancing markets, therefore mitigating risks related to wind forecast errors. A book "Puhallus – Tuulivoimalla menestykseen" evaluates such a business model for an average-sized utility operating on Nordic energy markets. It concludes that while investment in flexible thermal capacity is not feasible as a standalone investment, as a hedging product together with wind energy it enables the lowest-cost energy portfolio for Nordic energy utilities. On average, a portfolio consisting of wind energy, flexible thermal generation and market purchases has over 20% lower cost than a portfolio based on new nuclear power and market purchases.

Read more (in Finnish):
https://www.wartsila.com/fin/puhallus

# 2. THE CROWNE PLAZA COPENHAGEN TOWERS HOTEL COMES CLOSE TO ACHIEVING CARBON NEUTRALITY

As an example of sustainable design, Crowne Plaza Copenhagen Towers had 60% lower electricity consumption than comparable hotels operating conventional energy technology in 2015. Deploying the best environmental and energy technology, the hotel comes close to achieving carbon neutrality. The hotel, built according to the Danish building regulations' Low Energy Standard, Class 2, consumes only 42.6 kWh of energy per square metre annually.

In order for energy consumption and $CO_2$ emissions to be as low as possible, the hotel insisted on state-of-the-art energy technology throughout. One of its most significant features is an innovative groundwater cooling system. This supplies the heating and air conditioning for 366 guest rooms, conference rooms, kitchen, restaurant and offices in an adjoining wing.

Read more:
https://www.danfoss.com/en/service-and-support/case-studies/dds/the-luxury-hotel-of-tomorrow-that-s-driven-by-drives/

# 3. LIQUEFIED BIOGAS FROM WASTEWATERS AT NYMÖLLA MILL

Gasum and Stora Enso are building a biogas plant at Stora Enso's Nymölla paper mill in Sweden. The plant, built and operated by Gasum, will turn the mill's wastewater effluent into renewable energy. The biogas plant is a sustainable solution for the processing of wastewater.

Gasum plans to produce liquefied biogas (LBG) to be used as fuel for cars, buses, heavy-duty vehicles, and ferries. The Nymölla biogas plant project includes biogas production, upgrading and liquefaction. The expected LBG production of the plant is 220 MWh per day. Start-up is expected during 2020.

Read more:
https://www.gasum.com/en/About-gasum/for-the-media/News/2018/circular-economy-cooperation-with-stora-enso--gasum-to-produce-biogas-from-waste-waters-at-nymolla-mill/

# 4. TOWARDS FOSSIL-FREE STEEL

SSAB, LKAB (Europe's largest iron ore producer) and Vattenfall (one of Europe's largest electricity producers) joined forces in 2017 to revolutionise steel-making. The aim is to replace coking coal, traditionally needed for ore-based steel making, with hydrogen. The result will be the world's first fossil-free steel-making technology, with virtually no carbon footprint.

The steel industry is one of the highest CO2-emitting industries, accounting for 7% of CO2 emissions globally. A growing global population and expanding urbanisation are expected to trigger a rise in global steel demand by 2050. The carbon footprint in the steel industry is thus a challenge for Europe and the rest of the world.

Sweden has unique conditions for this kind of project, with good access to fossil-free electricity, Europe's highest-quality iron ore and a specialised, innovative steel industry. The initiative, called HYBRIT, has also started to investigate the possibilities of broadening the project to include Finland.

To be able to carry out the initiative, however, significant national contributions are still required from the state, research institutions and universities. There has to be good access to fossil-free electricity, improved infrastructure and rapid expansion of high-voltage networks, research initiatives, faster permit processes and the government's active support for the pilot and demonstration facilities and long-term support at EU level.

Read more:
https://www.ssab.com/company/sustainability/sustainable-operations/hybrit

# 5. FIRST TWO-WAY CHARGING POINT IN FINLAND INSTALLED IN HELSINKI

In a joint project with Virta and energy company Helen, the first two-way charging point in Finland was installed in the Suvilahti district of Helsinki in connection with Helen's solar power plant and electricity storage facility. The vehicle-to-grid (V2G) charging point enables not only charging of an electric vehicle, but also using it as an electricity storage unit and utilising it in the balancing of the electricity system.

With the V2G charging point, the vehicle's battery can be used as part of the energy system. In the future, EVs will no longer be a load on the network, but they can be used as part of it. With two-way charging, the batteries of EVs could be utilised, for example, in disturbances in the electricity network or to prevent any disruptions.

# 6. THE WORLD'S LARGEST SOLAR HEATING PLANT IN DENMARK REDUCES CO2 EMISSIONS BY 15,700 TONNES ANNUALLY

A solar heating plant in Silkeborg, Denmark, harnesses energy to heat the homes and workplaces of 40,000 citizens. It supplies 18-20% of the annual heat consumption in the city of Silkeborg, which has an ambitious target of CO2 neutrality in heat production by the year 2030.

Read more:
https://www.danfoss.com/en/service-and-support/case-studies/dds/solar-heating-plant-reduces-co2-emissions-by-15-700-tonnes-annually/

# 7. COOPERATION FOR ENVIRONMENTALLY FRIENDLY TRANSPORT

Elgiganten, one of the leading home electronics, white goods and kitchens retailers in Sweden, together with Gasum and Volvo, are now entering a testing period in which Elgiganten's transport partners will run the outgoing transport from Elgiganten's Nordic distribution centre in Jönköping on liquified biogas. On the procurement of Elgiganten's new transport agreement in spring 2020, there will be requirements for parts of the vehicle fleet to run on fossil-free fuels, of which liquified biogas is an option.

Elgiganten has chosen Volvo Lastvagnar and Gasum as partners for the testing period in which Elgiganten's transport partners will test and drive transport from the distribution centre in Jönköping to different shops and home delivery hubs in the Nordic countries on liquified biogas. The planned route is to initially run back and forth to Oslo, Norway.

Volvo Lastvagnar's gas-fuelled vehicles can run on 100% liquified biogas, which gives completely fossil-free transport. The hope is that the 70-100 vehicles that depart from the distribution centre in Jönköping every 24 hours to more than 250 destination will show the partners that are taking part in the testing that gas-fuelled vehicles reduce both fuel costs and emissions without any negative effect on performance.

# 8. ALL-ELECTRIC PASSENGER VESSEL FUTURE OF THE FJORDS – AN EXAMPLE OF ENVIRONMENTALLY RESPONSIBLE PASSENGER TRANSPORT

Future of the Fjords, a Norwegian passenger vessel, represents a new standard of environmentally responsible passenger transport, as the first fully electric carbon fibre vessel in the world. The development of this electric catamaran minimises environmental impacts in the Norwegian fjords while maximising the experience of natural beauty for the passengers – an essential approach for its route between Flåm and Gudvangen in the pristine Nærøyfjord, part of the UNESCO World Heritage park.

Optimising energy efficiency is a key strategy in ensuring the viability of the vessel and reducing its environmental impact. Therefore, Future of the Fjords uses high-tech solutions in a range of disciplines to achieve lowest possible energy consumption. Light carbon sandwich laminates for the hull and superstructures ensure approximately half the weight by comparison with conventional materials. Future of the Fjords's battery-powered propulsion system eliminates NOx and CO2 emissions, and reduces noise and vibrations.

Read more:
https://www.danfoss.com/en/service-and-support/case-studies/dds/future-of-the-fjords-meets-2026-emission-targets-today/

# 9. MANGA TERMINAL OY – AN IMPORTANT ENVIRONMENTAL MILESTONE FOR THE BALTIC SEA AREA

Manga Terminal Oy is finalising a liquefied natural gas (LNG) import terminal in Tornio, Finland. This terminal is the largest facility of its kind in the entire Nordic region. An efficient logistics chain is being developed around the terminal, which will create a diversified fuel market benefiting both Northern Finland and Sweden. The beneficiaries include shipping and road transportation companies, power and heat utilities, as well as numerous industrial and mining companies in the region. The parent company, Manga LNG, which buys and sells LNG, is owned by a joint venture of nearby companies, including Outokumpu, SSAB Europe, EPV Energia and Skangas. Finland-based Wärtsilä is the turnkey Engineering, Procurement and Construction (EPC) contractor for the project.

LNG is an environmentally friendly fuel that is becoming increasingly relevant for industrial facilities, the shipping industry and energy providers. However, diversification to cleaner fuels requires substantial upfront investments to terminals and logistics.

The new terminal opens significant opportunities for the region's steel mills, mining operations, factories and other industrial customers to reduce their dependency on conventional fossil fuels. Similarly, the terminal will provide bunkering fuel for the new generation of LNG-powered ships. LNG contains virtually no sulphur and far fewer particulates than diesel fuels, which is why it is an accepted means of complying with the latest maritime regulations, notably in Sulphur Emissions Control Areas (SECA).

# 10. ADVANCED ENERGY MARKETS REWARD FLEXIBILITY AND FACILITATE ENERGY COMPANIES' TRANSITION TO RENEWABLE PORTFOLIOS

Wärtsilä's flexible internal combustion engine power plants are used as a physical hedge against market price and volume risk in many parts of the world. This allows electric utilities and municipal energy companies to ıncrease their share of renewables in their portfolio. In a normal operating situation, a utility can supply most of its bulk energy from wind and solar resources. During times of low renewable generation, the utility can either purchase net electricity from the market, or if market price is high, start up the internal combustion engine plant that caps the maximum purchase price for the utility. The operational flexibility of Wärtsilä's internal combustion engines enables a highly innovative business model for the utilities in markets where flexibility is rewarded.

For example, Denton Municipal Electric in Texas, USA, made a strategic commitment to move from 40% to 70% renewable energy supply in the three years between 2016 and 2019 without any extra cost to consumers. This pressure challenged them to devise an innovative plan to opt out of coal generation and invest more in wind generation complemented by Wärtsilä's ultra-flexible internal combustion engine based capacity. This provides Denton Municipal Electric with a hedge against high electricity market prices from Electric Reliability Council of Texas (ERCOT) during times of low wind generation.