

The background image shows a row of white electric cars parked at a charging station. Each car has a charging cable plugged into its side. The cars are parked on a paved surface. In the background, there are green trees and a building under construction with a blue crane. The sky is blue with some clouds.

FUTURE AGENDA

Open Foresight

THE FUTURE OF ENERGY
A Nordic Perspective

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The Future of Energy

A Nordic Perspective

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With the combined challenges of climate change, air pollution and energy security, the opportunities from renewables and electrification are top of many a national agenda. While many are talking about changes to come and making tentative steps, in some key regions major transitions are underway. Bold ambitions are being delivered. The Nordics is one such region and its success and perspectives on the future hold lessons for many others.



The Global Energy Landscape



Although short-term energy priorities are prone to political influence in some regions, longer term there is an increasingly clear view around the future of energy. Today many agree that, at the macro level, there are 5 major shifts underway:

1. The escalating growth of renewables and particularly solar,
2. A continued need for fossil fuels in the energy mix for the next 50 years or so,
3. The increasing electrification of transport - especially for cities,
4. Rising national concerns over energy security and supply tensions, and that
5. The pivotal changes will often be local rather than global in nature.

In addition, it is clear that, over the past decade there has been a move for many from energy acting as an enabler and therefore operating in the background, to once again being a major centre for innovation in itself. This is expected to continue going forward as these 5 shifts all variously spur new technology, product, service, business model and policy development. Although each will drive new activities, many observe that it is the shift to electrification, especially in the transport sector, that has been the primary focus in recent debate.

In order to gain an objective view of how developments will play out and where innovation may have greatest initial and long-term impact, many recognise the need to understand better how some pivotal regions are supporting and leading the change. These include:

- China – with its scale, significant challenges and major investments in solar and EV;
- California – very much the leading US and moving ahead despite some federal policies;
- SE Asia – where countries such as Singapore are delivering future ambitions; and
- The EU – which is shifting standards via proactive regulation and collaboration.

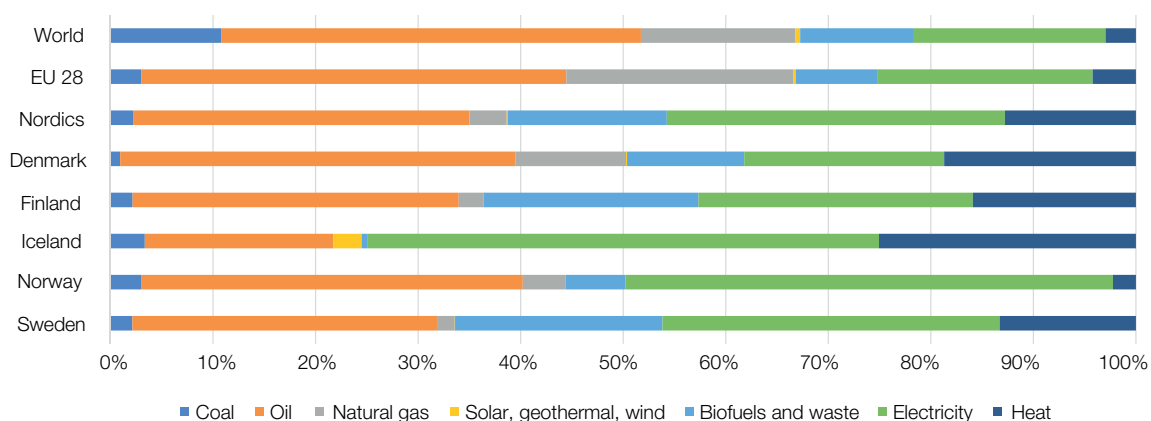
One of the key areas of note is the Nordics (Denmark, Finland, Iceland, Norway and Sweden) where the challenges and opportunities for a new energy paradigm are seen to be significant. Faced with both urban concentrations as well as highly dispersed populations, cold winters with limited potential for solar compared to other regions, and proactive socially focused policies, the way in which these countries are addressing the future of energy may hold lessons for others. This is especially the case for the plans underway towards greater renewable energy supply and moves towards accelerating the electrification of transport.

The Nordics in Context

Taking the big picture, compared to global averages of Total Final Consumption (TFC) by source, as of 2016, IEA data show that the Nordics as a whole consumed around 10% less oil but almost twice as much nuclear and hydro generated electricity. Relative to EU averages, oil and gas are both less significant sources of energy for the Nordic region

as a whole and, even though Norway (a major producer) and Denmark consume EU comparable shares of oil, natural gas is presently a less significant part of the mix. Much of the current oil use can be associated with transport – by road, sea and air.

Total Final Energy Consumption (TFC) by source (2016)



The Electricity Perspective

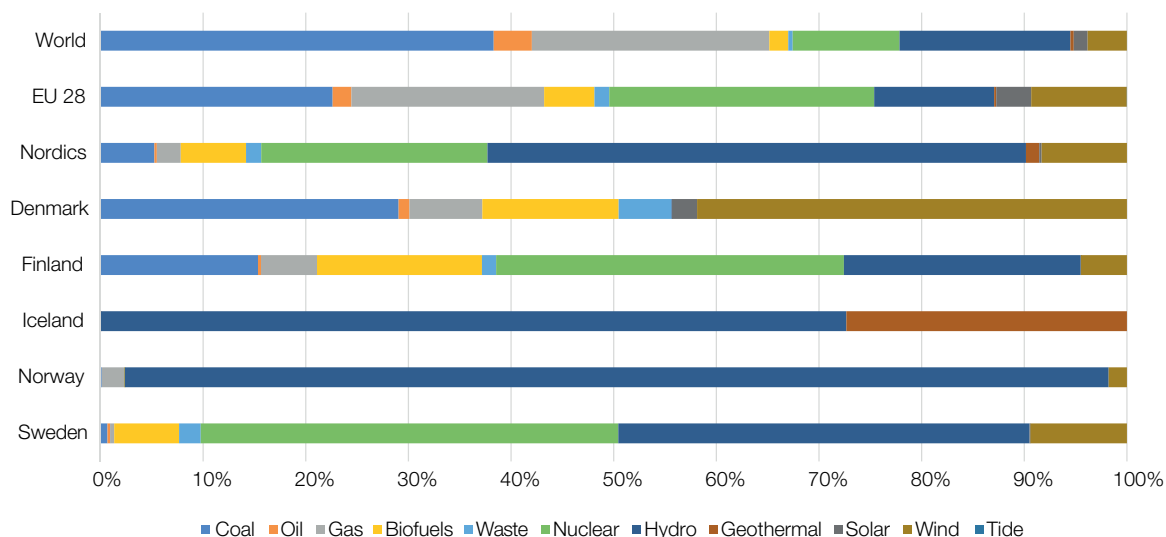
Given how much accelerating electrification is a common global ambition, looking more specifically at electricity generation by fuel for the same year, it is notable how small the contribution of coal, oil and gas is in the Nordics when compared to both global and EU averages. Moreover, over half the region's electricity comes from hydro - over 3 times global and 4 times EU norms. Nuclear is also significant for some. More specifically at shown below at a national level:

- With a well-integrated system that takes advantage of its physical geography, Norway gets over 95% of its electricity from hydro schemes;
- Alongside hydroelectricity, geothermal energy plays a significant role in Iceland;
- Both Sweden and Finland have major contributions from nuclear energy; while
- Denmark is a leading user of wind energy which generates over 40% of its electricity.

As the shift to the electrification of transportation accelerates, many see that it is the Nordics that will be able to take advantage of these significant renewable energy resources. As such the region can further decrease its oil and gas consumption quicker than many others and so reduce emissions faster. Potentially the Nordics can set new standards and become global benchmarks for transition.



Electricity Generation By Fuel (2016)



Future Ambitions

Given this, many can see why the Nordics have some of the most progressive and ambitious future energy consumption ambitions. Each country has bold targets and is making strong progress:

- Sweden has set a target of 50% more efficient energy use by 2030, and 100% renewable energy production by 2040 and is on course to hit the first of these targets 10 years early. It also has a target of net zero emissions of greenhouse gases by 2045.
- Finland has the second-highest share of renewable energy in Europe. In 2015, almost 80% of electricity generation was emission-free. This will rise to 90% by 2030 as the share of renewables and nuclear power increases. Finland has set the goal of 250,000 plug-in cars and 50,000 biogas cars on the road by 2030.
- Iceland already has 100% renewable sourced electricity via its hydro and geothermal supplies. In 2017, EVs had 15% of the market¹ and it is aiming for 100% of new vehicles to be electric by 2030.
- Denmark is on track to surpass its EU targets to have at least 50% of its energy needs supplied by renewable resources by 2030 and zero fossil fuel energy by 2050. Such is its success in the transition that the IEA considers that Denmark has become a world leader in decarbonisation in the last two decades.

But is Norway that is probably being the most ambitious as it moves “from oil nation to clean energy lab” with plans to be the world’s first fully electrically powered society by 2050.²

- Oslo is set to permanently ban all cars from its city centre by 2019. The Norwegian capital is investing heavily in public transportation and replacing 35 miles of roads with bike lanes.
- Nationally it has the largest share of EVs globally - half of new car sales in 2017 were plug-in electric or hybrid vehicles.³ The ambition is that by 2025 100% of all sales will be EVs with subsidies and tax incentives supporting this.
- Since 2015 MS Ampere, the first electric ferry has reduced emissions by 95%.⁴ With 53 more electric ferries already ordered, the plan is for all new ferries to be electric by 2050.⁵
- Perhaps, most dramatically, Avinor, the state aviation organisation, plans that by 2040 all domestic short-haul flights will be 100% electric.⁶ The first test was in June 2018⁷ and passenger flights will start in 2025.

While other countries such as Singapore and China, regions like the EU and key US states such as California also have bold ambitions, few would deny that it is the Nordics where the most significant change is already integrated into policy.



Future of Energy Discussions



We have been exploring the future of energy in depth since 2004 when the first Shell Technology futures project was undertaken. Over past few years there have been over 200 Future Agenda workshops globally exploring many related issues – cities, transport, food, water, resources – bringing together multiple different experts to challenge and build 10 to 20 years future visions. Within this, we have run ten events specifically focused on the future of energy – covering a broad range of views from London, New York, Dubai and Shanghai to Brisbane, Wellington, Delhi and Bangkok. The most recent of these have been in Finland and Norway. The first was in Vaasa – a leading energy cluster in the Nordics – and was hosted by Merinova, Wasa Innovation Centre and the University of Applied Sciences VAMK. The second, in September, was in Stavanger – the energy centre of Norway and home of Equinor (formerly Statoil). This workshop was undertaken in partnership with ISPIM and NordicEdge. From all these discussions we have a considerable portfolio of global and regional expert views of how the energy transition may well play out.

From all the events, there is a rich mix of future perspectives which identify many regional priorities but also highlight several common areas of global challenge and opportunity. The ‘top 5’ of these are:

- Energy storage – the missing piece in the renewable jigsaw for many;
- Distributed energy supply – especially in poorer economies where low-carbon supplies are limited;
- Fossil fuel dominance – still accounting for around 50% of total global energy supply in 2035;
- The falling cost of solar – with a 20% reduction for every doubling of production; and
- The rise of micro actors – a blurring of energy consumers and producers to P2P ‘prosumers’.

While in a country such as China state-led investment is able to drive major progress towards its ‘eco-civilisation’ ambition and the greening of its energy system,⁸ elsewhere market forces are more influential. With subsidies, energy taxes, cartels and national interests all playing a part, many see the need for new business models for energy – often driven by deeper collaboration between public and private bodies.

The Nordic Perspective

So, what is the future Nordic view? How does it align with the global perspective and where are the key points of difference? In the discussions in both Finland and Norway there were five central areas considered to have significant future impact. These were:

1. Energy storage
2. Smart grids
3. The falling cost of solar
4. Accelerating EV adoption
5. High-voltage DC transmission

In addition, in each location some additional issues were also considered to be important for the future. In Finland these included energy security, fossils fuels dominance, distributed energy supply and G20 subsidies. In Norway the extra topics were peer to peer networks for energy production and consumption, the potential opportunities from AI and more machines in the system as well as deeper collaboration between key parties.

What is clear from the areas of greatest potential future impact is a common theme around the challenge of managing the electricity supply. With such high levels of renewable energy already in the mix, and ambitions for more to come, the three central concerns focus around how best to store and *distribute* all the electricity and ensure that it aligns with a changing *demand* profile – especially from transportation.



Storage

The energy storage challenge is one requiring both overnight and multi-months solutions that are intrinsically linked to the growth of electric transportation. With the acceleration of EV adoption driving a reduction in the cost and optimisation of current batteries in the near term, as public concern around range limitations subsides and regulation drives further demand uptake, a technology breakthrough will be needed. In Norway some see that there may be a 10x improvement in large scale battery capacity on the horizon – in Finland it was proposed that this may potentially be a non-lithium solution. With the winter months a key challenge for the Nordics, an affordable and reliable approach will be a significant component of the future energy system. Having sufficient storage of energy as electricity at the right time and in the right place is a growing test for most national energy systems – but one which many in the Nordic region feels can be met.

Distribution

Although significant renewable energy is often by implication localised to community need, there is a requirement for faster and more efficient long-distance transmission which can then change supply dynamics. This will be not only across the different areas of supply and demand within one country connected by the national grid, but also between states. If enough electricity is to be available at the right time, in the right place then rapid movement with low losses is critical. In Vaasa there was specific focus on the need to find an alternative for traditional AC grid lines – possibly via the adoption of super high conductors and more wireless transmission. Although the options of using light and heat may have a long-term role to play, with AC typically requiring transformers every 25 miles, in the next decade or so the greater potential from a breakthrough in DC transmission may create the lower-cost / lower-loss power super highway.

Demand

Within this context, the role of smart grids is critical. While there is strong regional adherence to regulatory changes, such as the 100% adoption of smart meters in Norway, this will not just be about consumer behaviour and smarter appliances. The shift to more flexible, two-way, localised grids is not just a policy and education issue. There is a need for an improvement in infrastructure to better connect buildings and customers and a motivation to create and adopt more smart energy services

potentially driven by more private and public collaboration. Clearly with all the EVs, never mind the electric planes, new demand peaks will need to be managed in a different way to the past. There may be answers from greater automation. AI and especially machine learning have already proven capability to reduce Google's server farms energy demand.⁹ In time many see more automated grid balancing, more automated energy trading and more smart home technology that all match supply and demand in a 100% electric system.



Moving Forward

At a global scale, there are many challenges to be addressed - but also clear opportunities. These include dealing with harmful chemicals used in solar panel production during subsequent recycling; helping the car companies to accelerate the move to new mobility models with electric, automated vehicles a core part of the mix; supporting the next generation of nuclear reactors - with fission and maybe fusion; and ensuring that there is competitive advantage to be gained from scaling new technologies in an increasingly volatile market.

While only a small total population of 27m, the Nordics are very much pioneers in broadening the use of renewable energy use across several sources of supply – hydro, geothermal and wind as well as nuclear. Compared to many other regions today they are already in a good position. But how will things move forward?

Some fear that, with high levels of wealth and abundant clean energy supplies already to hand, the Nordic nations do not have the same future imperatives and incentives as some other countries for continued rapid change - and so may not innovate further and so could risk getting left behind. The policy may be in place, but will the Nordics move quickly enough?

Others consider that momentum is already there and building. Not only may the likes of Norway and Finland develop and adopt new solutions that help them meet their renewable and electrification ambitions, but they could also set new global standards.

For other nations, most of whom are seeking to make a strong but sustained transition to cleaner energy supply and use, key questions include:

- How quickly to move ahead both from an investment and a regulatory perspective?
- How best to manage concerns on energy security with the switch to renewables?
- How to deal with uncertainty around the adoption and cost of electric transport?

Across these, there seems to be three major lessons from the Nordic experience and future perspective:

1. A pragmatic, proactive, shared but flexible strategy that accommodates different energy sources,
2. Coherent partnerships across public and private systems aligning infrastructure and investment, and
3. Bold ambitions supported by clear policies, incentives and funding to drive rapid change.

The Nordic leadership in the future of energy creation, storage, distribution and supply could well become the lighthouse for many others. Time will tell - but the omens are positive.



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