HYDROPOWER

an indispensable part of tomorrow's energy system

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Next generation energy company | Fortum

FOREWORD

Hydropower paves the way for tomorrow's energy system

Hydropower has two important roles in the energy system. Firstly, mitigating climate change. Compared to other types of energy production, hydropower stands out with exceptionally low emissions over its whole life-cycle. The emissions mainly come from the building and start-up phases. The existing hydropower fleet in the Nordic countries is virtually free of any emissions.

Secondly, hydropower has flexible energy storage capabilities and can stabilise fluctuations between electricity demand and supply – therefore balancing the variable generation of many of the other renewable energy sources. Wind and solar power, for instance, are very weather-dependent. As their popularity and use increase also in Northern Europe, we need reliable and flexible energy sources to keep the electricity system in balance, the grid technically well-functioning and to bring stability in prices. Every kilowatt of hydropower enables 1.1 kilowatt of variable renewables into the system with a sustained effect on balance and security of supply.

Hydropower is, unfortunately, still often considered inferior to other renewables. Some see it as a threat to local biodiversity. Legislation, directives and taxation do not treat it equally with the other renewable energy sources. There is a lot of variation in hydropower legislation and its interpretation between countries and even between regions within a country. Too often the regulation focus is limited to local issues only without an understanding of the broader role of hydropower in the electricity system and in energy and climate policy.

The economic viability of hydropower has declined in recent years due to historically low electricity market prices, high and increasing societal requirements, which increase the capital costs, and a high tax burden. Hydropower is one of the few renewable energy sources that is not heavily subsidised, and it is subject to unfair competition with, for example, the heavily subsidised wind power production.

There are obvious advantages with hydropower, whether assessed from an energy system perspective or an environmental point of view. The question is: How can we utilise the full potential of hydropower?

We hope that this Energy Review promotes an active discussion at the local, national and European level.

Fortum Corporation

Every kilowatt of hydropower enables 1.1 kilowatt of variable renewables into the system with a sustained effect on balance and security of supply.

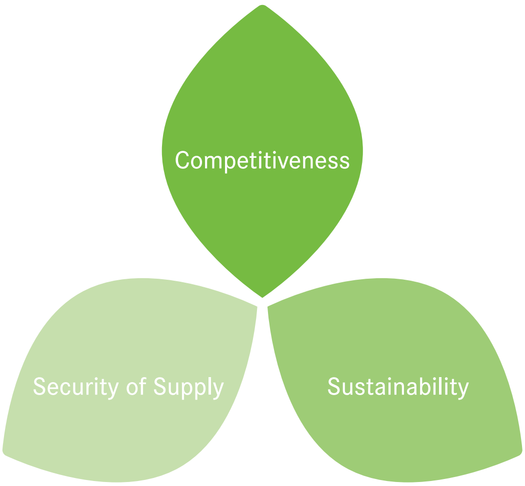
Hydropower at the centre of Nordic electricity production

Hydropower is a major source of power generation in the EU, Norway and Switzerland providing nearly 1/5 of the needed electricity and more than half of the total renewable electricity generation. Close to 40 per cent of this production comes from the Nordic countries, mainly Norway and Sweden[1].

More than 50 per cent of power generation within the Nordic countries is based on hydropower, making it the backbone of the energy system both in terms of energy production and installed capacity. Hydropower is also the most important source of renewable – and essentially CO_2-free – energy in the Nordic countries.

Historically, hydropower in Finland and Sweden has played a central role in terms of energy production and security of supply. Starting in the early 20th century, it facilitated the electrification of society and, eventually, the industrialisation.

Three dimensions of energy production



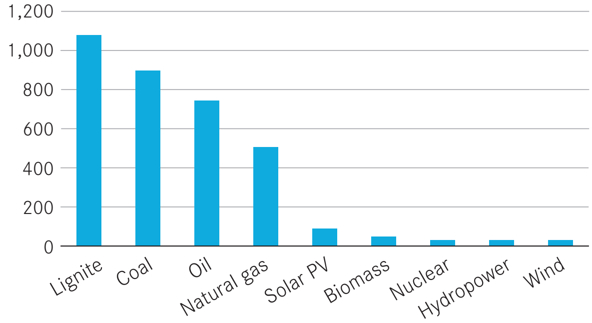
Competitiveness: Hydropower has no fuel costs and low production cost. New plant requires considerable investment, but its economic life is long.

Security of supply: Hydropower provides large-scale and stable energy production. It also functions as balancing power. It is, however, dependent on weather conditions.

Sustainability: Hydropower is virtually free of any emissions. However, hydropower plant has local environmental impacts.

Greenhouse gas emission from different types of power plants

Lifecycle average GHG emissions intensity (CO_2 equivalent) g CO_2e/kWh



Source: World Nuclear Association, Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources, July 2011

[1] ENTSO-E Statistical Factsheet 2014.

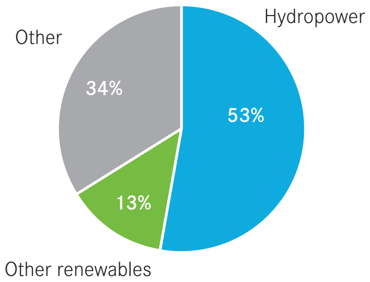
Illustrative map of major hydropower plants (>20 MW) in Norway, Sweden and Finland

More than 50 per cent of the total Nordic power production is based on hydro, which makes it the backbone of the energy system both in terms of energy production and installed capacity.

Source: NVE, Svensk Energi, Energiateollisuus, Fortum

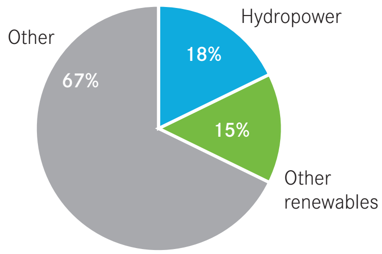
Share of hydropower generation in Nordics and Europe

Power generation in the Nordic and Baltic countries



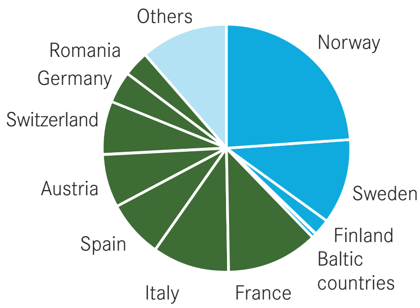
Total power generation 410 TWh in 2014

Power generation in the EU and Norway and Switzerland



Total power generation 3,185 TWh in 2014

Hydropower generation in EU and Norway & Switzerland in 2014



Total hydropower generation 570 TWh in 2014. Hydropower generation in Nordic and Baltic area 217 TWh.

Source: ENTSO-E Statistical Factsheet 2014

How does hydropower work?

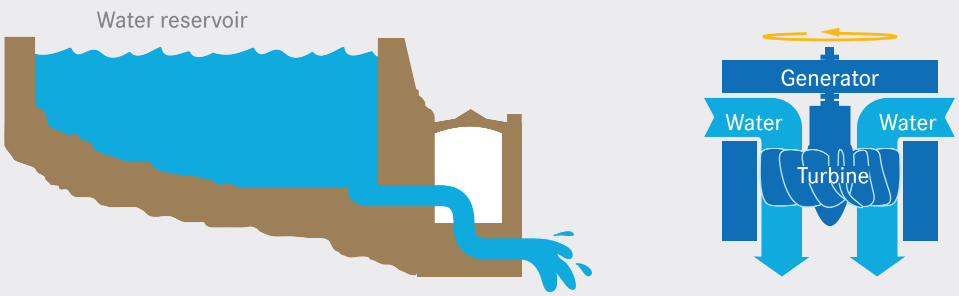
Hydropower is based on the natural cycle of water. Hydropower plants utilise the difference in height between the dammed water and the water's outflow; this difference is called the head. The dammed water is released through the power plant to the outflow. The energy harnessed from the water flow rotates a turbine that drives a generator. The generator converts the waters' energy into electricity.

Hydropower provides more than 220 TWh of electrical storage to the European power system. This makes hydropower an important instrument for dealing with the challenges of integrating growing volumes of intermittent renewable energy sources into the system. The largest share of total hydro storage capacity is located in the Nordic countries and Turkey.[2]

The water systems in the Nordic countries typically have a high fluctuation in flow rates. One of the advantages of hydropower is that water can be stored in lakes and reservoirs to be used to even out fluctuations in demand, for example during peaks in electricity consumption, as well as fluctuations in production due to variable renewable energy generation. Moreover, hydropower plant start-ups, output adjustments, and shutdowns can be implemented more quickly than with most other types of power plants.

Hydropower production is weather-dependent. On one hand, it can be used for flood protection in regulated water systems: spring flood waters can be stored in lakes and reservoirs for use in dry seasons. On the other hand, in years with low precipitation, there can be a shortage of water to be stored, resulting in lower production volumes.

How hydropower works



Hydropower is an energy source that can be stored in dams and large water reservoirs during spring, summer and autumn.

When energy is needed during winter, exactly the right amount of water is released through a turbine in the hydropower plant.

The turbine runs a generator which in turn converts kinetic energy into electricity.

[2] DNV GL Policy Report June 2015

Energy system needs hydropower to balance production and consumption

The Nordic electricity system is more sustainable than ever: approximately 2/3 of the electricity is produced with renewable energy sources. This has, however, made the electricity system increasingly volatile. As more variable renewable energy production is introduced to the energy system, more balancing power is needed for times when the sun does not shine or the wind does not blow. Hydropower is the most efficient and climate-friendly way to produce this balancing power. If the capacity of hydropower is allowed to increase, it could play an even more important role in the shift towards a fully sustainable energy system.

Hydropower is critical for power system stability and the security of power supply. It acts both as base load capacity and balancing power in systems with variable production with renewables. The introduction of weather-dependent renewables, such as wind power and solar, requires a backup to cover for when there is no delivery. This backup has to be able to step in on very short notice. Hydropower is the perfect backup: within minutes, production can be increased to cover the required production capacity. This makes hydropower an indispensable asset in a system based on renewable production.

Hydropower also helps to stabilise the electricity price, as its variable production costs are low compared with other alternatives for balancing power, like gas turbines or coal-fired plants.

A renewable energy system has to stand on three pillars – flexibility, base and peak load capacity – in order to keep the system in balance. Since 2009, the amount of variable renewable energy sources, especially wind and solar, have increased dramatically in Europe. The trend is expected to continue, due to the European Union's ambitious goals to decrease greenhouse gas emissions by 40% below 1990 levels and increase the share of renewable energy sources to 27% by 2030[2].

This will lead to an increasing demand for balancing power to guarantee the stability of the energy system and stabilise fluctuations between demand and supply. A usual rule of thumb is that the security of supply requires 0.9 MW of firm capacity where the production can be pre-determined for each 1 MW of power produced with renewables. Typically, this capacity comes from hydropower, nuclear or fossil-fuelled plants. So, even if we manage to increase the amount of renewables, a major part of the traditional power production has to be maintained. This may

As more variable renewable energy is introduced to the system, more balancing power is needed when the sun does not shine or the wind does not blow.

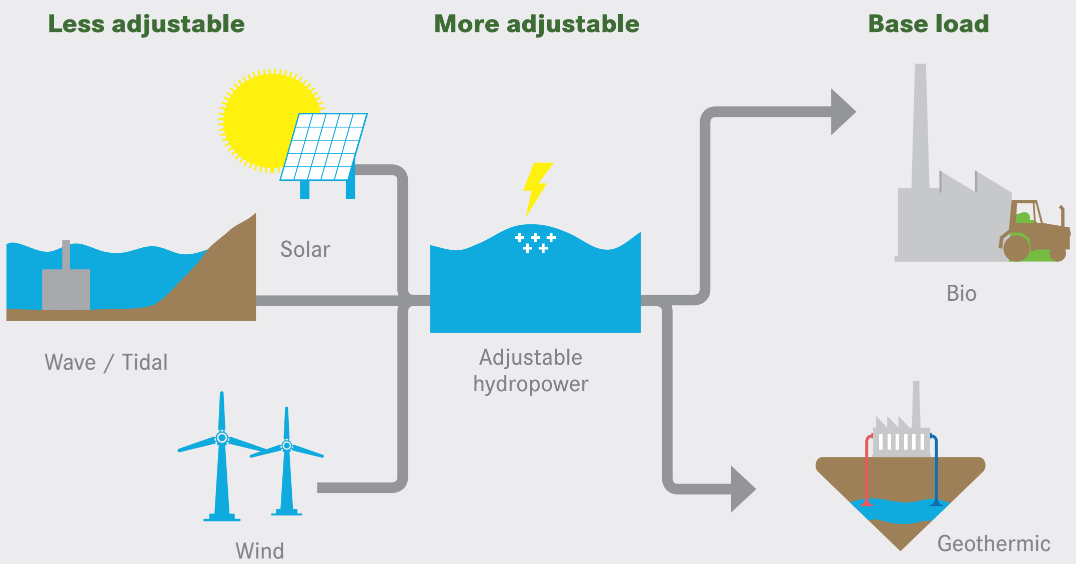
[2] EU council decision, October 2014. In addition, the EU targets to cut greenhouse gas emissions by 80% below 1990 levels by 2050

change over time with new and more efficient ways of storing energy.

Thanks to its flexibility and storage capacity, hydropower plants provide energy and capacity when it is required by the system – and thus contribute to long-term reliability and security of supply. With its quick ramp-up times, hydropower can also flexibly balance sudden changes in base load production. It takes just minutes to start up a plant or increase the load to the energy system.

If the capacity of hydropower is allowed to increase, it could play an even more important role in the shift towards a fully sustainable energy system.

Hydropower balances the renewables-based energy system



Curbing price volatility

Most of the low variable renewable energy production is heavily subsidised with the goal of accelerating their introduction. This has led to increased price volatility. Conventional base load utilities struggle with profitability in this changed environment since they often have to be in operation for some 5,000 to 8,000 hours a year to be profitable[3]. Wind and solar power have very low marginal production costs, and, thanks to subsidies that cover their capital expenditures, they may be economically viable to run even at negative power prices. Consequently, the other generation forms may not long be willing to commit to new investments or even maintenance of capacity that would nevertheless be needed as base load or balancing capacity. In the long run, this will pose a problem for system security of supply[4].

In contrast to fossil-fuelled power plants, hydropower has low marginal production costs and no costs for emissions. Therefore hydropower, together with other renewables, contributes to more stable electricity prices and power system stability. Hence, hydropower cost-efficiently provides leverage to the increase of other renewables.

However, the economic viability of hydropower has also declined in recent years due to historically low electricity prices, high and increasing societal requirements that increase the capital expenditures, a high tax burden and an unfair competitive position. Hydropower is the only renewable energy form that is not heavily subsidised. Furthermore, hydropower producers must tackle with long permit procedures and an uncertain future regulatory framework.

Hydropower, together with other renewables, contributes to more stable electricity prices and power system stability.

[3] In countries with heavily subsidised renewable energy production there is a discussion on the growing need for capacity remuneration in order to maintain traditional base load production. Exactly for how many hours a traditional base load unit has to be in operation to make a profit may vary but the investments are often calculated on close to 8,000 hours yearly.

[4] Maintaining sufficient capacity in the system is a growing concern with the introduction of more renewable energy in the system. Capacity Remuneration Mechanisms (CRM) to maintain base load capacity is high on the agenda of several EU countries.

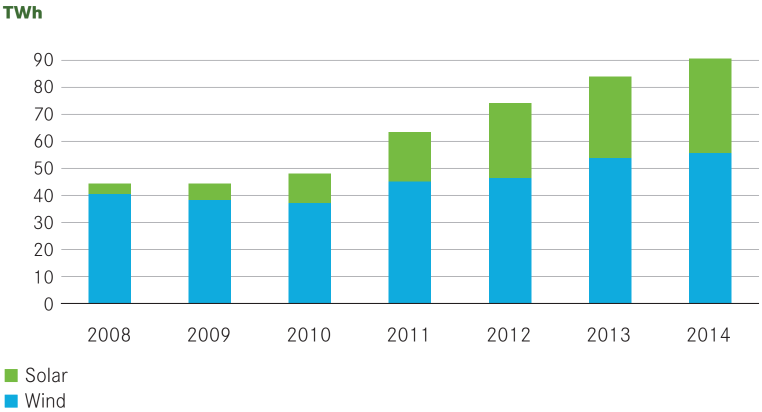
Challenges with balancing power in Germany

The German Energiewende is often mentioned as the prime example of the transformation from traditional production based on fossil fuels and nuclear to renewables. The Energiewende's increasing challenge, as more weather-dependent production is introduced, is to provide enough balancing power to guarantee the security of supply to customers at all times.

In Germany, the rapid introduction of solar and wind combined with the decommissioning of nuclear generation had the unfortunate result of increased emissions of greenhouse gases from fossils fuels, as coal-fired power plants remained the source of balancing power.

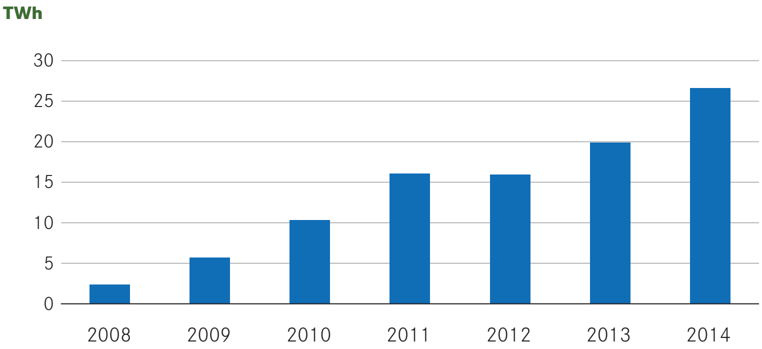
The increase of renewable energy increased the intraday market volumes in Germany in 2008–2014

The increase of wind and solar generation in Germany



Source: Figures from ENTSO-E Yearly Statistics

EPEX SPOT's Intraday market volume in Germany/Austria



Source: Figures from EPEX SPOT annual reports

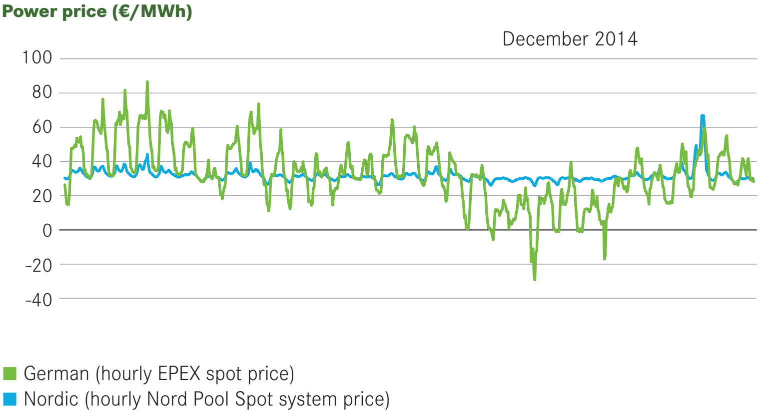
Short-term price volatility growing due to increasing amount of renewable energy – hydro power balances

Electricity prices are extremely volatile today. When comparing the Nordic and German spot market, the average electricity prices have been about the same at 30€/MWh. However, in the German market, the price variation is big and the peaks are steep due to the introduction of more variable renewable energy, which can be a problem for industry and the consumers unable to be flexible in their use of electricity. The price tends to peak when demand is high or renewable energy production is low. In the Nordics, the electricity prices are more stable due to hydropower.

Average power prices in Nordics and Germany were very close in December 2014

Source: Nord Pool Spot, Bloomberg Finance LP

Hourly prices, however, were very different. Price pattern is becoming more important than average price.



Source: Nord Pool Spot, Bloomberg Finance LP

Hydropower is a key in climate change mitigation

Climate change and global warming are our generation's number-one challenge. Virtually all available research predicts that with the current development we are heading for at least 2 and more likely 3-4 degrees warmer climate by the end of this century[5]. As energy production and use account for two-thirds of global greenhouse-gas emissions, the energy industry is in a key role to cut emissions – while powering economic growth, boosting energy security and increasing energy access.

Global challenges need global solutions. Hydropower can make a major contribution to climate change mitigation, as it is practically CO_2-free, and it can be used as balancing power for more weather-dependent renewable energy sources like wind and solar power. Hydropower is more efficient and flexible compared with existing fossil alternatives for base load and balancing power.

ENVIRONMENTAL IMPACT

Hydropower's own overall environmental impact is limited. The construction of hydropower alters the water system and its natural conditions. Hydropower production and regulation change the range and rhythm of the water level and flow rate. Hydropower dams and the use of power plants can hinder the migration of fish, cause changes in the local flora and fauna, and affect recreational use. When planning for new plants or major updates on existing ones, the mitigating of environmental impact is always a part of the equation. Utilities in Finland and Sweden take an active part in the research and development aiming to reduce local environmental impact[6].

Hydropower companies are cooperating with local communities in Finland and Sweden in fish stocking, restoring habitats and building fishways. Releasing small fish through fish stocking is perceived as support to recreational fishing, but often the role of fish stocking is the conservation of an original population or even the reintroduction of a lost species. The problem is that migrating species in many of the regulated rivers are unable to breed naturally. One way to overcome this is to catch and transport the fish to the spawning areas[7] .

IMPACT ON LOCAL ECONOMY

Ever since hydropower was introduced in the Nordic countries in the early 20th century it has played a central role in creating wellbeing to local communities. In the early days, it facilitated the electrification of society and paved the way to industrialisation by providing the power needed to establish energy-intensive production facilities, such as steel and paper mills. Historically, a major part of the revenue generated benefited the local communities through direct income and taxes, but also through competitive energy prices.

Today's more efficient operations mean there are no longer as many people working at the plants on a daily basis. The plants are increasingly automated and controlled remotely. However, plant maintenance and upgrades create many job opportunities in remote areas and contribute to the local economy[8]. Moreover, the tourist industry has grown over the years and it is mainly situated along the regulated rivers that have the necessary infrastructure and good fishing opportunities.

In Finland, the real estate tax from hydropower plants goes to the local communities. This is not the case in Sweden. Sharing tax revenues with the hydro municipalities or regions is an important component in increasing local acceptance and thereby facilitating the development of hydropower – both in terms of production and environment. Fortum has proposed that part of the real estate tax in Sweden be allocated directly to the municipalities where the hydropower plants are located.

[5] According to the International Energy Agency IEA meeting the emission goals pledged by countries under the UNFCCC would still leave the world 60% above the level needed to remain on track for just 2ºC warming by 2035

[6] E.g. Energiforsk research on behalf of the energy sector and other joint sector research initiatives, like KLIV (Power and Life in water), involving the hydro utilities and responsible authorities; additionally, the utilities are participating in numerous of local initiatives.

[7] Read more about catching and transporting fish from the Klarälven and Oulujoki case on pages 20–21.

[8] Fortum alone annually invests approx. 100 MEUR in Nordic hydropower.

Challenges in hydropower and how to tackle them

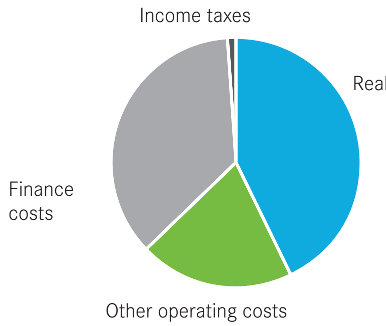
There are three main perspectives in hydropower: society, the environment and the energy system. In all cases, hydropower's contributions are significant, affecting issues like security of supply, competitiveness, tax revenues and climate change mitigation. If we want to benefit even more from hydropower, there are major challenges to overcome. New investments – or even maintaining existing capacity – are being curbed because of low electricity prices, high taxes and, most of all, the unfavourable regulatory framework.

Taxation

Today, the taxation of hydropower in both Finland and Sweden is significantly higher compared with that of other energy production forms. This puts hydro in an unfavourable and unfair competitive position and, with the current historically low energy spot prices, it can make new investments even into existing hydro power plants virtually impossible. The tax environment is especially challenging in Sweden.

In Sweden, the real-estate tax base for hydropower is really a tool for unfair windfall taxation: The real-estate taxation valuation is based on the historical power production and price for the past 6-year period – not on the actual technical value of the property. For example, the current real-estate taxes are determined by the production volumes and prices from the 2006–2011 period. Consequently, the

Taxes account for nearly 45% of total cost; nearly 70% of operating cost

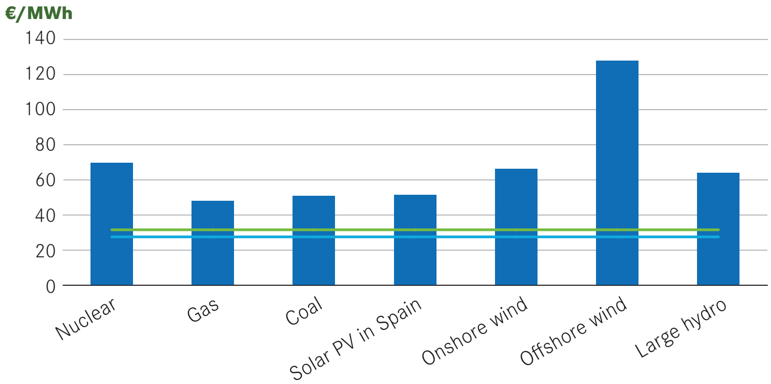


An illustrative example based on the data of five Swedish power companies with hydro assets shows that real estate tax and income tax account for nearly 45% of the total cost of a power company – including net finance cost. When looking just at the operating costs, the share of real estate tax is nearly 70%.

Source: Fortum

Investment costs vs current market prices

Average levelised costs of new electricity generation, LCOE (including 20% corporate tax)



- LCOE (fuel and CO_2 prices based on futures as of August 2015)
- German futures for 2020 (as of 12 August 2015)
- Nordic futures for 2020 (as of 12 August 2015)

The levelised cost shows the achieved electricity price required for an investment to break even over the lifetime of the project.

Disclaimer: The presented figures do not represent Fortum's own view on the levelised costs of electricity.

The figures are based on recent external publications. Key assumptions: real discount rate 5%, corporate tax 20% . Overnight costs, €/kW 5,400 for nuclear, 747 for gas, 2,304 for coal, 1,269 for onshore wind, 3,400 offshore wind, 2700 for hydro, 975 for ground mounted solar. Peak load factor for ground mounted solar 19%; for onshore wind 27%; for offshore wind 34%, for large hydro 40%, for nuclear, gas and coal 91%. Economical lifetime: 30 years for solar, 40 years for nuclear and hydro, 25 years for others. Fuel prices are the market forward prices as of August 2015 extended by applying inflation of 2%. Note, there are large variations in cost of hydro, wind and solar depending on location and conditions.

Sources: World energy council 2013, Cost of energy technologies, European PV Tehcnology Platform Streering Committee, PV LCOE working Group: PV LCOE in Europe 2014-30, Final report
IRENA: Renewable power generation costs in 2014
Fraunhofer: Levelised cost of electricity, Edition November 2013, Lazard's Levelized Cost of Energy Analysis - Version 8.0. 2014

tax is more like a progressive income tax, which is based on income made years ago, and on much higher price level. Generally, property tax should be stable and long-term in nature reflecting the value of real estate, while now the Swedish hydropower producers must pay for their business risks also in the form of a real-estate tax.

The current real-estate tax rate for hydro power plants in Sweden is at 2.8%. Other generation forms (including other renewable energy) pay only a 0.2% or 0.5% real-estate tax based on a fixed taxation value of the property; power prices or amount of production do not have any effect on the value of a plant. It can even be claimed that the higher tax rate of hydropower is a subsidy for other energy forms since they do not have to pay such high taxes.

With the current historically low electricity spot prices, the tax burden for hydropower is unbearable; in some cases, the market price income after real-estate taxes does not even offset the related fixed and variable costs of running a hydropower plant. In other words, the market price of power per MWh has been lower than the tax per MWh. At the same time, the value of the real estate has not changed.

Hydropower production is very capital intensive. Even the maintenance and refurbishment of existing plants require big investments. However, for some reason, the interest reduction allowed for hydropower is much smaller and the controversy costs much higher compared with other production forms. All in all, the tax environment is making it difficult to make the required investments in refurbishment, maintenance and productivity.

As the valuation of a hydropower plant is based on the amount of production, it can also be considered to be in breach with the EU Energy Tax Directive. According to the Directive electricity is to be taxed when delivered for consumption, not when it is generated.

In Finland, the real-estate taxes for hydropower are calculated technically based on specifications that are congruous with other industrial real estates. Furthermore, the real-estate tax is a municipal tax, which benefits the local communities and can help to foster better cooperation between the communities and the hydropower operators. In Sweden, the real-estate tax is a government tax that does not directly benefit the local municipalities.

According to the Finnish Real-Estate Tax Act, the real-estate tax scale on power plants can range between 0.8% and 2.85%. As of 2016, the Finnish Government has proposed to increase the tax rate to 3.1%. Almost always, the level of tax for hydropower plants has been set at the very maximum of the scale by municipalities, as it leads to high tax revenue for them. In Finland, too, there are some hydropower plants that are struggling: while the plant revenues vary greatly based on the Nordic electricity price, the tax burden remains stable.

Fortum's solution:

There is no justification to set different tax rates for different power generation technologies, or power generation and other industrial activities. Hydropower taxation value should equal that of other generation forms.

The Swedish real-estate tax on hydropower should be based on the same technical value as other energy production forms. Furthermore, there should be a cap on real-estate taxes – the taxes should never exceed either the market price income or net profit before real-estate tax.

Part of the real-estate tax in Sweden should be allocated directly to the municipalities where the hydropower plants are located.

In Finland, too, the real-estate tax rate for all energy production forms should be equalised.

In general, the real-estate tax should be stable and predictable over the long term. If hydropower plants are required to compensate for their environmental burdens or other risks in some way, a real-estate tax is not the right form.

The need for modern environmental legislation

The hydropower utilities in the Nordic countries recognise that there is also a need to mitigate environmental impact on a local level. Nevertheless, there needs to be a balance between the micro- and macro-level goals. While hydropower has an impact on local biodiversity, it is a key solution for climate change mitigation and the backbone of renewable energy production. And global climate change is also one of the largest long-term threats to local biodiversity.

The EU Commission has started carrying out a fitness check of several directives in an effort to achieve better alignment between different directives and goals and to study how the directives fit in relation to the actual preconditions in each member state. From a hydropower perspective, reviewing the fitness between the Habitat, Bird, Renewable and Water Framework directives, e.g., should be a priority.

There is a need for a well-aligned regulatory framework giving grounds for the implementation of various biodiversity-related directives at the national level, with the goal of safeguarding both the local and the global perspectives regarding competitiveness, biodiversity and the introduction of more intermittent renewables. On a national level, the fitness of environmental legislation and global environmental challenges is a growing concern. A study of Swedish court decisions regarding environmental permits shows that global factors are seldom taken into account[9]. In essence, this means that the courts only look at local environmental issues. If we are unable to make decisions at a local level based on a global perspective, we will not be able to cope with our most important challenges.

We need a modernised regulatory framework for the environment that is based on the same priorities as the national- and EU-level climate and energy policies. This should apply to regional, national and EU environmental legislation, acts and legal practices. In many cases, national environmental legislation deprioritises larger climate, energy and global environmental policy concerns in favour of local biodiversity issues and concerns. National environmental legislation often neglects climate change, despite the fact that this is likely the largest single threat to biodiversity and the main driver of other major policy actions in other areas. National environmental legislation cannot be practiced in isolation of EU-level or global policies, it must be aligned. There has to be a reasonable cost-benefit analysis between the value of production and the gained local environmental benefits built into the system.

While hydropower has an impact on local biodiversity, it is a key solution for climate change mitigation and the backbone of renewable energy production.

[9] Law firm Fröberg & Lundholm study 2015.

As a large hydro power producer, Fortum also acknowledges the need for ecological compensation for the adversities of hydropower. However, the compensation demands need to be reasonable and in line with the overall policy priorities. There has to be a fair balance between the value of lost power production, the measures to safeguard local biodiversity and the curbing of climate change. The starting point for the demands and requirements set on hydropower today are often unrealistic and irrelevant.

Today any environmental permitting for hydropower in Sweden or Finland takes several years or even decades. This is far too long, as the power system needs more flexible generation when renewable energy production grows rapidly. The permitting processes seem to fully ignore this reality today. Processes should be simplified and the right to appeal verdicts should be limited to only those affected by the actions, thus limiting unreasonably long permitting processes.

Fortum's solution:

There needs to be a fitness review of EU-level directives, such as the Habitat, Bird, Renewable and Water Framework directives.

National ecological compensation demands need to be evaluated in line with the overall policy priorities related e.g. to climate change mitigation, energy system development and flood protection.

In Sweden, the Environmental Act needs to be reviewed and aligned with other broader environmental, climate and energy policy priorities. The environmental courts' interpretation of the current Act tends to consider only the local and potential direct impact, ignoring the benefits of more renewable carbon-dioxide-free energy.

In Finland, there needs to be clear alignment between the nature conservation act and water act implementation. The currently unclear order of priority of the laws delays environmental verdicts.

In addition, the environmental management requirements in Finland need to be kept at a reasonable level (in proportion to damage caused). The currently discussed multifaceted fishery fee needs to be in proportion to the damage caused and in proportion to the benefits for the fish population and it should be possible to spend the fees on corrective actions.

Both in Finland and Sweden the environmental permitting processes need to be improved and significantly accelerated. The right to appeal verdicts should be limited to only those affected by the actions.

Implementation of the Water Framework Directive

The implementation of the EU Water Framework Directive[10], the WFD, is another major challenge in utilising the full potential of hydropower, or even in maintaining today's levels. The directive's aim is to achieve good qualitative and quantitative status or potential of all water bodies by 2015 in order to safeguard biodiversity. This is very desirable, but the directive is not able to take into account the different countries' unique preconditions, and there are significant differences in the national interpretation and implementation of the directive. There is a lot of freedom given to each member state to investigate, classify, and set goals for the ecological targets of water bodies.

So far, there have been considerable differences in the interpretation and implementation of the WFD both nationally and regionally. According to estimates made by the Swedish national energy utility Vattenfall, there could be losses of up to 20 per cent, or 13 TWh of today's production, as a result of the WFD implementation in Sweden[11]. This would increase the costs for industry and consumers. The cost of replacing the lost hydro production with for example onshore wind power is estimated to be 7 billion euros worth of new investments.

Finland's approach to the implementation seems to be more balanced than Sweden's. The regional water authorities in Sweden have divided the country into 26,439 water bodies, while the corresponding number in Finland is 9,957. In Sweden, one river system can be fragmented into many individual water bodies with separate evaluations and isolated measures. In Finland, a river system is more or less regarded as one water body with a holistic view on what needs to be done in order to reach good ecological status or potential.

In order to avoid major losses of production, the Swedish Energy Agency and the Swedish Agency for Marine and Water Management have presented a national strategy for hydropower in an effort to strike a balance between power production and local biodiversity. According to the strategy, the environmental goals can be reached with an overall loss of 2.3 per cent of today's

The regional water authorities in Sweden have divided the country into 26,439 water bodies, while the corresponding number in Finland is 9,957.

[10] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000.

[11] Vattenfall report 2014, analysing the impact on the 200 largest Swedish hydropower plants when implementing proposed measures to reach good ecological potential in heavily modified waterbodies (Konsekvensanalys - Förbättringsåtgärder som kan bli aktuella för att uppnå God Ekologisk Potential (GEP) i Kraftigt Modifierade Vattendrag (KMV).)

production[12]. The cost of measures connected to the national strategy has been estimated at 1.6 billion euros, covering fish ways and decommissioning of parts of small hydropower. This would lead to a cost of approx. 100 million euros per installed MW. Replacing the lost hydro production with wind power would require about 500 MW of wind capacity costing approx. 800 million euros of additional investments.

There is a clear need to review the balance of various policy areas tackling hydropower. There is clear need for a fitness check of the Water Framework Directive and the broader EU-level environmental, climate and broader energy policy priorities.
In addition, the implementation of the directive considers hydropower in isolation of the other EU-level targets on mitigating climate change and increasing RES energy[13]. It also ignores the need to balance the increasing intermittency in the energy system. Especially in Sweden, the national implementation of the directive could seriously endanger the achieving of the broader environmental, climate and broader energy policy priorities.

Fortum's solution:

There needs to be an EU-level fitness check of the Water Framework Directive and its alignment with the broader EU-level environmental, climate and broader energy policy priorities.

The Swedish Environmental Act should be amended with a clear global perspective on the environment in order to better balance global and local biodiversity issues.

The Swedish authorities need to review the current implementation of the directive since implemented in the right way with the member state's possibility not to impede the important use of hydropower, it does not cause significant losses for hydropower production.

[12] Energimyndigheten och Havs och Vatten myndigheten: Strategi för åtgärder i vattenkraften.

[13] EU council decision, October 2014, to cut CO2 emissions by 40% and increase RES by 27% from 1990 levels by 2030.

Global challenges need global solutions – Our recommendations

In order for hydropower to reach its full potential as a reliable and renewable backbone of the energy system, the perspective on hydro has to radically change. Hydropower plays a very crucial role in mitigating climate change so we need to secure its competitiveness. Our recommendations aim at promoting increased flexibility and efficiency of the existing capacity as well as making it possible to build new hydropower.

- Policies and legislation addressing hydropower should always be considered from three angles: local environmental impacts including flood protection, role of hydro in the existing and future energy system, and climate change mitigation.

- Hydropower's better utilisation should be assured in several ways: maintaining the competitiveness of the current hydropower fleet, modernising the current fleet for capacity utilisation, increasing the flexibility of the existing hydropower plants through reservoirs, enabling construction of new hydropower in river systems already used for hydropower including reservoir, and consideration of constructing new hydropower in rivers not previously used as well as allowing short-term water level fluctuations to fully utilise hydropower's potential as effective back up and balancing power.

- Regional, national and EU environmental legislation, acts and legal practices should be based on the same sustainable environmental, climate and energy policy priorities.

- Hydropower should be treated equally with other renewables in terms of taxes and subsidies.

- Current implementation of the EU Water Framework Directive needs to be reviewed and aligned with other global environmental, climate and broader energy policy priorities. The directive needs to be implemented without losing existing hydropower capacity.

- In Sweden, the interpretation of the Environmental Act tends to focus only on the local and potential direct impact, while ignoring the benefits of more renewable carbon-dioxide-free energy. It needs to be reviewed and aligned with other broader environmental, climate and energy policy priorities.

- In Finland, there needs to be clear alignment between the nature conservation act and water act implementation. Today the unclear order of priority of the laws delays environmental verdicts.

Our recommendations aim at promoting increased flexibility and efficiency of the existing capacity as well as making it possible to build new hydropower.

- The environmental management requirements in Finland should be kept at a reasonable level (in proportion to the damage caused). The discussed multi-faceted fishery fee needs to be in proportion to damage caused and in proportion to the benefits for the fish population; it should be possible to spend the fees on corrective actions.

- Both in Finland and Sweden the environmental permitting processes need to be improved and significantly accelerated. Today permitting takes several years or even decades. The right to appeal verdicts needs to be limited to only those affected by the actions.

Case 1: Transportation of spawners more effective than fishways on Klarälven river

The salmon and trout populations in Lake Vänern represent some of the last remaining large bodied, landlocked salmon stocks worldwide. The historical large catch levels declined considerably by the late 1800s, and even more during the 1900s. However, through purposeful actions based on the upstream transport of adult spawners (‘trap and transport’), returns of wild salmon to the River Klarälven have rebounded during the last 20 years[14].

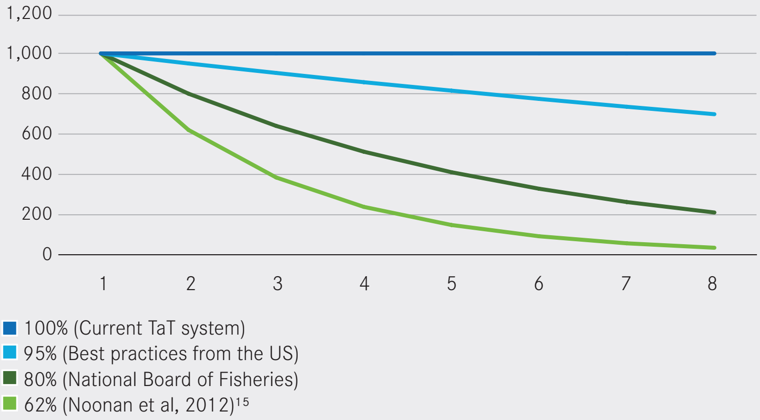
The County Administrative Board of Värmland has undertaken a project with the goal to guarantee free migration routes for the salmon all the way from Lake Vänern to the upper Norwegian part of the river.

The project encourages measures to reduce migration delay and mortality by increasing migration rates using approaches such as increasing spill, construction of multiple fish passage facilities at each dam and, in extreme cases, dam breaching. If the project is realised, it will be at great expense to both biodiversity and sustainable energy production.

According to best available technology for Atlantic salmon migration in run-of-river hydropower plants and systems (see, e.g., review by Noonan et al, 2012[15]), it is not possible to build fishways efficiently enough to pass fish both upstream and downstream of 8 to 11 hydropower plants (in the main stem, additional dams in tributaries) in numbers that will sustain the population growth seen during the last decades in the River Klarälven. The cumulative losses and delays for Atlantic salmon passing this many hydropower plants will result in such great losses of spawners not reaching the spawning grounds that it will jeopardise the wild salmon population (unpublished stock-recruitment model by JJ Piccolo, Karlstad University).

Thus, based on current ecological and technical knowledge, a change from today’s trap-and-transport operations to migration through the present state-of-the-art fish passages in this kind of specific case can be seen as a high-risk gamble that threatens the future existence of the Klarälven salmon population.

Passage efficiency scenarios for upstream migrating wild salmon and trout heading for remaining spawning areas in the River Klarälven (n=1,000 spawners)



The chart shows the calculated efficiency of fishways in the River Klarälven - a system with multiple barriers - compared with the efficiency of the current trap and transport solution. The most likely outcome in this specific river system would be that non or only a few individuals would make it to the remaining reproduction areas if fishways were introduced. However - if 50 percent of the fish managed to reach their spawning areas the cost for each individual salmon would equal approx. 300,000 €.

[14] Piccolo et al, 2012: Department of Biology, Karlstad University 2011, Conservation of endemic landlocked salmonids in regulated rivers: a case-study from Lake Vänern, Sweden

[15] Noonan et Al, 2012: Fish and Fisheries, Volume 13, Issue 4, December 2012. A quantitative assessment of fish passage efficiency.

Case 2: Fishways alone will not restore viability of Oulujoki's salmon population

The 107-kilometer-long Oulujoki river runs from Oulujärvi lake to Bothnian Bay next to the city of Oulu, in northern Finland. Fortum has a total of 11 hydropower plants along the Oulujoki river's main channel and the Hyrynsalmi water system upstream from Oulujärvi lake. These hydropower plants were commissioned in the 1950s and 1960s, and their combined capacity is about 540 MW.

Hydropower production's fishing industry obligations in Finland are based on permit regulations set by the authorities. The obligations set for Fortum are primarily for fish stocking. Fortum annually stocks salmon, whitefish, rainbow trout, trout, zander and grayling in the Oulujoki water system. In addition to the obligations, Fortum voluntarily participates in many ways in environmental management and the advancement of recreational use in collaboration with local residents, municipalities along the river, research facilities and environmental authorities. In this collaboration, Fortum has also participated in drafting fishway reports and plans and in the funding of them.

A fishway was completed in 2013 at the Oulun Energia-owned Merikoski power plant, the first plant upstream on the Oulujoki river. This fishway allows fish to swim from the sea up the river to just below the next hydropower plant, i.e. Montta hydropower plant. Fishways have been planned also for the six Fortum-owned power plants upstream in the Oulujoki river but they are yet to be implemented.

Particularly in the initial stage of restoring migrating fish populations, like in the Oulujoki river, many measures are needed – with the fishways being just one measure. To strengthen the Oulujoki river's salmon population, also upstream transportations, stocking and habitat restorations are needed. There is hardly any natural reproduction of salmon in the Oulujoki river, so fishways alone will not restore fish to the river. Upstream transportations, in which fish are caught and transported beyond multiple power plants to better spawning areas, have been tested in the Oulujoki river since 2014. The aim of the 'trap-and-transport' operations is to strengthen the population of river-imprinting salmon and to balance the sex ratio of the population. This is especially needed in the Oulujoki river because only a fraction of the fish travelling through the Merikoski fishway are the larger, roe-bearing female fish.

In the future, the aim with transportations is to move the fish as safely and efficiently as possible to their reproduction areas; consequently, Fortum, the municipalities along the river, and the Centre for Economic Development, Transport and the Environment are planning for fish catching equipment at the Montta power plant. The catching equipment is scheduled to be built in 2016. The possibility to eventually turn the equipment into a fishway (if it appears that there are enough fish wanting to swim upstream) has been factored into the design of the equipment.

Improving the living conditions for migrating fish is an important goal, and their opportunities for natural reproduction must be promoted as much as possible. However, when improving living conditions, it must be realised that all measures do not necessarily work in the same way in all river systems. The choice of measures must always be made on a case-specific basis.

Case 3: Untra hydropower plant's necessary modernisation denied

The Untra hydropower plant is situated in the lower parts of the Dalälven river in the middle of Sweden. There are several areas along the Dalälven that, according to the Swedish Environmental Act, have been classified as protected river stretches. This classification was made decades after the hydropower plant was established, with no concern for hydropower and its benefits to the environment, society, or the energy system. Untra is situated in one of these sections along with three other plants: Söderforsen, Lanforsen and Älvkarleby. Together these plants have an installed effect of 250 MW producing a total of more than 1 TWh of renewable electricity annually. This represents somewhere between 1.5 and 2 per cent of the total Swedish hydropower production. Notably, the national strategy for hydropower states that the implementation of the EU Water Framework Directive, WFD, shall be carried out with a maximum of 1.5 TWh lost production. Totally, there are approximately 100 power plants of significance for the energy production situated in protected river stretches. The case of Untra is an example of how all of this production is threatened. Additionally, a vast number of plants are situated in or in direct proximity to Nature 2000 areas and other areas subject to nature preservation, making maintenance and development increasingly difficult.

The Swedish Environmental Act is strict regarding the local environmental impact of hydropower. According to chapter 4, § 6 of the Act, regarding protected river stretches, no projects can be carried out if there is more than a proven insignificant impact on the environment. In reality, the absence of impact has been near impossible to prove in the Environmental courts. At the same time, no one else has proven that there will be more than an insignificant impact.

Commissioned: 1918
Annual production: 270 GWh
Installed effect: 42 MW

The Untra power plant was first commissioned in 1918 and was built to supply the City of Stockholm with all the power it needed. Now the time has come to modernise the production. However, this has proven to be difficult. Fortum wants to renew and increase the production, construct a biochannel for upstream and downstream migration, and make necessary improvements on the dam in order to meet increased water flows due to climate change. An initial application for an environmental permit was filed in October 2007 and was denied by the Supreme Environmental court in June 2013, almost six years later. Since then, one out of five turbines is now permanently out of order and the biochannel and reinforcements of the dam are still pending. The reason for denial, so far, has been that more than insignificant environmental impact during the building phase cannot be ruled out.

According to the original plans, Fortum would have invested more than 30 million euros, creating job opportunities, increasing the production of renewables by 13 per cent and simultaneously contributing to local biodiversity. Fortum has revised the plans and filed a new application in order to replace three of the five turbines, reinforce the dam and build the biochannel. Denial of this application will inevitably lead to the decommissioning and loss of valuable production of renewable energy – all without gaining any other environmental benefits.

Together with cases like Edeforsen[16], Untra has set a strong precedent for a large part of the Swedish aging hydropower fleet. This is a precedence that has to change if we want to reduce local environmental impact and, at the same time, increase production of renewable energy to benefit the global environment. This is one of the reasons why the Swedish Environmental Act must be revised in order to better balance micro- and macro-level issues. We also see a need to revise the court procedures to make them more time- and cost-efficient. One way of doing this could be by reducing the number of stakeholders representing the same interests.

At present, the hydro utilities wanting to maintain or develop production face strong opposition in the process by forces looking only at the issues of local biodiversity. There are many stakeholders such as the Swedish Environmental Protection Agency, the Swedish Agency for Marine and Water Management, and Kammarkollegiet at the national level, the County administrations and the Water Authorities at the regional level, and several different stakeholders at the municipal level. In addition, non-governmental organisations, like the Swedish Society for Nature Conservation (SSNC), the Anglers Association, and the River Savers, participate in the legal process.

[16] In June 2015, the Swedish Supreme Environmental court denied Fortum's application regarding replacement of the Edeforsen hydropower plant on the Ljusnan river. Fortum wanted to replace an old and inefficient plant with a new one that would increase the production of renewable electricity by seven-fold, from 3 to 23 GWh. The project also included free passage for migrating species. The court paid no attention to the global benefits of increasing and securing CO_2-free renewable production. The ruling was based only on the risk of limited environmental impact during the building phase.

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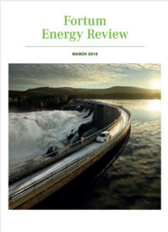

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The energy sector is in the middle of a transition. Global megatrends, such as climate change, emerging new technologies, changes in consumer behaviour, and questions regarding resource efficiency, have a major impact on the energy sector globally. Our intention is to actively participate in the market transition and to be part of the solution.

The Fortum Energy Review series highlights the challenges and opportunities we see in the energy sector and outlines our solutions to them. We want the Fortum Energy Review to engage our stakeholders in a dialogue about the future direction. In our view, energy should improve life for present and future generations.

Fortum's key messages regarding hydropower:

- Hydropower is renewable, practically emissions-free, competitive and a flexible way to produce energy.
- As more and more weather-dependent renewable energy production is introduced to the system, more balancing power is needed. Hydropower, with its quick ramp-up times, is the most efficient and climate-friendly way to produce this balancing power.
- A large amount of variable renewable energy in the system causes high volatility in the power price. Hydropower used in combination with other renewables contributes to more stable power prices and system stability.
- Hydropower production is currently subject to significantly higher taxation than other renewable energy production; this puts it in an unfair competitive position. The taxation value for hydropower should equal that of other generation forms.
- Regional, national, and EU environmental legislation, acts and legal practices should be based on the same sustainable environmental, climate and energy policy priorities so that also global climate and environmental concerns are taken into consideration alongside local issues.