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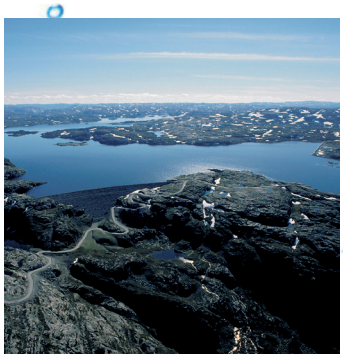
HYDROPOWER FOR A SUSTAINABLE EUROPE

Hydro Equipment Association

ESHA

In cooperation with the Hydro Equipment Association (HEA) and with the support of the European Small Hydropower Association (ESHA)

EURELECTRIC Fact Sheets, FEBRUARY 2013

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EURELECTRIC represents the common interests of the electricity industry at pan-European level. Our current members represent the electricity industry in over 30 European countries, including all EU member states. We also have affiliates and associates on several other continents.

Our well-defined structure of expertise ensures that input to our policy positions, statements and in-depth reports comes from several hundred active experts working for **power generators, supply companies or distribution network operators (DSOs).**

We have a **permanent secretariat** based in Brussels, which is responsible for the overall organisation and coordination of EURELECTRIC's activities.

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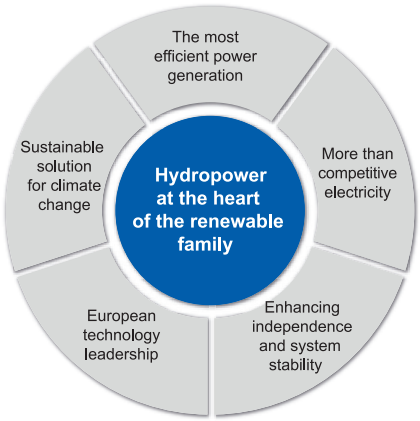
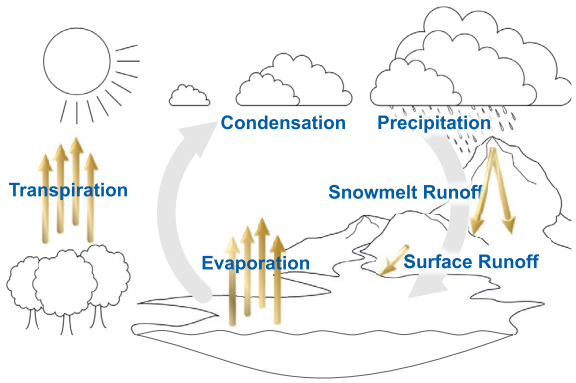
Hydropower
The heart of the renewable family

Renewability, cooperation, experience



Hydropower – renewable energy

Mankind has benefited from using renewable energy sources since long before industrialisation and the start of large-scale exploitation of fossil fuels. People have produced power from the energy in falling water for more than 100 years. Hydropower comes in different sizes and forms, which makes it flexible and gives it the ability to regulate the energy system in a secure and stable way.



According to the Intergovernmental Panel on Climate Change (IPCC), close to half of all solar radiation reaching the earth is used to evaporate water, driving precipitation and the hydrological cycle. That is how nature itself secures hydropower's renewability.

The family of renewable technologies

The renewable energy "family" consists of different energy sources – sun, wind, water, biomass – and technologies we can use to exploit these sources.

Examples for water are hydropower, tidal power, wave power and osmotic power.

At a glance

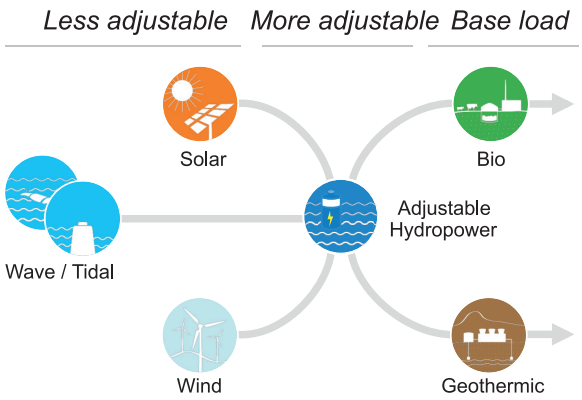
Hydropower...

- is the most efficient power generation technology
- has long-term profitability and important multi -purpose benefits
- is crucial for system stability and security of supply
- is an enabler for large-scale integration of renewables
- is reliable for centuries to come
- represents both long experience and innovation
- is a globally leading industry
- has a very low carbon, water and land footprint
- has a unique role in mitigation and adaptation to climate change

What the family members have in common is renewability. But wind, sun, waves and to some extent the tides, are variable and often unpredictable. This is why power production from other sources is necessary when the wind stops blowing or there is no sun, while other power plants have to reduce their output in very windy or sunny periods. We can offset that variability by storing energy in a hydro reservoir. There are two main ways to do this; Storage hydro takes advantage of large reservoirs with natural inflow of water and the possibility to stop the water outflow instantaneously. The water is stored in the reservoir and no pumps are needed. Pumped storage is based on pumping water to a reservoir with limited size and water inflow. Both enable us to receive and store energy in periods of low demand or excessive production and generate electricity in times of higher demand. The storage possibilities combined with the instant startup and stop of generation makes hydropower very flexible. Other sources, such as biomass and geothermic energy, are more predictable, but have longer lead times for changes in production when demand is peaking.

Hydropower at the heart

As a family, the renewable energy technologies create synergies where the whole is larger than the mere sum of technologies. As a consequence, the cooperation among them brings us faster to a future with greener electricity. With its excellent flexibility and vast network of installations, hydropower is at the heart of this cooperation among the renewable energy family members.



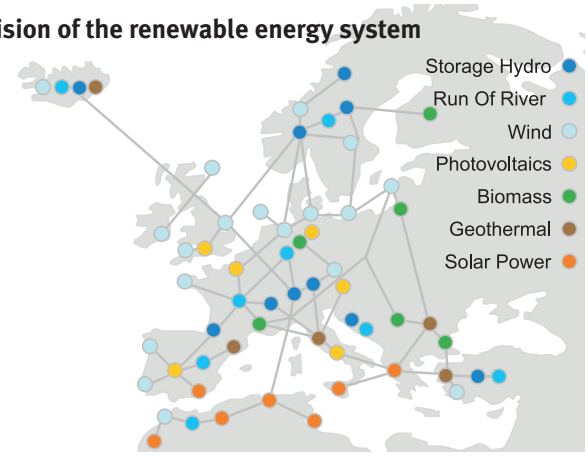
Hydropower differs from other renewable sources due to its large capacity range (going from several KW to hundreds of MW), flexibility and storage capability when coupled with a reservoir. It can operate both in stand-alone systems as well as in grids of all sizes, so it delivers a broad range of services. Hydropower has very high conversion efficiencies (about 85-95%), low operational expenditures (OPEX), and a plant capacity range that varies from a few watts to several GW. This great variety in the size enables the technology to meet large centralised urban energy needs as well as decentralised rural needs.

Hydropower also has extremely short response times and the ability to black start (to start up without help from the grid). Together with its flexibility and energy storage potential, these characteristics enables hydropower to enhance the performance of all renewable technologies, act as a "battery" that can enhance total output from renewables and increase energy security. For these reasons, hydro resources are instrumental when developing energy supply in emerging markets and the technological know-how may be usefully transferred to new renewable deployment.

Snapshot

- Renewable technologies interplay as a family.
- Different sizes, capacities, and characteristics create synergies and make each other stronger.
- With its storage capacity and flexibility, hydropower is at the heart of the renewable family.

Vision of the renewable energy system



Water availability

As a consequence of economic growth and climate change, water availability and management has emerged as a political issue, both in existing and emerging markets. Hydropower reservoirs can increase the residence time of fresh water and secure water availability for a multitude of purposes such as flood control, irrigation, water supply, recreation, and of course, power production.

Snapshot

- Most of Europe's hydropower storage capacity is concentrated in Scandinavia, the Alps and the Pyrenees.
- The undeveloped hydropower potential in Europe is 47 % of the technically feasible potential (IPCC and EURELECTRIC).
- Hydropower secures water availability for several purposes other than power generation, such as flood control, irrigation, water supply, cultural heritage and recreation.
- The hydropower industry's know-how of sustainability issues may be usefully transferred to new renewable technology.

Key figures on hydropower in Europe
(source: EURELECTRIC)

	EU-27	EURELECTRIC Members
Generation	338 TWh	553 TWh
Capacity	136 GW	198 GW
Further generation potential	276 TWh	650 TWh

Outlook and challenges

Given the ambitious European climate and energy policy targets, a massive shift from fossil to renewable sources is underway. The European Wind Energy Association (EWEA) expects electricity production from wind power to nearly triple by 2020. Ambitious European goals for renewable power generation will be achieved largely by introducing significant amounts of variable wind power into the European power system. A system with possibilities for energy storage and balancing services through storage hydro and pumped storage would allow more wind power in the system without compromising the security of supply (German Advisory Council on the Environment (SRU, 2010)).

The flexible hydropower production in Europe in its varying sizes creates large value and at the same time increases energy security and local supply as well as the speed and amounts of phasing in more renewable power into the European energy system.

Policy recommendation

- Facilitate for sufficient transmission capacities in order to exploit the full potential of the renewable family.

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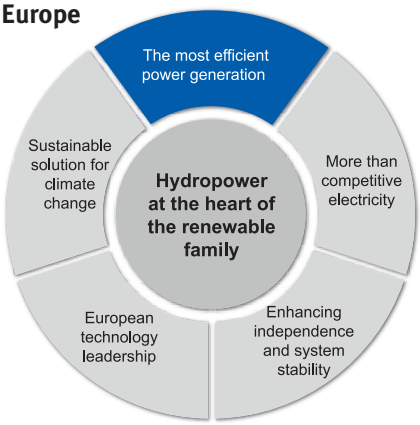
Hydropower
The most efficient power generation

Hydropower - crucial for a sustainable and wealthy Europe



Hydropower, in all its sizes, plays a key role in the European electricity system and still has an important development potential:

- It provides important quantities of low-carbon electricity at low costs, limits society's expenses for the movement towards carbon neutrality of the energy system, and supports Europe's competitiveness in the global economy.
- Utilising hydropower's whole range of installations – from small to large, volatile to storage, decentralised to centralised – enables the reliable and cost-effective integration of growing wind and solar power.
- Hydropower reduces dependency on fossil fuel imports and creates value and employment in Europe.

Highest energy payback ratio

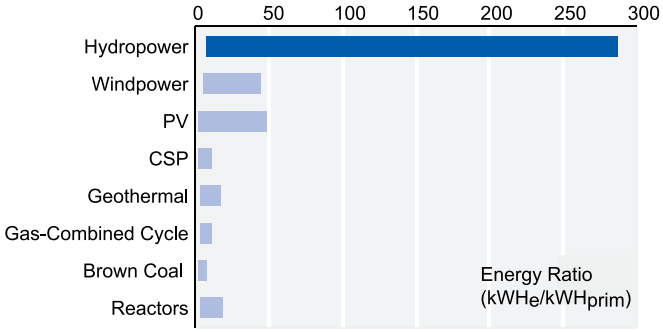
The energy payback ratio is the ratio of total energy produced during a technology's lifetime divided by the energy needed to build, fuel, maintain and decommission the plant in question. It is a very important benchmark, when considering the sustainability and efficiency of a power plant. The higher the ratio, the better the environmental performance.

Hydropower shows the highest energy payback ratio in comparison with all other technologies – renewables as well as conventional ones. During its lifetime a hydropower plant produces more than 200 times the energy needed to build, maintain and operate it.

Reasons for the high-energy payback ratio are the very long lifetime of hydropower schemes and the short energy conversion process. Once built, hydropower infrastructure can generate electricity for many decades,

At a glance

- Hydropower shows the highest energy payback ratio.
- Hydropower is resource efficient.
- Hydropower has the highest electricity efficiency rate (85 % to 95 %).
- Hydropower provides the most efficient storage technology.



(Source: EURELECTRIC (2011), Life Cycle Assessment of Electricity)

often even for more than 100 years. For this reason, life-cycle assessments for hydropower generally provide a very good carbon footprint and energy efficiency profile.

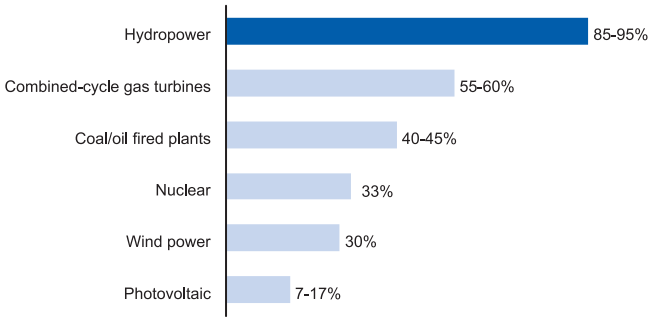
Resource efficient electricity generation

Given its low carbon footprint and high energy efficiency profile, hydropower can help to meet the increasing pressure on natural resources. As hydropower uses water as its fuel, by running it through turbines and discharging the identical volume into a water body further downstream, the hydropower production process in itself does not consume water. The land used for hydropower creates opportunities for other users, but can change landscapes and can have impacts on biological systems. However, each hydropower station can be tailor-made adapted to local conditions. This enables the optimal utilization of the resource while negative impacts can be minimized. Local and air pollution as well as waste production from hydropower generation are very limited. Hydropower plants with reservoirs create availability of water for a multitude of purposes and enhance the control of the resource. Instead of letting water flow unused from source to sea, it can be stored in reservoirs to make it available when needed.

Highest electricity efficiency rate

Hydropower efficiency rates are the highest of all energy technologies, ranging up between 85% and 95%. The electricity generation process is simple, avoiding losses in the transition process. It directly converts mechanical energy into electricity.

Electricity conversion ratio



(Source: EURELECTRIC (2011), Hydro in Europe: Powering Renewables)

The only efficient large-scale storage technology of today

With the steadily rising share of variable renewable energy sources, such as solar and wind, storage facilities will become increasingly important. Storage facilities are necessary to bridge the gap between demand and supply, especially in time periods when wind is low or the sun is not shining.

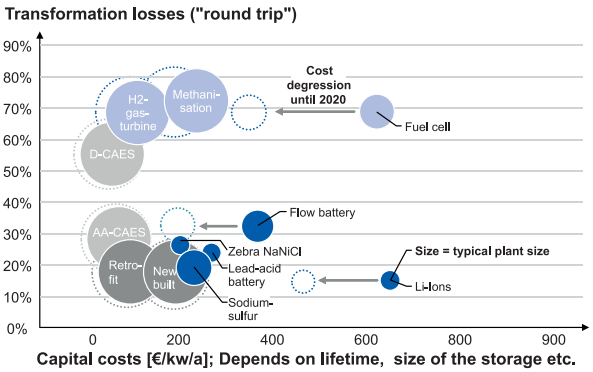
Hydropower's quick response capabilities allow providers to follow changes in electricity demand and supply almost instantly which is crucial for balancing the grid and for securing system stability.

The total installed storage capacity in Europe amounts to more than 180 TWh delivering short-, medium- and long-term storage capacity, depending on the size of its reservoirs.

Storage hydropower is the only mature storage technology in today's market. It can provide large volumes of electricity over long periods of time on very short notice at competitive prices. This makes hydropower the most cost-effective storage option.

In areas where no conventional storage hydropower is available, pumped storage plants (PSP) can be more easily installed, for example, by using abandoned mines as a lower basin. Despite the fact that the pumping activity consumes electricity, PSP is still a more cost-effective solution compared with other storage options as shown below.

Hydro storage technologies are the most efficient



(Source: Frontier Economics (2011))

Outlook

Hydropower can and should play a key role in achieving the EU 20-20-20 goals, as it is the most efficient form of power generation technology.

Hydropower's excellent performance in terms of efficiency and flexibility should be better communicated in the debate around the transition to a low-carbon future in order to increase the public awareness of this energy source.

At the same time, the industry needs to continuously improve the performance of existing and new hydropower.

Policy recommendations:

- Establish appropriate and consistent framework conditions to guarantee the best possible use of existing and future hydropower.
- Create a level playing field in Europe for power generation from domestic water resources, compared with other electricity production and storage technologies, with a special focus on the value of providing flexibility to the electricity system.

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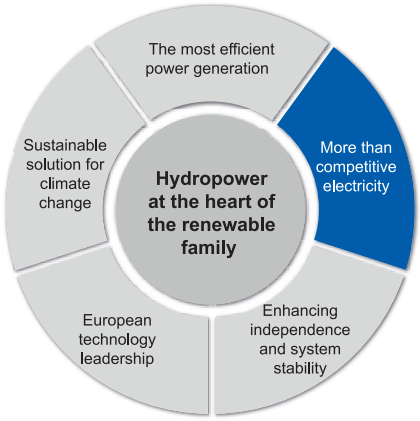
Hydropower
More than competitive electricity

Hydropower - crucial for a sustainable and wealthy Europe



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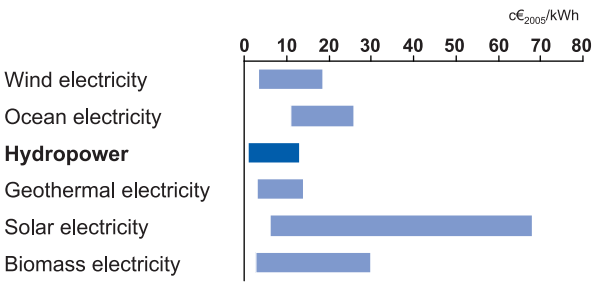
- Utilising hydropower's whole range of installations – from small to large, volatile to storage, decentralised to centralised – enables the reliable and cost-effective integration of growing wind and solar power.
- Hydropower reduces dependency on fossil fuel imports and creates value and employment in Europe.

Hydropower plants are competitive

According to the Intergovernmental Panel on Climate Change (IPCC), hydropower has the lowest generating cost compared with other electricity production technologies.

Levelized cost of electricity



(Source: adapted from IPCC, 2011)

At a glance

- Hydropower is competitive and fully integrated in the markets.
- Hydropower has proven long-term profitability.
- Hydropower has important multipurpose benefits (e.g. culture and tourism , flood control, irrigation, navigation, drinking water).

EURELECTRIC has estimated[1] that half of the technical hydropower potential in Europe has not yet been developed. Further development of the economically and environmentally acceptable part of this hydropower potential could contribute to meeting the EU energy and climate goals.

Hydropower provides storage and flexibility, allowing us to generate electricity at the moment it is needed.

Hydropower is predictable, and can easily match demand. Hydropower also provides, as one of the few renewable technologies, ancillary services (primary regulation, secondary regulation, fast reserve, etc.) and electricity supply in remote areas, which are needed for balancing the grid.

There may be significant price spreads between base and peak load in many electricity systems. But hydropower production can be planned according to price expectations. This contributes to reducing power price volatility for the electricity customers.

Optimising environmental and societal goals is also part of hydropower's business model. Hydropower is already a highly regulated sector and requirements from regulators affect the investment climate.

A lack of harmonisation between regulation coming from environment, energy and climate action authorities has already led to regulatory uncertainty, which is detrimental to new investment decisions and to the viability of existing projects. This may lead to reducing the flexibility performance of hydropower and increase the need of thermal modulation if the grid has to integrate more and more volatile renewable energy. Inappropriate regulation can also decrease the attractiveness of investments by making mandatory requirements that are economically not feasible.

Hydropower operators agree with the need for balancing different political goals and measures, and operators are continuously developing solutions to meet the need. Examples are fish passes and the appropriate management of flows and sediments.

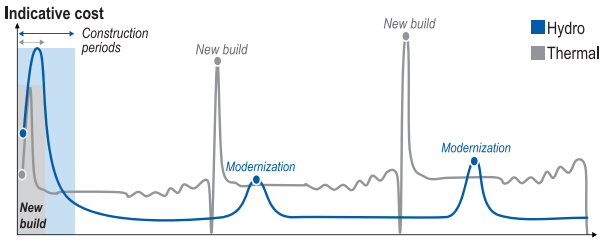
1 EURELECTRIC (2011), "Hydro in Europe: Powering Renewables"

Hydropower has proven long-term profitability

The longevity of infrastructures allows a profitable cycle of economic life. For instance, the 32-metre St. Ferréol dam on the Canal du Midi (southwest of France) was built in 1675 and is still in operation after 338 years. With adapted controls and maintenance, dams can last for many future generations, and extensive refurbishment of electro-mechanical parts can occur in longer intervals (every 60 to 80 years).

Whereas the capital costs of hydropower are quite high, operation and maintenance costs are relatively low, even when including the cost of periodic refurbishment. The high upfront capital costs combined with long construction periods and the relative late start of the payback period represent a challenge to large hydropower investments. The value of hydro assets' longevity is not adequately captured in economic models, when the investment is compared with similar generation capacity in other technologies with a lower asset life time. This is illustrated in the graph below.

Financing challenge of hydro vs thermal plants of similar capacity (illustrative)



For some existing hydropower plants it is possible to add more power (new sets) and to invest to generate more peak energy. For others it is also possible to increase the average generation by modernising the existing generation units.

Hydro has important multipurpose benefits

Hydropower technology can have important multiplier effects by providing energy as well as other environmental and societal services such as water supply services. Reservoirs for hydropower increase water availability and add the possibility of storing water and energy. The storage makes it possible to produce energy according to the demand profile. Water availability and storage is also useful and necessary for irrigation, water supply, navigation and flood control. In addition to these primary objectives, reservoirs can provide a number of other uses like recreation and aquaculture.

Harmonious and economically optimal operation of such multipurpose schemes may involve trade-offs between the various uses, including hydropower generation. This is why we must recognise all those non-energy services, and to find ways to value them in economic models. The International Energy Agency, the International Hydropower Association, and others continue to work on that issue.

Outlook

Hydropower deployment in Europe faces several challenges concerning competitiveness. Capital costs are high, and payback starts late due to long permit granting procedures and construction times. Such a long permit granting procedure increases the uncertainty about the future regulatory framework, and represents a high risk at the time of the investment decision. Moreover, administrative barriers and regulatory changes during operation represent additional challenges. Grid fees can disadvantage pumped storage plants compared with other competing flexibility options.

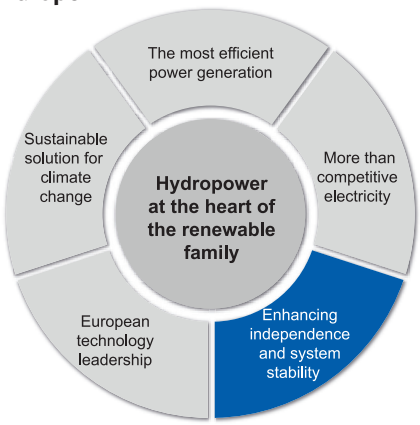
Policy recommendations

- Simplify the permit granting procedure and improve the administrative framework.
- Commit to further explore the possibilities of using the still available hydropower potential.
- Recognise and value the multipurpose function of hydro infrastructures.
- Guarantee a level playing field with other generating technologies (e.g. by avoiding increased market distortion due to subsidies for other technologies).
- Harmonise conflicting policy goals as well as the implementation of existing EU directives in the field of water management, renewable energy generation and climate change adaptation and mitigation.

Hydropower

Enhancing EU security of supply and system stability

Hydropower – crucial for a sustainable and wealthy Europe



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- It provides important quantities of low-carbon electricity at low costs, limits society's expenses for the movement towards carbon neutrality of the energy system and supports Europe's competitiveness in the global economy.
- Utilising hydropower's whole range of installations – from small to large, volatile to storage, decentralised to centralised – enables the reliable and cost-effective integration of growing wind and solar power.
- Hydropower reduces dependency on fossil fuel imports and creates value and employment in Europe.

Hydropower fosters EU energy independence[1]

Hydropower contributes to EU energy independence and self-sufficient energy supply in several ways. Today, the EU27 gross inland energy consumption is about 20 500 TWh, of which 53% is imported. Hydropower is a renewable domestic resource. According to the EU-Commission, the import dependence is expected to increase to 70% unless policy measures are taken. Optimising the use of existing as well as developing new potential hydropower can help to limit the growing import dependence. To increase the EU energy independence, electricity supply based on renewable sources will be key.

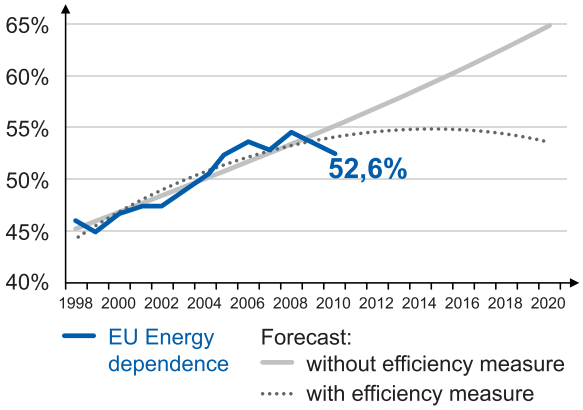
1 EUROSTAT, Statistical Pocketbook 2012

At a glance

- Hydropower fosters EU energy independence.
- Hydropower is crucial for system stability and security of supply.
- Hydropower is the enabler for the integration of large RES volumes.

Hydropower produces pure electricity from a clean process and increases the possible amounts of other renewable energy to be developed due to its storage possibilities. Using more wind and solar power reduces fossil fuel consumption and fosters EU energy independence.

EU energy dependency



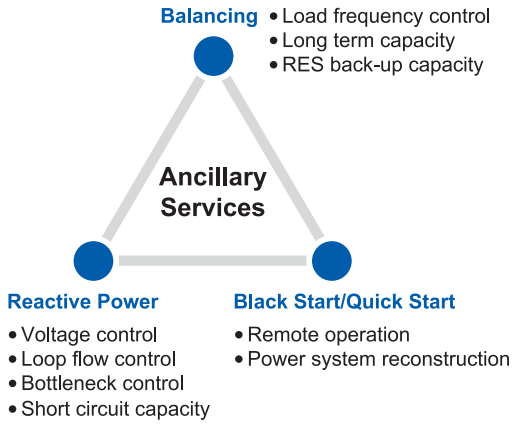
(Source: Eurostat, Statistical Pocketbook 2012)

The EU's recent 2050 roadmap discusses reducing gross energy demand by 50% and meeting the rest with 80% RES share of inland production. This will lead to an increase in electricity production in order to substitute fossil fuels with electricity. Electricity production from renewable energy source (RES) can meet the goals of the 21st Century energy system, but the volatile wind and solar power will be a challenge for system stability and security of supply.

System stability and security of supply

Electricity system performance depends on stable frequency in the grid, which requires instantaneous adjustments to supply in order to match variations in demand. Therefore, a number of ancillary services are needed to manage the transmission system in a way that secures system stability

and supply. Due to the individual technical characteristics of generation technologies – RES and non-RES – generation pools need economically efficient flexibility. Hydropower meets all these goals; it is efficient, effective, predictable, controllable, mature, proven, reliable and renewable.



A liberalised Pan-European electricity market requires Trans-European energy flows in a stable transmission grid. Because of its high flexibility, hydropower helps to stabilise transmission voltage without requiring more fuel or leading to increased CO_2 emissions. In this way, hydropower helps to manage voltage dropouts and to reduce loop flows that may cause bottlenecks.

After a system collapse, the grid operator needs power plants to reconstruct the grid. Black start capability (start-up without help from the grid) of hydropower plants at any time is a basic precondition for grid reconstruction. With sufficient transmission capacity storage hydro and pumped storage strengthen system stability and security of supply.

Hydropower - enabler for variable RES

Hydropower, particularly large storage hydro and pumped storage hydro, is a basic enabler for large-scale integration of variable renewables, such as wind and solar, into the power system and helps to improve efficient operation of thermal plants at low gradients, cutting their costly peak power production and CO_2 emissions.

Outlook and challenges

The electricity system of the 21st century will soon be in need of highly efficient, cost-effective large-scale system balancing. Storage hydro and pumped storage power plants are high-tech facilities that operate in a smart world closely with grid operation, other power plants, as well as loads and meet the interests of a highly effective demand-side management accordingly.

Snapshot - storage hydro and pumped storage plants (PSP)

Storage hydro takes advantage of existing large storage basins (reservoirs) with natural inflow of water. Typically, due to their size, they store energy for several days, months or even years. In periods of excess electricity generation from variable renewables, the flow of water from the reservoirs through the turbines can be stopped instantaneously and the water is kept as indirect energy storage in the reservoirs. Pumping is usually not required in these storages.

PSP pump water to a storage basin when there is excess power supply. PSP are mainly used to balance the grid as well as generation-driven fluctuations in supply (peak, off-peak). Typically, they store energy for several hours or days. They can be combined with natural storage, but are increasingly installed where natural storage is not possible.

The availability of stored energy will become increasingly important with the growing share of variable renewables in the electricity system. This energy can be used on extremely short notice for electricity generation at a time when demand is especially high and/or variable sources are not available. If storages are coupled to large variable renewables, through a sufficient grid system and interconnectors, they can provide a high degree of flexibility to the electricity system.

Policy recommendations

- Define harmonised grid fees for PSP on a European level.
- Establish a level playing field for storage hydro and PSP versus other storage technologies.
- Define PSP as part of the competitive, not the regulated arm of the industry.
- Establish incentives to invest in increased grid capacity and more interconnectors between storage hydro and markets in need of flexibility.
- Define adequate framework conditions as well as system responsibilities of all actors in a competitive market.
- The legal framework should permit more hydro projects and speed up administrative decisions for plant building

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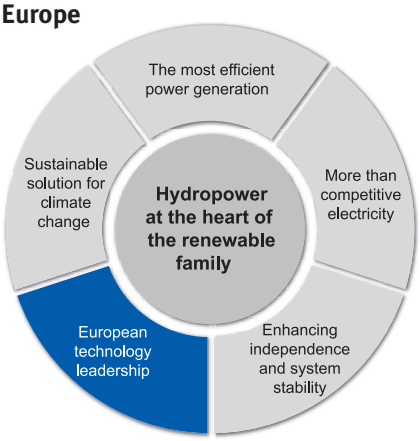
Hydropower
European Technology Leadership

Hydropower - crucial for a sustainable and wealthy Europe



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A core European industry

Hydropower technology is a core European industry. The three current global leaders in hydropower equipment technology are all EU based. Together, they account for more than 50% of the worldwide market. Some 50 other smaller scale equipment suppliers complete the picture of this very European industry with locally strong anchored traditions that led the European hydro equipment industry to account for more than two-thirds of the world market.

In addition, many of the leading universities and research centers in the field of hydropower are located in Europe where the improvement of the technology is fostered and cultivated.

The European hydro equipment industry accounts for several tens of thousands of highly qualified jobs, for millions of research and development expenses and for a strong contribution to European exports success. In addition to the equipment industry, hydropower operators also invest in R&D, top-level education and training for their thousands of employees.

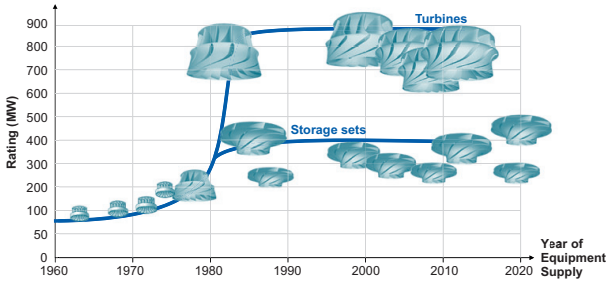
At a glance

- A core European industry with a two-thirds world market penetration which secures thousands of high skilled jobs in Europe
- Renewable and reliable for centuries to come
- Tailor-made and innovative system solutions for each and every hydropower site in the world

Reliable since centuries and for centuries to come

Hydropower technology has a long history. The first hydropower plants go back to the 19th century. The technology has developed towards ever-larger power output and higher performances and efficiency.

Turbine development



(Source: Hydro Equipment Association)

The lifetime of hydropower plants is by far the longest of all power generation technologies – on average 80 years and often longer.

Tailor-made and innovative system solutions for the energy system

Conditions at each site include head, flow, water amplitude, ecological and social surrounding, as well as operating pattern. Hydro is the only tailor-made energy technology that can respond to all such constraints.

The hydro equipment industry is continuously improving its technology to better respond to tomorrow's questions and requirements, as well as to meet the increasingly volatile and demanding electricity grid needs.

Integrated and site-specific solutions

The hydropower industry and operators have developed integrated solutions for civil works and machinery taking into account the environmental aspects of hydropower schemes. The requirements of the Water Framework and the Habitats Directive as well as the need for higher energy output have stimulated European competences in developing integrated hydropower solutions that are recognized worldwide.

Hydropower stations are built and upgraded to combine intelligent turbine and generator elements, multipurpose capabilities, (e.g. flood control devices and locks), river basin management and environmental enhancement measures.

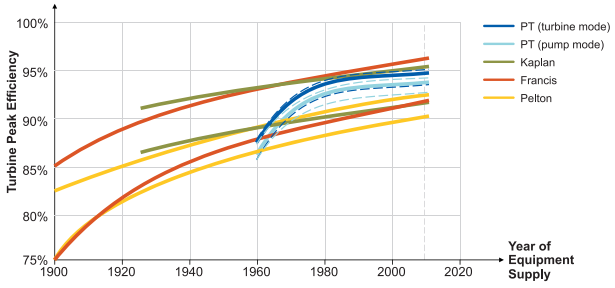
Researchers have carried out extensive research to improve the living conditions for fish, especially migrating fish. They have found different solutions for the various types of fish to facilitate their repopulation and their migration up- and downstream of dams. Examples of these solutions include ladders, passes and lifts. In addition to many measures that prevent fish from passing through the turbines (protective grids and ultrasound barriers, for example), research has resulted in "fish-friendly turbines," which increase the survival rate of fish in quickly spinning turbines.

Turbine technology

The pumped storage technology has evolved greatly in the past few years to absorb volatile electricity surpluses and meet the new grid requirements.

With fixed speed reversible units, variable speed pump turbine or ternary pump turbine units, pumped storage technology can change from pumping to generating mode and vice versa in up to 25 to 30 seconds and less. It is the fastest large-scale electricity storage technology.

Efficiency development



(Source: Hydro Equipment Association, Andritz Hydro)

In order to eliminate the risk of oil spills, the industry has developed oil-free solutions for blade runner hubs, which also allow easier maintenance, lower friction without lowering the bearing performance.

Modern turbine design using three-dimensional flow simulation tools allows not only better efficiencies in energy conversion by improved shape of turbine runners and guide/stay vanes but also results in a decrease in cavitation damages.

Utilizing small differences in height

A new challenge for hydropower is to capture the energy potential of water flows and sites with a very low height difference between the upper and lower water level (head). New technologies that can be installed at existing structures include irrigation dams, low head weirs, and ship locks. These newly available technologies open an important potential for future renewable and clean power generation.

Outlook and challenges

Having provided reliable services for more than 100 years, hydropower has faced challenges both technical and social, such as managing environmental and social impacts and public acceptance. This experience could easily be shared with other renewable energy technologies.

The European hydropower sector is pursuing its R&D efforts to better answer the steadily evolving challenges of the electricity market and societal expectations. Market developments will require significant steps forward in the following areas:

- highly dynamic operation of the units delivering frequency control
- adaptation of existing hydropower technologies to meet the ever-changing requirements of the electrical grid
- management and upgrade of existing facilities
- new materials and coatings
- environmental benefits and reduction in costs

Policy recommendations

- A strong hydropower market in Europe will enable the industry to keep its leadership in an increasingly competitive world where foreign players are supported by their respective governments.
- Policies have to support and guarantee the highest education standards for highly qualified jobs.
- Respective EU R&D and technology programmes should support hydropower in order to maintain the hydropower technology leadership in Europe.

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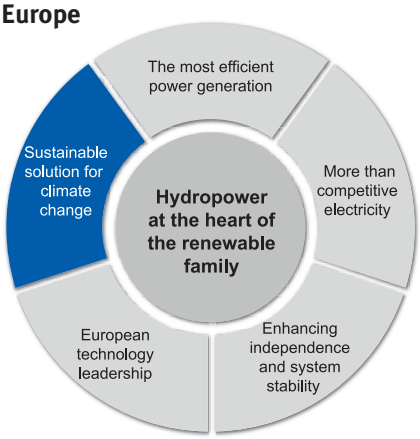
ELECTRICITY FOR EUROPE

Hydropower
Sustainable solution for climate change

Hydropower - crucial for a sustainable and wealthy Europe



Hydropower, in all its sizes, plays a key role in the European electricity system and still has an important development potential:

- It provides important quantities of low-carbon electricity at low costs, limits society's expenses for the movement towards a greener energy system and supports Europe's competitiveness in the global economy.
- Utilising hydropower's whole range of installations – from small to large, volatile to storage, decentralised to centralised – enables the reliable and cost-effective integration of growing wind and solar power.
- Hydropower reduces dependency on fossil fuel imports and creates value and employment in Europe.

Climate change

The 20th century was the warmest measured century so far, and temperatures still continue to rise. Experts say that an increase in the average temperature of more than two degrees Celsius relative to pre-industrialization level will have drastic consequences for people and the environment. According to the Intergovernmental Panel on Climate Change (IPCC), the main cause of ongoing climate change is burning fossil fuels, which produces greenhouse gases (GHG), such as CO_2. To prevent temperatures from rising more than two degrees the world must cut GHG emissions in half before 2050. Since the energy sector is responsible for more than 50% of global emissions, replacing fossil fuel with renewable energy sources and carriers (such as electricity) is crucial.

At a glance

- Hydropower plays a unique role in both mitigation of and adaptation to climate change
- Hydropower has a very low carbon footprint
- Hydropower contributes to EU climate targets
- Hydropower development follows strict sustainability criteria
- Hydropower offers water management opportunities

Unique role in mitigation and adaptation

With its low-carbon footprint, hydropower is crucial in mitigating climate change. It can provide significant volumes of renewable low-carbon electricity, both base and peak load. Storage hydropower provides quick and cost-efficient flexibility – necessary with the increasing share of other variable renewable sources. Tapping the whole spectrum of hydropower – small-scale to large-scale, centralised and decentralised, run-of-river and storage - allows us to quickly integrate other renewable sources.

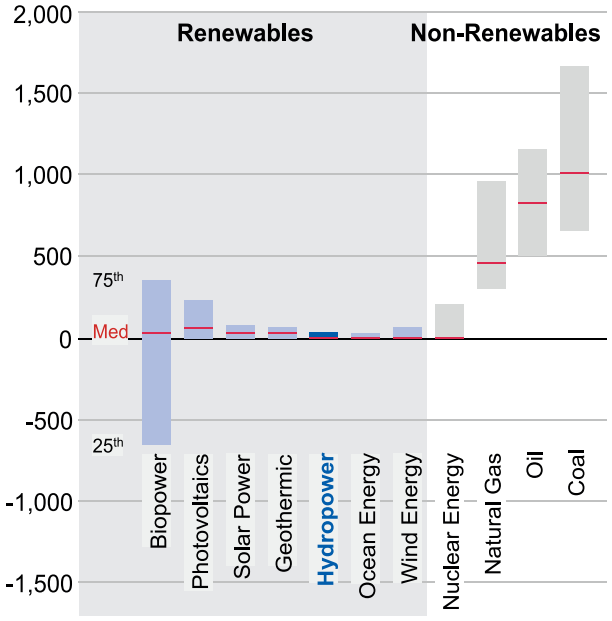
How well Europe can adapt to a changing climate depends on our ability to react to, and lower the impact of, extreme weather events. Hydropower reservoirs help ensure supply when more variable sources cannot deliver. Hydropower plants with storage capacity help us avoid flood disaster, and provide water in dry seasons. Integrated water management will become an important tool in adapting to climate change.

Low carbon footprint

The carbon footprint accounts for the total quantity of GHG emitted over the lifecycle of a product or a process. A low-carbon footprint is essential if we are to successfully transition to a low-carbon future. Examining the lifecycle GHG emissions for different electricity generation technologies shows so far that hydropower plants have the lowest carbon footprint. Emissions from hydropower are caused indirectly during the construction phase and GHG emissions can also occur from some reservoirs.[1] Fossil-fuelled electricity generation produces emissions continuously during plant operation and has the highest carbon footprint, at 840 g CO_2/kWh for the ENTSO-E mix.

1 Methane emissions from some reservoirs have been registered. It is important to identify net emissions in this context. When IPCC assessed emissions from reservoirs, the impact of hydropower was considered to be very small (IPCC; SREEN 2011).

Lifecycle GHG emissions, g CO2 eq/kWh

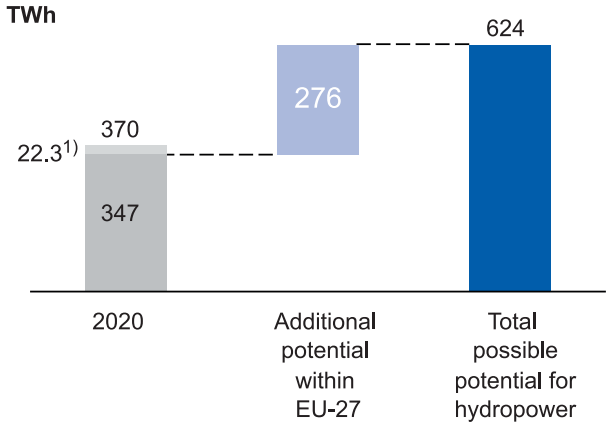


(Source: IPCC 2011, Summary for Policymakers)

Contributes to EU climate targets

As of 2010, hydropower provided 16% of electricity in Europe, representing 67% of all renewable energy. According to the various national renewable action plans, we can expect an increase of only 20 TWh until 2020. However, the technically feasible potential for hydropower in Europe is significantly higher. The higher the share of hydropower in the electricity mix, the more CO2 emissions we can avoid. This means that hydropower is crucial in order to reach the ambitious EU 20-20-20 targets.

Hydropower's potential in Europe



1) According to national renewable action plans

Strict sustainability criteria are applied

Making use of the energy in water has an impact on water systems and the environment. Modifying a water body will directly affect those who are near the influenced ecosystem. As for all construction projects, we must thoroughly evaluate the short- and long-term costs and benefits for society, environment and economy before construction work starts.

In the case of hydropower plants, including all stakeholders in the planning process can improve a region´s value from both a socio-economic and environmental point of view. The industry is developing guidelines that will optimize all the impacts of hydropower. As well, criteria for sustainable development of hydropower are being developed, improved and increasingly applied.

Offers water management opportunities

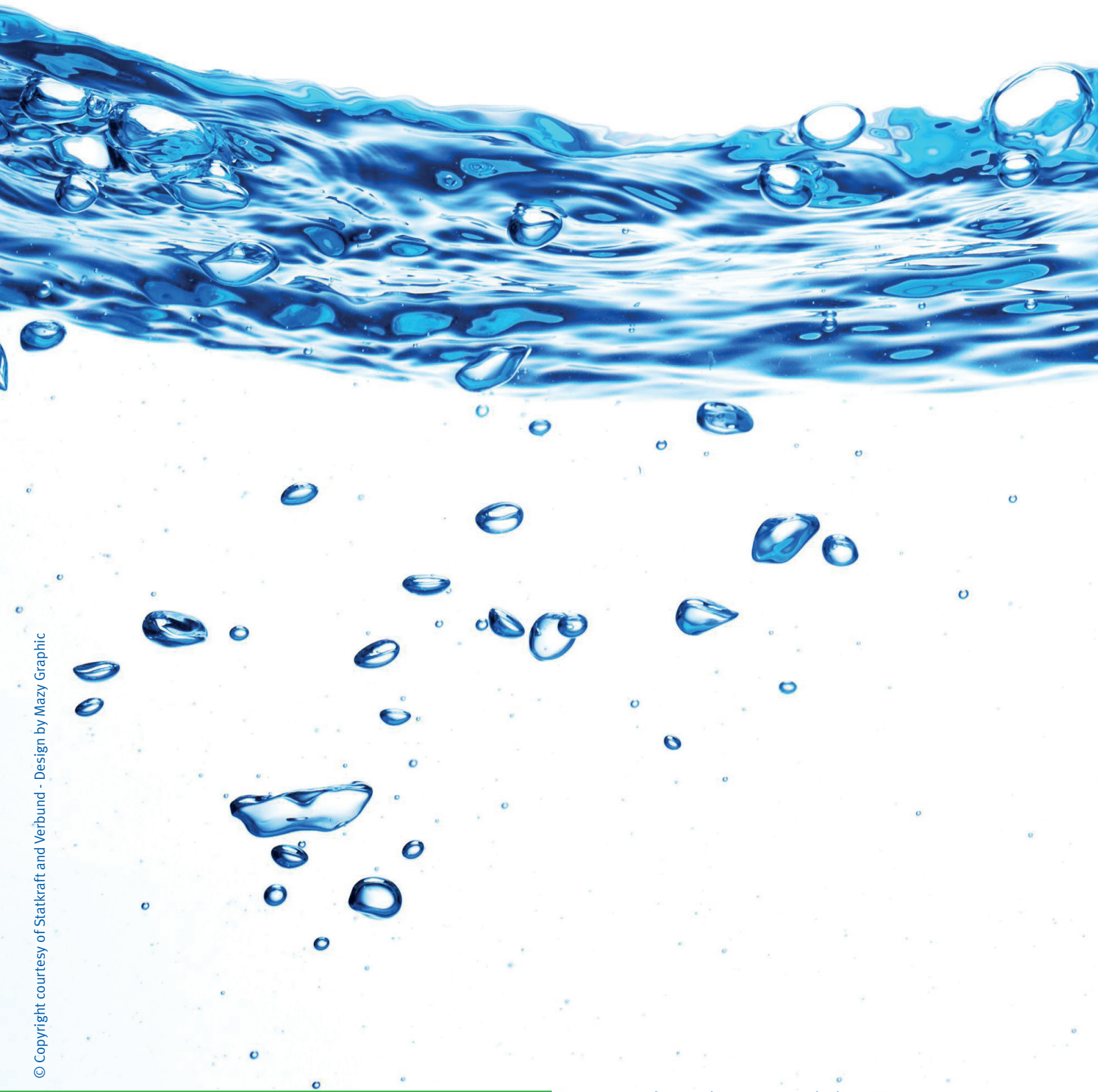
With ongoing climate change, extreme weather conditions are more frequent, leading to both water scarcity and floods. Hydropower offers us the ability to manage water through reservoirs, dams and waterways. Creating reservoirs is often the only way to adjust the uneven distribution of water in space and time. So-called multipurpose hydropower can deliver on a broad spectrum of services, i.e. irrigation, water supply, flood control, recreation, etc. and will be a key tool for water management.

Outlook

Hydropower's contribution to the challenge of climate change is key. All energy sources affect the environment and climate, measured by carbon footprint, water footprint, and other indicators. The hydropower industry is willing to develop and continuously improve standards for balancing the different social, economic and environmental goals. As we face the severity of climate change consequences and the political targets for combating this threat, it is important to weigh the different environmental impacts against each other, and review further hydropower development potential. This could turn the technically possible into the economically and environmentally feasible. Increasing renewables in Europe will require flexibility and storage capacity to compensate for variable electricity production. Reservoir and pump storage hydropower in their diversity can provide that flexibility and capacity.

Policy recommendation

- Base policies on thorough impact assessments in order to secure a consistent EU energy, environment and climate policy (e.g. a possible effect of the implementation of the EU Water Framework Directive is a decrease in the hydropower potential, although water quality in Europe will not be improved by lowering the potential).



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