HYDROPOWER EUROPE

POWERING EUROPE IN A SUSTAINABLE WAY

STRATEGIC INDUSTRY ROADMAP

EXTENDED EXECUTIVE SUMMARY BROCHURE

NOVEMBER 2021

www.hydropower-europe.eu

The HYDROPOWER EUROPE project is built on the ambition to achieve a research and innovation agenda and a technology roadmap for the hydropower sector, based on the synthesis of technical and transparent public debates through a forum that gathers all relevant stakeholders of the hydropower sector.

The present brochure is an extended executive summary of the Strategic Industry Roadmap. The full report of some 140 pages can be found on :
www.hydropower-europe.eu

Photos provided by EDP.

Contact us:

contact@hydropower-europe.eu
@euhydropower
/company/hydropower-europe/

Disclaimer

The HYDROPOWER EUROPE Forum is supported by a project that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 826010

Contents

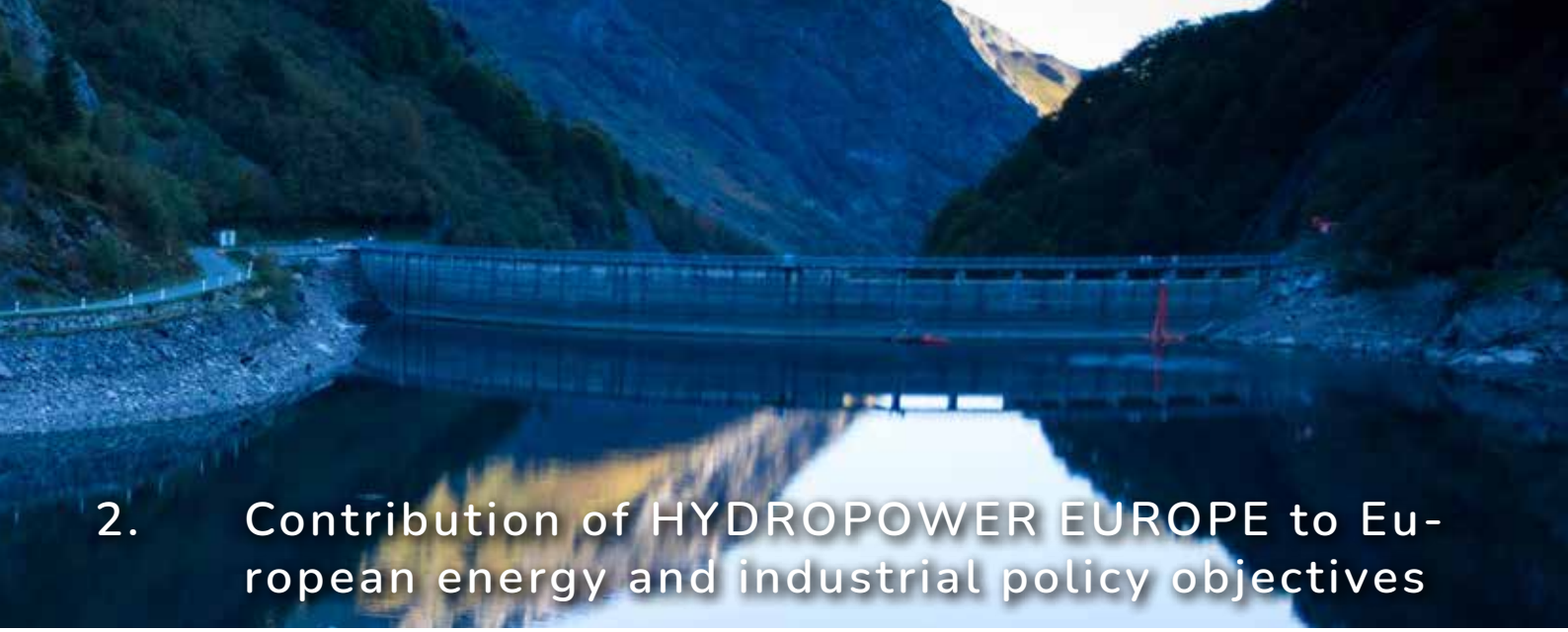
List of Boxes

1. Introduction – A vision for hydropower in Europe

The ambitious plan for the energy transition in Europe seeks to achieve a low-carbon, climate-resilient future in a safe and cost-effective way. The uptake of renewable energy sources is consistently growing in many European countries, boosted by the "Fit for 55" package in order to reduce net greenhouse gas emissions of up to 2030 by at least 55 percent compared to 1990 levels. However, this uptake of renewable energy sources creates new obstacles, such as difficulty in aligning electricity generation with demand. Fortunately, hydropower, which is still the most important renewable energy resource, already supports integration of solar and wind energy into the supply grid through flexibility in generation as well as its high potential for storage capacity. These services are, and will be, indispensable on the path to achieve the desired energy transition in Europe and worldwide. Hydropower has all the characteristics to serve as an excellent catalyst for a successful energy transition. Our vision is that Europe will require a more flexible, efficient, environmentally and socially acceptable increase in hydropower generation to achieve the new European energy system (BOX 1).

Increasing hydropower production through the implementation of new sustainable, multipurpose hydropower schemes and by using the hidden hydro potential within existing infrastructures	Increasing the flexibility of generation from existing hydropower plants by the adaptation and optimisation of infrastructure and equipment combined with innovative solution\s for the mitigation of environmental impacts	Increasing storage through the heightening of existing dams and construction of new reservoirs, which must ensure not only flexible energy supply, but which also support food and water supply and thus contribute to the Water-Energy-Food Nexus and achievement of the Sustainable Development Goals of the United Nations	Strengthening the contribution of flexibility from pumped-storage power plants, by developing and building innovative arrangements in combination with existing water infrastructures

Box 1 - The HYDROPOWER EUROPE vision



2. Contribution of HYDROPOWER EUROPE to European energy and industrial policy objectives

The HYDROPOWER EUROPE forum has brought together all relevant stakeholders of the hydropower sector including workshops and online discussion groups in order to share knowledge at a European level, to support the discussion with up-to-date information and to identify research and innovation needs and priorities.

The Forum has produced a synthesis of expected research developments and research needs for the coming decades in a Strategic Industry Roadmap (SIR) and Research and Innovation Agenda (RIA) for the hydropower sector, targeting an energy system with high flexibility and renewable share.

The Research and Innovation Agenda (RIA) outlines the research and development actions required for hydropower to overcome technical and environmental barriers and the Strategic Industry Roadmap (SIR) outlines the strategic actions to overcome non-technical barriers to projects.

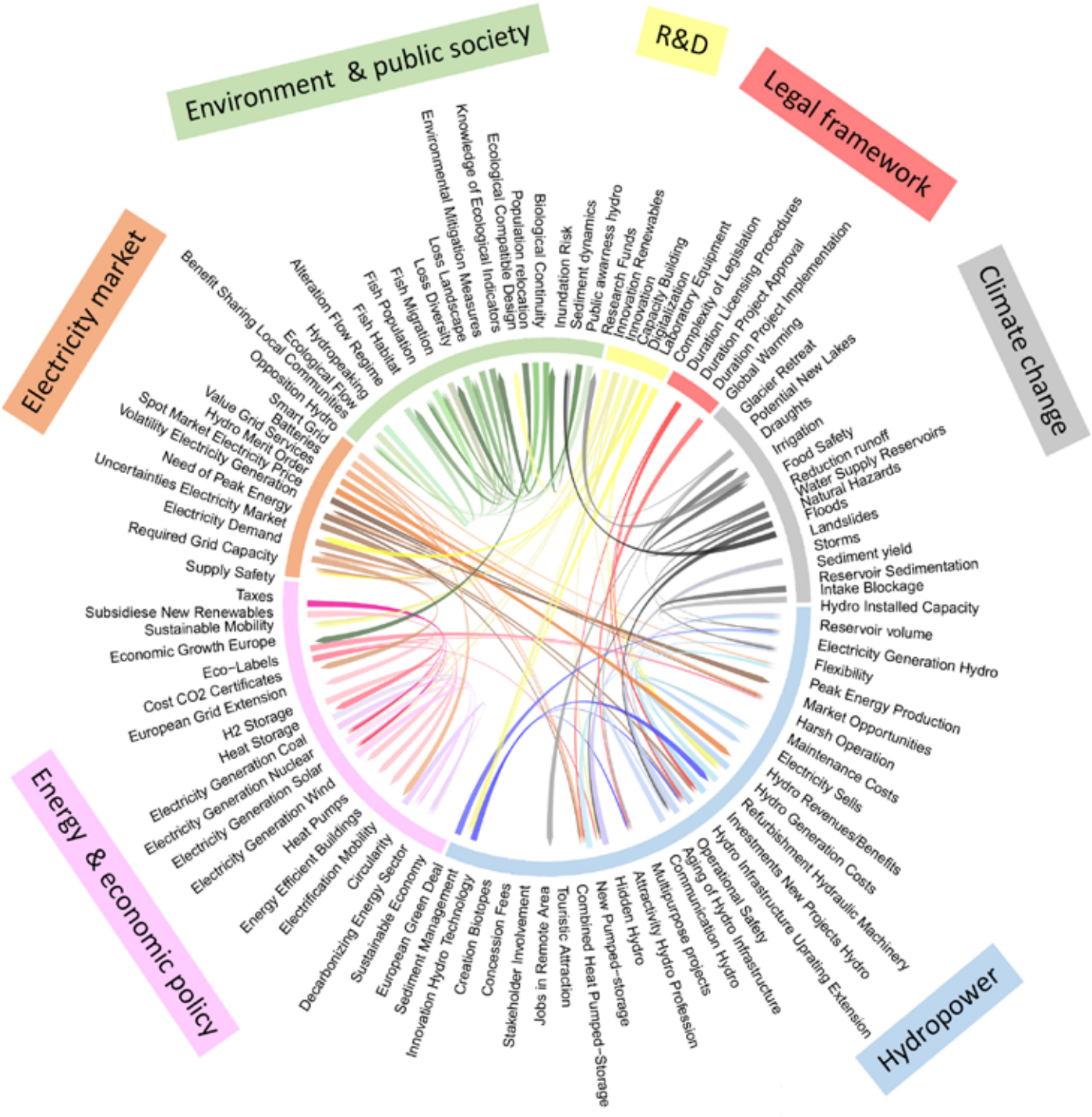
The goal of the Strategic Industry Roadmap (SIR) is to provide recommendations for European regulators, policymakers, civil society, NGOs, technology developers, planners, utilities and system operators to discuss together and to take balanced decisions on further hydropower development to enable the new energy system to benefit fully from the storage and flexibility potential of this valuable resource.

3. The process of building the Strategic Industry Roadmap

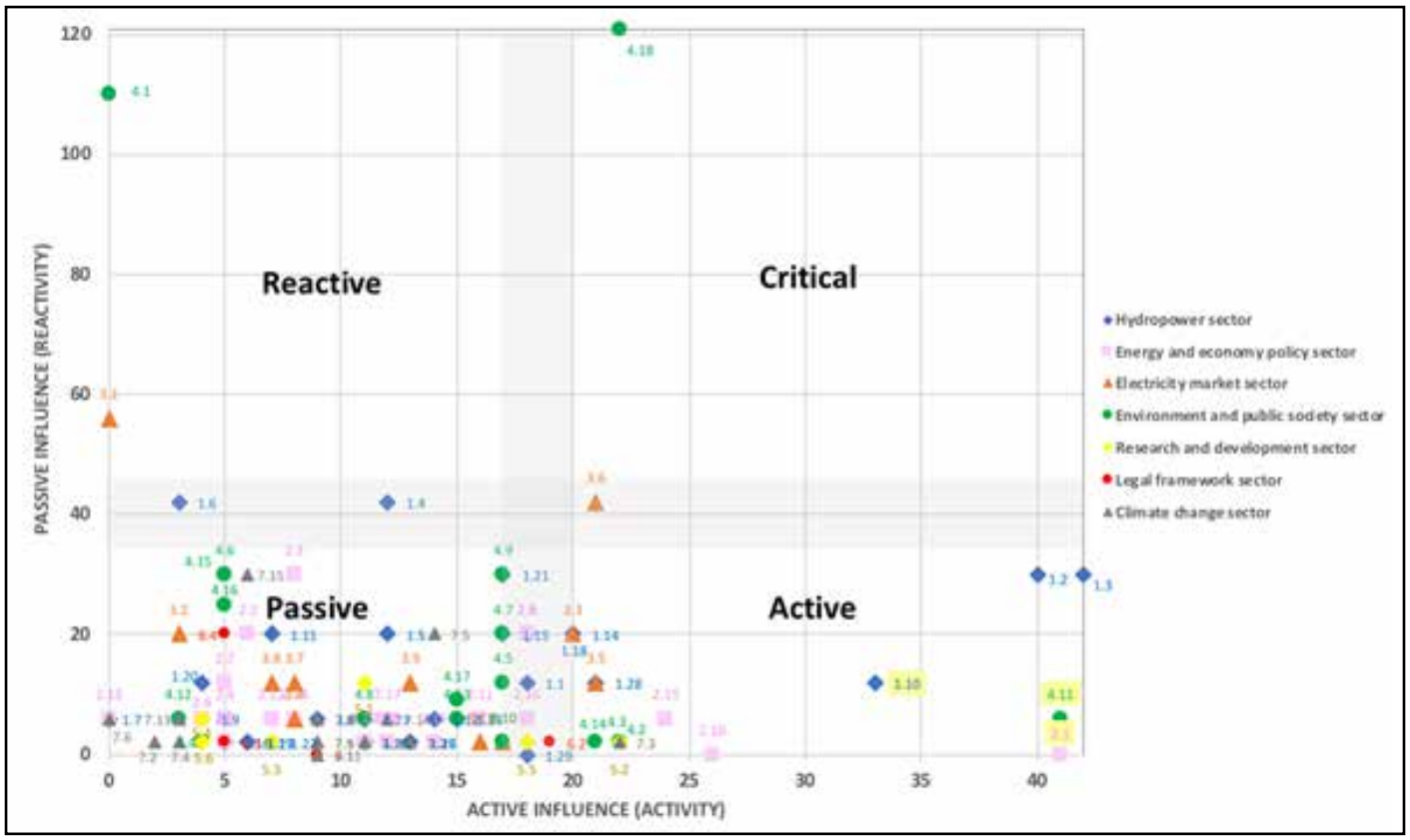
Through an extensive programme of review and consultation (from 2018 to 2021) addressing the whole hydropower sector and gathering some 600 stakeholders, the HYDROPOWER EUROPE Forum has developed a first edition of the Strategic Industry Roadmap (SIR). An initial online questionnaire, completed in February 2019, shaped 7 strategic directions. During three regional workshops in 2019 (Northern, Alps and Southern parts of Europe) the strengths, weaknesses, opportunities and threats for hydropower in Europe were analysed. Based upon a first wider stakeholder consultation process that took place from August to November 2019, the critical factors for future hydropower deployment were identified and analysed with the help of a comprehensive complex system analysis of hydropower in Europe (HYDROPOWER EUROPE, 2020). A list of 103 factors were identified which were considered relevant for the comprehensive complex system analysis. With these factors a network representing the hydropower market in Europe was built. A circular visualisation of the activity of the factors that are influencing the whole network is shown in Box 2.

Through a matrix analysis of the interconnection of all factors within the network, their activity and reactivity could be determined (Box 3). Two important categories for the active or critical factors have to be distinguished: those that can be controlled directly by an action and those that are not controllable. The controllable factors can be used as a lever and are therefore important for the prioritisation of any actions.

The priority categories of the strategic actions obtained from the consultation process and feedback of the Consultation Expert Panel (CEP - a group of 34 experts representing all sectors of the value chain), could be validated by the results of the global complex system analysis, by comparing them with the controllable, active factors having a high impact level on the network describing the hydropower system in Europe.



Box 2 - Circular visualisation of network factors showing their activity (influencing intensity) for the sectors Hydropower, Energy and economic policy, Electricity market, Environment and public society, Research and development, Legal framework and Climate change

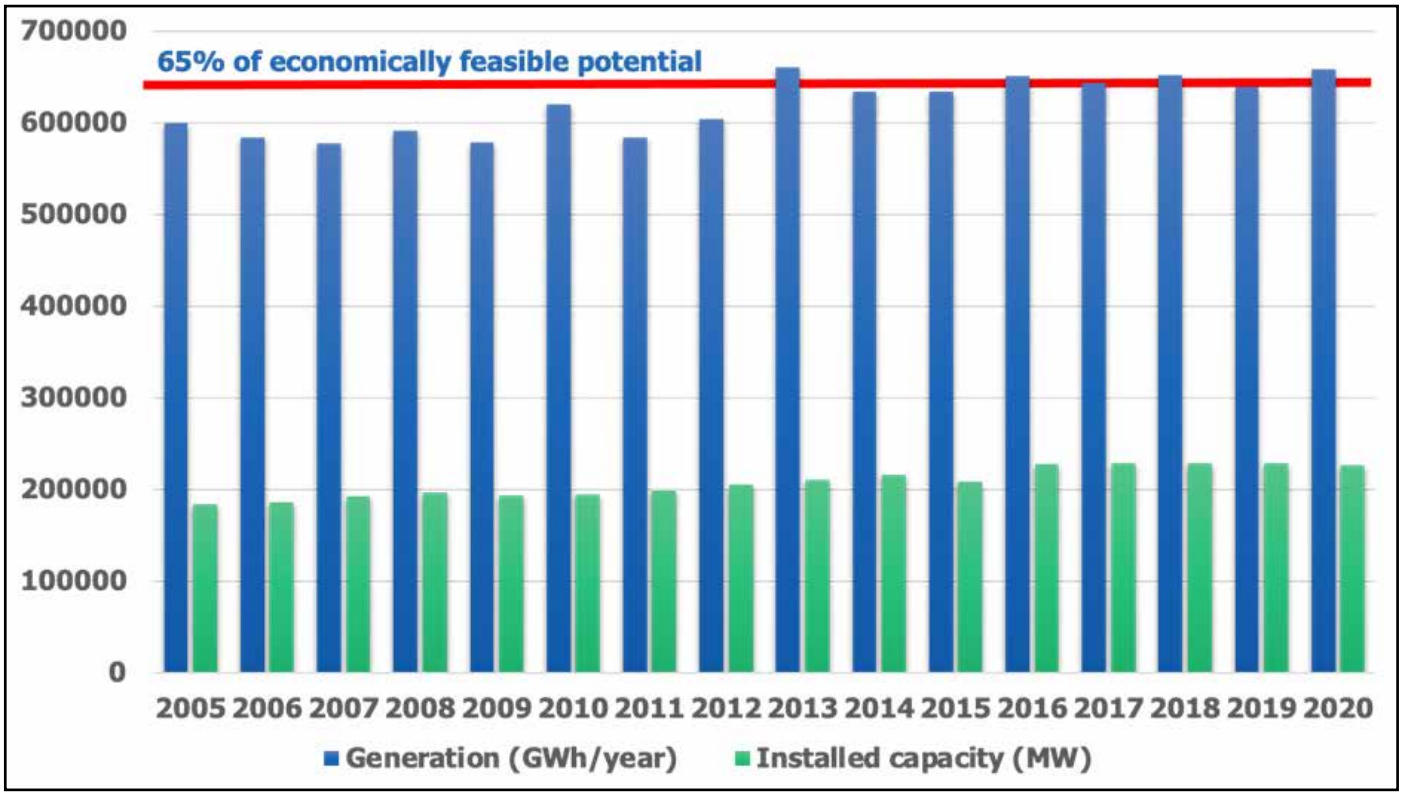


Box 3 - Result of the matrix analysis of the network representing the complex situation of hydropower in Europe. Key critical factors: Public Awareness Hydro (4.18) and Volatility of the Electricity Generation (3.6). Key active factors: Electricity Generation Hydro (1.3), Environmental Mitigation Measures (4.11), European Green Deal (2.1), Reservoir Volume (1.2) and Hydropower Benefits (1.10).

In the second wider stakeholder consultation process the most promising strategic actions for hydropower deployment in Europe were refined and ranked by priority. Finally, the Consultation Expert Panel (CEP) consolidated and validated the prioritisation of the key strategic directions needed to support the role and development of hydropower during a total of four workshops. These key strategic direction recommendations should help hydropower to deliver the reliable and secure provision of affordable electricity, whilst meeting environmental goals as well as contributing to the European Green Deal, as a catalyst for the energy transition.

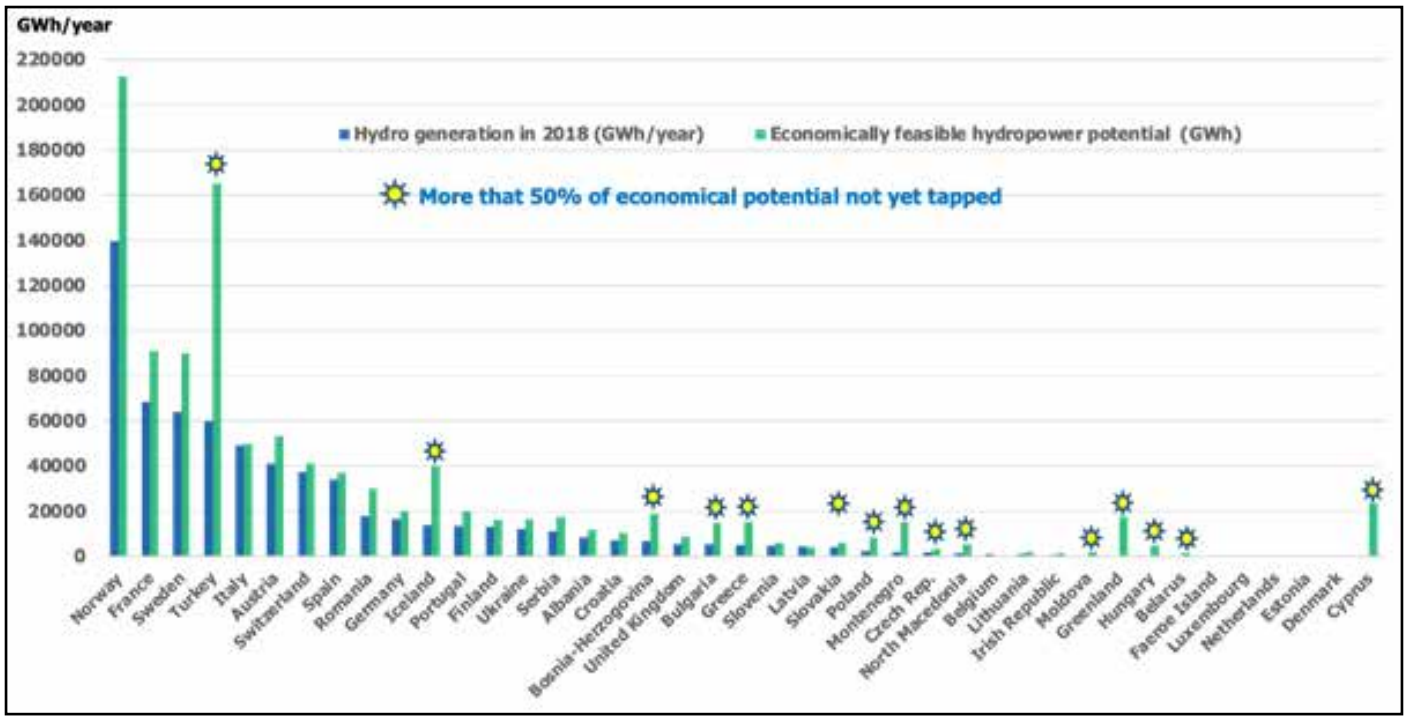
4. Current situation of hydropower in Europe

Since the late 19th century, hydropower has developed as a clean, safe, reliable and inexpensive source of power (short-term) and energy (long-term). Today, more than 180 countries worldwide utilise hydropower and in Europe (EU-28) hydropower generation corresponds to about 12% of the European net electricity generation and 36% of electricity generated from renewable resources (Eurostat, 2019). In an average hydrological year, hydropower generation reaches almost 650 TWh and this arises from using only 65% of the economically feasible hydropower potential within Europe including Turkey (Box 4). Since 2013 annual production has stagnated near 650 TWh and the total installed capacity near 250 TW. It should be noted that in principle the yearly hydropower production is influenced by the hydrological situation each year.



Box 4 - Evolution of yearly production and installed capacity of hydropower in Europe including Turkey since 2005 (according to Hydropower & Dams World Atlas 2021).

Box 5 shows the situation for hydropower use versus untapped potential in different countries within the European region. It can be noticed that many countries still have considerable potential for hydropower development. The countries highlighted in Box 5 have developed less than 50% of their economically feasible potential (assuming market conditions demand for it).



Box 5 - Generation and extension potential of hydropower in countries in the European region (according to Hydropower & Dams World Atlas 2018).

Hydropower is technically mature and is usually economically competitive under liberalised market conditions. It also provides significant benefits to the whole power system; in fact, the fast response capabilities provided by hydropower reservoirs and pumped storage plants provide critical energy and flexible power to electricity networks with considerable long-term reserves, helping to match fluctuations in electricity demand and supply from intermittent and less flexible electricity sources. Moreover, since hydropower is situated at the crossroads of two major issues for development – water and energy – hydropower reservoirs can often deliver services beyond electricity supply, such as the mitigation of freshwater scarcity by providing security during low flow and drought conditions and for drinking water supply, irrigation, flood control, fish farming or navigation services. Furthermore, many reservoirs in Europe have created new biotopes and have become a tourist attraction with high potential for leisure activities. Accordingly, multipurpose hydropower projects may have an enabling role beyond the electricity sector to secure freshwater availability and thus contribute directly to the Water-Food-Energy Nexus approach.

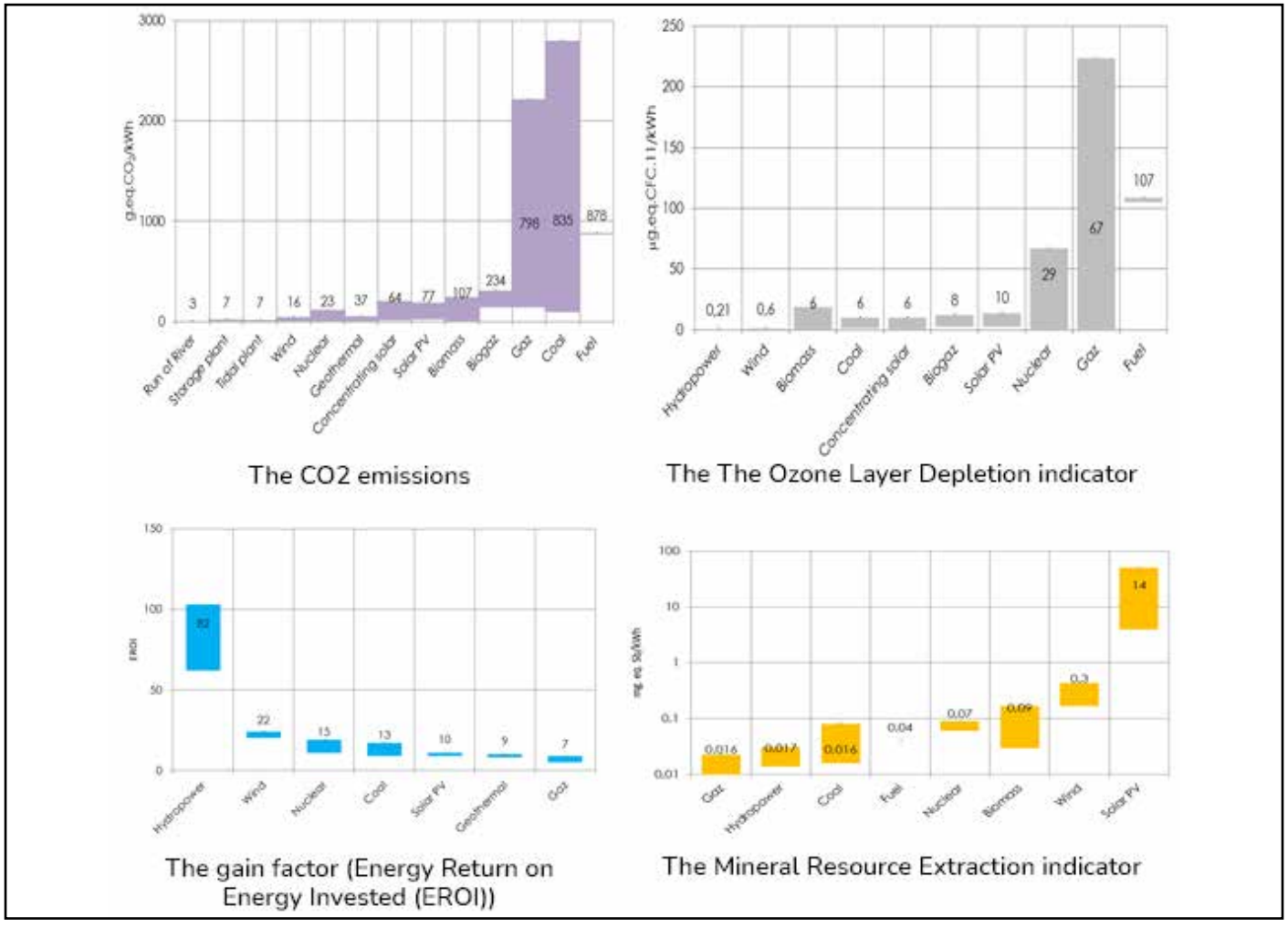
The next generation of hydropower professionals has a huge responsibility in preserving a centenary legacy of excellence, not only in Europe but also for the worldwide market. To successfully achieve these goals, it is essential that the industry (i.e. promoters, consultants, engineers, project/asset managers, etc.) embraces a structured approach to knowledge management and organisational culture to encourage its creation, transmission and retention.

5. Hydropower is a robust pillar of the 2050 net zero economy in Europe and in the world

Hydropower is the most climate friendly form of renewable energy.

Climate change due to global warming is the biggest threat to humanity in the 21st century. If we do not address the causes of climate change in time, communities across the world stand to face multiple intensifying climate hazards that pose a broad threat to humanity. To protect our world from these climate hazards, our carbon-based energy consumption has to be reduced and our energy system has to be decarbonised.

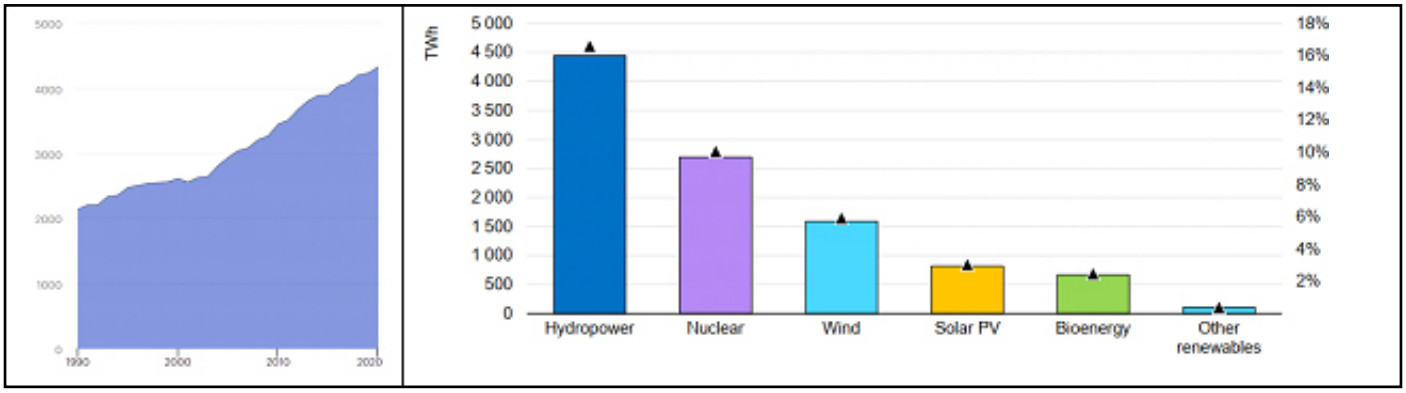
Fortunately, hydropower is a renewable energy source providing the lowest Global Warming Potential, the lowest Ozone Layer Depletion indicator, the lowest Mineral Extraction Indicator and the best Energy Return on Energy Invested. Consequently, hydropower has a significant role to play in climate change mitigation and attenuation (Box 6).



Box 6 - Significant contribution of hydropower in climate change mitigation (CIRAIG, 2014)

Hydropower is the first global form of renewable energy

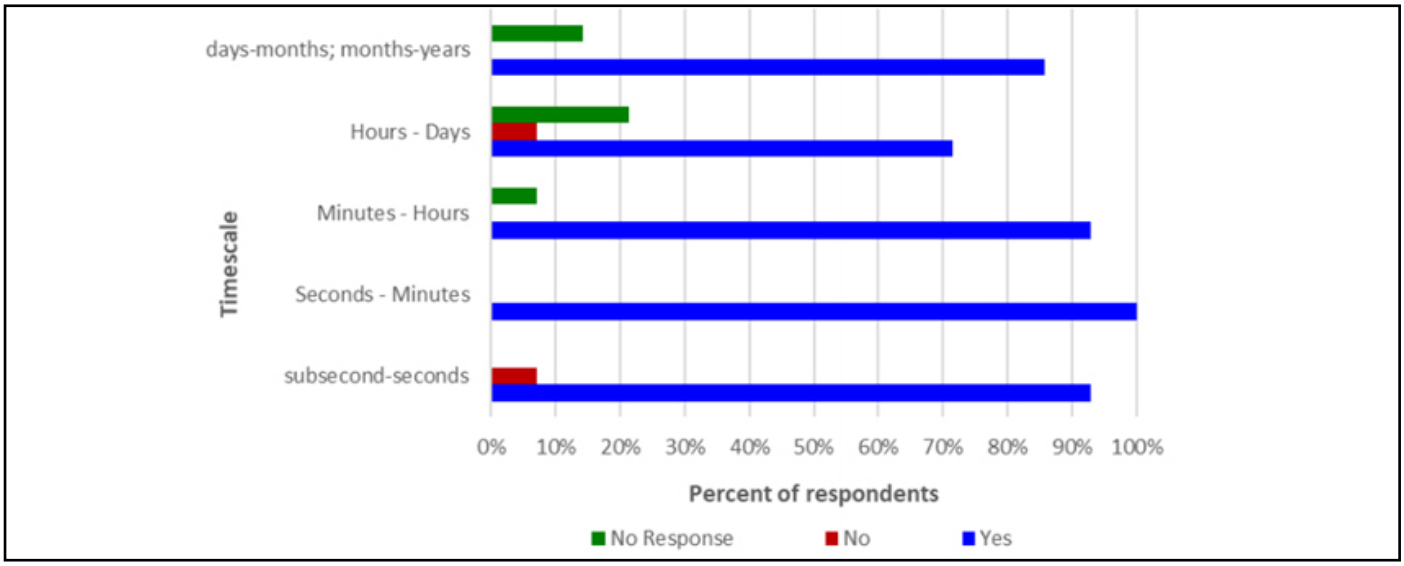
In 2020, hydropower supplied 16% of global electricity generation. In 2020, hydropower is the largest global form of renewable energy resource. Hydropower's contribution to electricity generation is larger than that of all other renewable resources combined, including wind, solar PV, bioenergy and geothermal (Box 7).



Box 7 - Global generation of hydropower (left). Low carbon generation by technology and shares in global electricity supply (right) from IEA (2021)

Hydropower is an enabler, integrating solar PV and wind generation

The growing share of variable renewable resources increases the need for flexibility in supply. With low operational costs and large storage capacities, existing reservoir hydropower plants provide the most affordable source of flexibility in supply today. In a lot of countries, hydropower offers about 90% of the supply flexibility needed by system operators (Box 8). Global electricity storage is underpinned by hydropower dams: 1500 TWh is generated by hydropower power plants and 8.5 TWh stored by pumped storage hydropower (IEA, 2021). Our electricity system relies on hydropower. Today, the energy transition relies on hydropower.



Box 8 - Responses to the question as to whether hydropower provides flexibility services across timescales (IEA, 2021)

Hydropower secures our electricity networks

Pumped-storage hydropower is the only renewable technology providing long duration storage and delivers almost 85% of the world's total installed electricity storage capacity of 190 GW. Hydropower is a low-cost renewable energy resource which avoids CO2 emissions and energy imports, secures the electricity network and strengthens EU independence and recovery. In addition, small hydro turbines secure power to some of the most remote points in Europe.

Hydropower is a driver of national and regional economies

In the 19th century, hydropower boosted the electrification of cities and the development of industry in western countries. In the middle of the 20th century, hydropower boosted the industrial and economic recovery of Western countries after the Second World War. At the beginning of the 21st century, hydropower boosts the development of emerging economies in Asia and Africa, which are developing their untapped hydropower potential to meet growing demands and increasing access to electricity (Box 7).

6. Strategic actions required for the development of hydropower as a catalyst for the energy transition in Europe

There is a gap between hydropower services to society and policy support

In contrast to the huge contribution to society, and although hydropower has all the features which the European Union needs for a sustainable, secure and competitive energy supply, there is little emphasis on the role that hydropower could play in the future European energy system.

The Strategic Industry Roadmap has the ambition to fill the gap

An innovative roadmap built from lessons learnt from unsuccessful projects recommends strategic steps for bridging the gap between parties and convincing society that hydropower delivers the reliable and secure provision of affordable electricity whilst also meeting environmental goals. The prioritised strategic actions are shown in the following boxes. These are all high priority actions.

According to the global system analysis (HYDROPOWER EUROPE, 2021), two critical factors which are influencing the success of hydropower development in Europe in a dominant way, namely the "Volatility of the Electricity Generation" and the "Public Awareness Hydro". The first one is not controllable. However, the "Public Awareness Hydro" can be influenced directly by each of the high priority strategic actions increasing public acceptance, as listed in Box 9. These may be considered according to the following priority actions:

1. Increase public awareness with communication and dissemination
2. Develop best practices for sustainability for successful projects and win-win situations
3. Increase security, decentralization and independence of the European energy system with PSH
4. Give a collaborative platform to the hydro sector.

Amongst the most controllable active factors, there are "Environmental Mitigation Measures" and "European Green Deal". All of the strategic actions on "Environmental Mitigation Measures" (Box 10) can be considered under the following priority actions:

1. Collect best practices for sustainability and biodiversity protection
2. Increase the knowledge on environmental impacts
3. Develop innovative compensation measures for the protection of biodiversity
4. Develop comprehensive approaches allowing compromises.

Amongst the first highest level, controllable active factors, there are also "Electricity Generation Hydro" and "Reservoir Volume" which actively influence the future of hydropower deployment. They can be increased in the short term by upgrading power plants, dam heightening and by effective sediment management of current facilities and in the mid-term by installing new hydro capacity, new multipurpose projects and last but not least new pumped-storage.

The implementation of new capacity (power and storage) should be boosted by the high priority strategic actions supporting a better hydropower deployment (Box 11), adapting regulations to the energy transition (Box 12), investing more

thanks to new business models (Box 13), and simplifying approval procedures and legislation (Box 14). Reservoir capacity and water uses also need a future resilience to climate change (Box 15). Reservoir volume is mainly depending upon the most reactive factors also: “Flexibility” and “Markets opportunity”. Consequently, it will be more difficult and uncertain to be successful with all of these actions. It means that hydropower needs a strong collective strategic framework to be adopted, for instance comprising:

1. Improvement of flexibility markets
2. Best practice for investing under uncertainties
3. Development of a more pertinent regulation framework.

Finally, a critical issue is also capacity building. The need for training and education in order to maintain and enhance hydropower knowhow in the long-term has to be identified.

Priority	Box 9 - Strategic Actions to Increase Social Acceptance
Very High	Collect a catalogue of examples of best practice of successful multi-purpose projects creating a win-win situation between all stakeholders
Very High	Develop innovative approaches to address environmental issues and biodiversity protection with comprehensive approaches allowing compromises
Very High	Increase awareness of European citizens of the importance of hydropower development
High to Very High	Develop methodologies to create win-win situations between all stakeholders of multi-purpose projects (linked to a catalogue of best practices)
High to Very High	Development of regional multi-stakeholder forums
High to Very High	Increasing the availability of information on the environmental impacts, the energy benefits and other water uses arising from hydropower plants
High to Very High	Development of tools and approaches to increase social acceptance
High to Very High	Development of strategies for better communication of the value of hydro for society
High	Developing strategies on how to successfully address issues related to hydropower in cultural heritage sites and protected areas
High	Giving a single voice to the sector within Europe

Priority	Box 10 - Strategic Actions to Develop Environmental Mitigation Measures
Very High	Develop sustainability best practices with the help of international associations (IHA, ICOLD, World Bank, etc) including taxonomy for sustainable finance and biodiversity strategies
Very High	Develop sustainable sediment management strategies for ensuring sustainable reservoir capacity and sediment dynamics in rivers
Very High	Protection of biodiversity in hydropower projects by innovative compensation measures
Very High	Collect experience with Water Framework Directive and lessons learnt solutions to maintain or improve water quality in rivers and reservoirs
Very High	Provide hydropower with environmental innovations thanks to large investments, such as investment in flexibility, to comply with the European Green Deal
High to Very High	Collect a catalogue of best examples of biotope creation and restoration through uprating of existing hydropower or new projects
High	Develop and share increased knowledge on ecosystems and how hydropower may affect these
High	Develop innovative determination and planning of environmental flow releases
High	Develop new methods to assess and attenuate the effects of new and harsher operation regimes on aquatic ecosystems

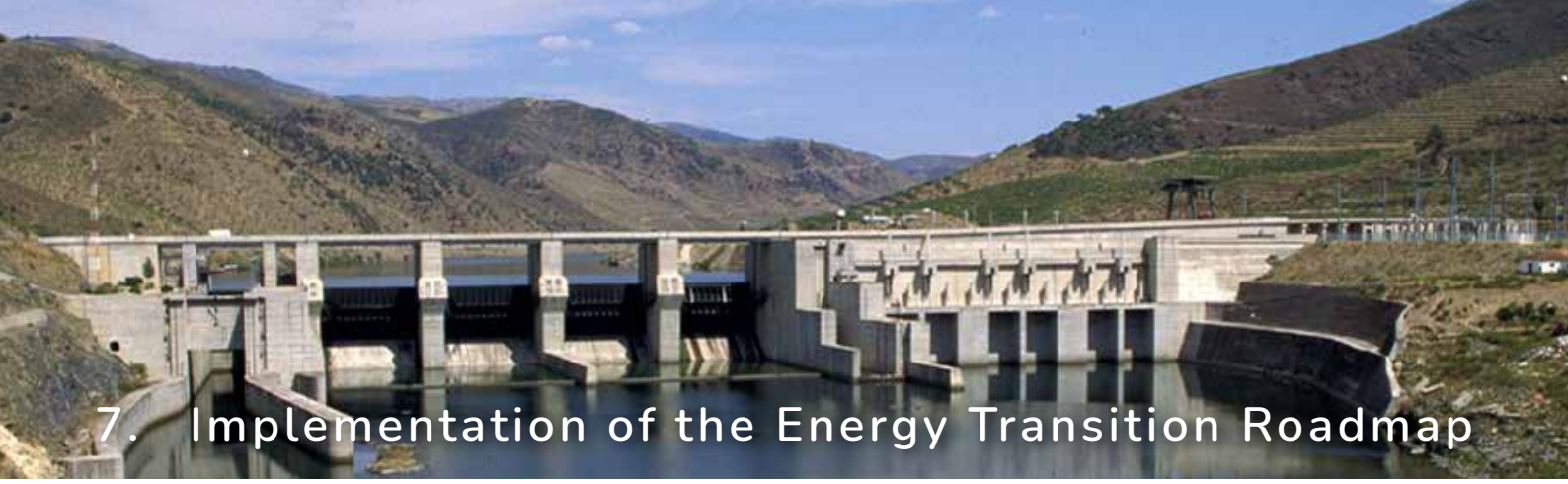
Priority	Box 11 - Strategic Actions to Better Deploy Hydropower
Very High	Solve the “missing money” issue with adequate remunerations in future flexibility markets and considering storage as a service
Very High	Contribute to supply security, decentralisation and independence of the European energy system with pumped storage hydropower
Very High	Increase resilience by mitigating the impact of ageing and maintaining the high safety level of power plants
High to very High	Develop technical, social and environmental innovations for supporting the European Green Deal

Priority	Box 12 - Strategic Actions to Adapt Regulation to Energy Transition
Very High	Research and development for regulation improvements (increase CO2 cost, abolishment of the double taxation of pumped storage hydropower, concessions, safety, taxes, etc)
Very High	Development of a more stable regulation framework which promotes green renewable power with a fair price, tax policy and subsidy model designed for a level playing field amongst different technologies, based on a comprehensive analysis of the carbon footprint and life cycle

Priority	Box 13 - Strategic Actions to Increase Investment thanks to New Business Models
Very High	Research and development for mechanisms of enhanced revenues and market structures (identification of market mechanisms and regulatory frameworks necessary to create attractive investment conditions)
Very High	Research and development for re-evaluation of the market design and its ability to provide signals for investments and electricity supply security
Very High	Research and development for identification of new financing schemes (green bonds, non-conventional project evaluation approaches, portfolio/bundling approach, long term investments, etc.)
High	Development of an efficient market model suited to the neutral carbon energy system where flexibility and storage are properly valued (CO2 market price, emission trading system)
High	Assessment of strength and opportunities of hydropower under fully liberalised conditions, without distortion by subsidies suited to new carbon-neutral technologies and fair evaluation and remuneration of flexibility and storage services
High	Compiling, disseminating and implementing best practices for investors for hydropower development under uncertainties
High	Providing details of the business case for new hydro generation under uncertainties

Priority	Box 14 - Strategic Actions to Simplify Approval Procedures and Legislation
Very High	Enhanced dialogue between civil society and the European commission to define appropriate ways and tools to deploy more hydropower and to balance environmental protection legislation and climate friendly energy legislation
High	Simplification and reappraisal of licensing processes in order to favour uprating of existing hydropower with valorisation of investment

Priority	Box 15 - Strategic Actions to Improve Climate Resilience and Mitigate the Impacts of Climate Change
High to Very High	Design / modification of new large, multi-purpose reservoirs built for natural hazard protection used for energy storage and power supply, creating new sources of revenue and payback for investments
High to Very High	Collect a catalogue of how hydropower reservoirs can attenuate the effects of climate change under regional climate conditions
High to Very High	New approaches to identify, assess and manage climate-related risks so that operators and developers are prepared for the impacts and opportunities that may arise from climate change



7. Implementation of the Energy Transition Roadmap

Through this substantial programme of consultation, the HYDROPOWER EUROPE Forum has defined three key strategic directions needed to support the role and development of hydropower:

A. Providing economic and legal support for an effective hydropower contribution to flexibility and storage within the new electricity system in the Net Zero Economy.
B. Raising public awareness, increasing societal resilience and local employment.
C. Preserving biodiversity and improving river ecosystems.

A. Market, political and legal pathways to the 2050 net zero energy system

There is a large consensus concerning the necessity to re-design the electricity market. A new energy system, where renewable energies sources will only be used, needs a n**ew market model**. Fundamentally, storage and flexibility are externalities of variable renewable energy supplies. Externalities are not addressed by the market; they are only controlled by regulation. The lack of compensation for many 'flexibility services' is called: "**the missing money problem**". Consequently, public regulation is crucial to properly remunerate storage and flexibility services. To implement a Zero Net Economy, investors need **a more stable regulation framework**. Policy measures that recognise the value of storage in the European power system, like **abolishment of any kind of double taxation**, will provide future revenues for flexibility and storage projects and can reduce investment risks and thus help ensure the economic viability of the European Green Deal. An **economic model giving a value to flexibility** in the European power system is therefore needed. A comprehensive modelling exercise, simulating a 100% renewable resources-based European energy system, would build quantitative evidence to support policy making in pricing flexibility. All services provided to the grid should be fully compensated according to their value. A well-functioning single European energy market and an **effective EU Emissions Trading System**, which promote green renewable energy with a fair price, tax policy and a subsidy model designed to provide a **level playing field amongst different technologies**, based on a comprehensive analysis of their carbon footprint and life cycle, are the best way of ensuring fulfilment of the European energy policy objectives. **Multi-criteria analyses** should be considered in the tenders, giving value to indicators of energy consumption, carbon footprint and costs of the production, exploitation, recycling, and decommissioning. European policy could bring back a **long-term vision** and set **long-term revenue streams** securing future long-term investments.

B. Sustainability is the social pathway to the European Green Deal

Communication and dissemination are needed to increase public awareness regarding the benefits and further support of new sustainable hydropower plants. Actions towards increasing social acceptance of hydropower are to make information more readily available, to develop specific strategies to **quantify the benefits of hydropower** and to share these messages with society. **Regional workshops, gathering all stakeholders**, under an appropriate administrative framework, are good opportunities to explore specific barriers and to promote best practice and uptake of hydropower. Large hydropower development may only occur if it is included within a **coherent national energy policy**, ensuring public water and energy services and security. In addition, **robust sustainability standards** and enforcement measures by national authorities are needed to increase investor confidence and gain public acceptance. The hydropower sector needs to adopt a **holistic position** considering the new social context, climate change, grid requirements and more generally the use of water for increasing social welfare. Development of comprehensive, **innovative approaches, methods and tools using social sciences and humanities** are needed to help balance the European energy market rules and European environmental goals. **Large reservoirs provide very important electric system security services** such as prevention of network crashes, black-start, and regulation capabilities, that decision-makers and regulators must quickly **protect and secure the independence** and flexible operation of the European Electric System by **launching new pumped-storage power plant solutions** in Europe. Long-term support for **European hydropower 'know-how'** is required to maintain and enhance hydropower in the future and to support continued employment in the sector.

C. Environmental commitment in the European Green Deal

A key collaborative action between hydropower stakeholders is to collect, share, disseminate and apply knowledge on **best practice for protecting freshwater ecosystems**. Collecting best practice with the help of international associations, best examples of **biotope creation and restoration** and lessons learnt from experiences with the Water Framework Directive, drawbacks and limitations will help prevent, minimize, or support compensating for environmental impacts at the European level and support the discussion of approaches with up-to-date information. **Increased monitoring and processing big data** will help develop and share enhanced knowledge on ecosystems and how hydropower affects and can mitigate these whilst supporting the Green Deal. A **scientific program** investigating, monitoring and benchmarking the application of best practice **for protecting biodiversity and addressing climate change impact** to improve knowledge and minimize impacts of industry and climate change on aquatic ecosystems is needed. Improvement of biodiversity protection and river continuity in hydropower projects thanks to innovative design and compensation measures is a key strategic action that would show the environmental commitment of the hydropower sector. The **development of innovative and comprehensive approaches to address environmental issues and biodiversity protection** undertaking a synthesis of lessons that can be drawn from best practice and the latest research outputs, and allowing sound and transparent discussion between all parties, is a top priority.

8. Outlook and closing remarks

The Strategic Industry Roadmap provides a key contribution to the growing debate on the net zero economy and the European Green Deal. It will be highly relevant for discussions on finding the best solutions to provide the new energy system with flexibility.

It will help European regulators, policymakers, civil society, NGOs, technology developers, planners, utilities and system operators to discuss together and to take balanced decisions on further hydropower development to enable the new energy system to benefit fully from the storage and flexibility potential of this valuable resource.

Hydropower technology is established, widely deployed and highly efficient. Hydropower provides ancillary and important back-up services which help stabilise the grid for intermittent and non-dispatchable renewable resources such as wind or solar power. Hydropower was born to be a catalyst for the Energy Transition.

Sustainable hydropower is not only generation of sustainable energy but in parallel also brings huge added value to society through the provision of infrastructure in remote areas as well as supporting vital services like water supply for irrigation and households, flood and drought protection, navigation, tourism and leisure activities. These services can be developed to provide civil society with greater resilience to climate change impacts.

New demands are now being asked of the hydropower sector. Hydropower technology can and must evolve to respond to new environmental and societal challenges. By fostering innovative environmental approaches, hydropower will stay as a core element of the future renewable energy system. Without innovative hydropower, the sector will not have a sustainable future.

Hydropower can have a bright future in Europe under two conditions. Firstly, policy makers and regulators need to solve the “missing money” issue for the provision of flexibility services and secondly, industry needs to develop sustainable schemes with improved protection of biodiversity based on reasonable consensus between renewable energy needs and environmental requirements.

There should be no fully renewable energy system without hydropower, as hydropower is one of the best technologies to combat climate change (i.e., global warming) and to integrate the impressive growth of other intermittent and non-dispatchable renewable energy sources into the electricity system.

References

CIRAIG (2014) RAPPORT TECHNIQUE - Comparaison des filières de production d'électricité et des bouquets d'énergie électrique Novembre 2014

EUROSTAT (2019), https://ec.europa.eu/eurostat/fr/home

HYDROPOWER EUROPE Forum (HPE, 2020), Hydropower in Europe in a complex world - A global system analysis approach, HYDROPOWER EUROPE Technical Report WP2-DIRp-47, June 2020. www.hydropower-europe.eu

HYDROPOWER EUROPE Forum (HPE, 2021), "Strategic Industry Roadmap (SIR)", www.hydropower-europe.eu

HYDROPOWER EUROPE Forum (HPE, 2021), "Research and Innovation Agenda (RIA)", www.hydropower-europe.eu

IEA (2021), Valuing Flexibility in Evolving Electricity Markets: Current Status and Future Outlook for Hydropower. Draft. February 2021.

IPBES (2019), "The Global Assessment Report on Biodiviersity and Ecosystem Services", Summary for policymakers