The hydropower sector‘s contribution to a sustainable and prosperous Europe.

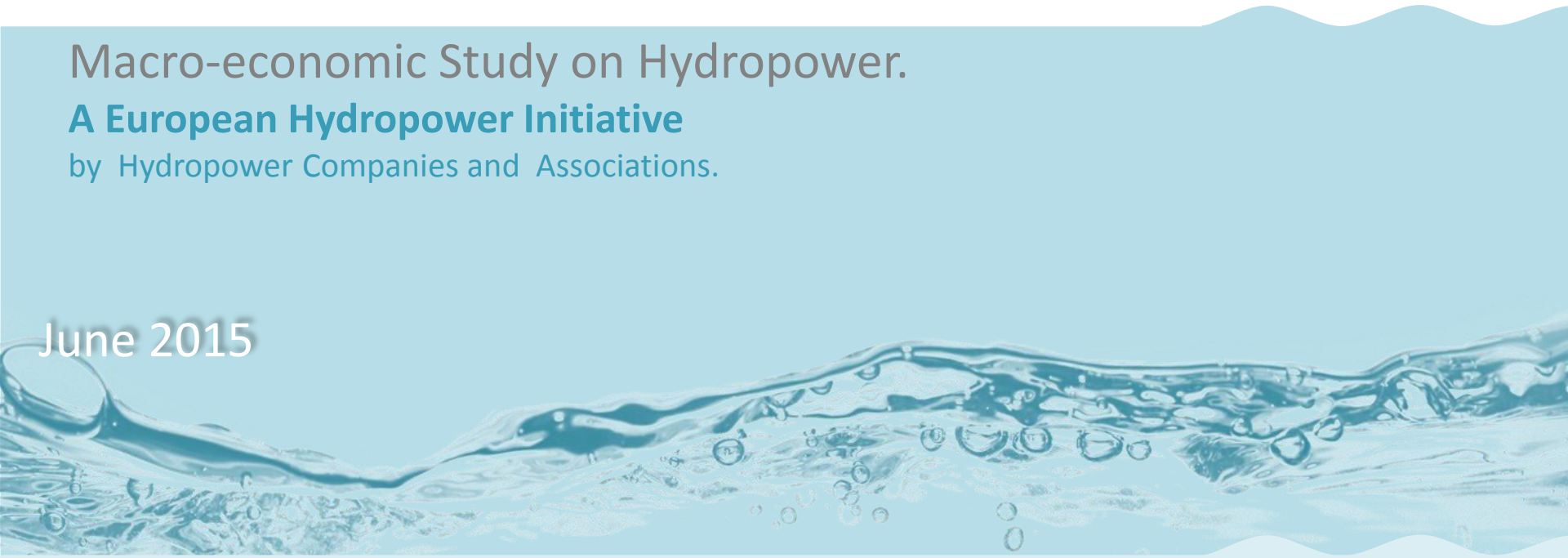
Presentation of study results and policy recommendations.
Final Version | 16.6. 2015

Macro-economic Study on Hydropower.

A European Hydropower Initiative

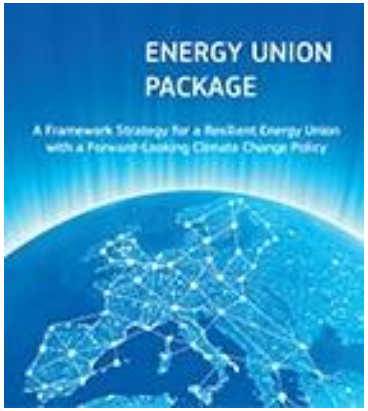
by Hydropower Companies and Associations.

June 2015



Challenges for EU energy and climate policy

European Energy Union with forward-looking climate change policy



Five key priorities for secure, sustainable, competitive and affordable energy:

- **Ensuring security of supply** for Europe
- **Deeper integration** of EU national energy markets
- **Reducing EU energy demand**
- **Reducing carbon emissions** from the energy sector
- **Promoting research and development in energy**

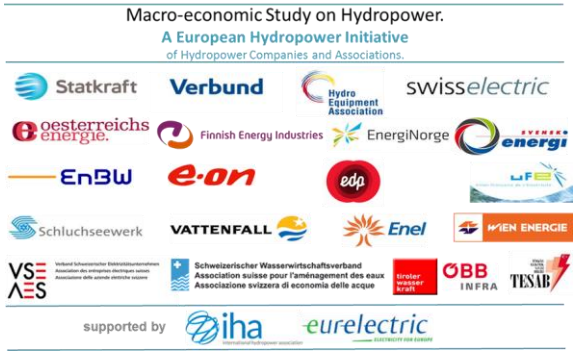
315bn € Investment Package

2030 Framework for Climate and Energy

≤ - 40%	≥ 27%	≥ 27%	15%
Greenhouse Gas Emissions	Renewable Energy	Energy Efficiency	Inter-connection

The Study: Most comprehensive assessment of European hydropower to date

Study on behalf of 21 European hydropower companies and associations from the EU-28, Norway, Switzerland and Turkey.



Study has been conducted by **DNV GL**, a world-renowned company delivering counselling, testing, and certification services to the energy value chain. DNV GL had a partnership with École polytechnique fédérale de Lausanne (EPFL), Laboratory of Hydraulic Constructions.

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EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Study is based on a comprehensive analysis of relevant aspects, based on different tools and benefitting from contributions by the European hydropower industry

Electricity Market Modelling
- Comprehensive simulation of European power market
- Several scenarios and sensitivities for 2030
- Impact on wholesale prices, fuel consumption, CO2 emissions etc.

Macroeconomic analysis
- Comprehensive survey of European hydropower companies and associations (>90% of capacity covered)
- Input-output analysis of induced price effects

Technology & Innovation
- Based on survey among hydropower generation companies and equipment manufacturers
- Research of publicly available studies and reports

Value of European Hydropower

At a glance: Hydropower sector‘s contribution to a sustainable and prosperous Europe.

Hydropower‘s contribution to European welfare, energy security and a low-carbon society is significant today!

- **380 TWh electricity generation in EU-28** and 600 TWh in Europe. Accounting to 13% (Europe: 18%) of total electricity generation.
- **More than 150 GW of firm capacity**, which is able to supply more than 25% of maximum peak load in recent years.
- **220 TWh of storage capacity** in Europe.
- Technology leadership of European equipment manufacturers: **2/3 of global market share**; 5% of annual turnover invested into R&D
- Up to **24bn € of savings from avoided fossil fuel imports** into EU-28.
- **More than 180 Mt of CO_2-Emissions are avoided p.a.**
- **25bn € contribution to EU-28 GDP** and 38bn € to European GDP p. a.
- **80.000 high-qualified jobs** in EU-28 (120.000 in Europe). Value creation per person eight times higher than European average in the manufacturing sector.

Hydropower‘s perspective and effects

Significant economic potential for increasing the use of hydropower exists in Europe:

+ 7% in EU-28 (+ 20% in Europe) **by 2030**

+ 19% in EU-28 (+ 31% in Europe) **by 2050**

Up to 180bn € future investments in hydropower are possible by 2030 - under the right market and regulatory condition **– if the +20% generation potential will be explored in Europe.**

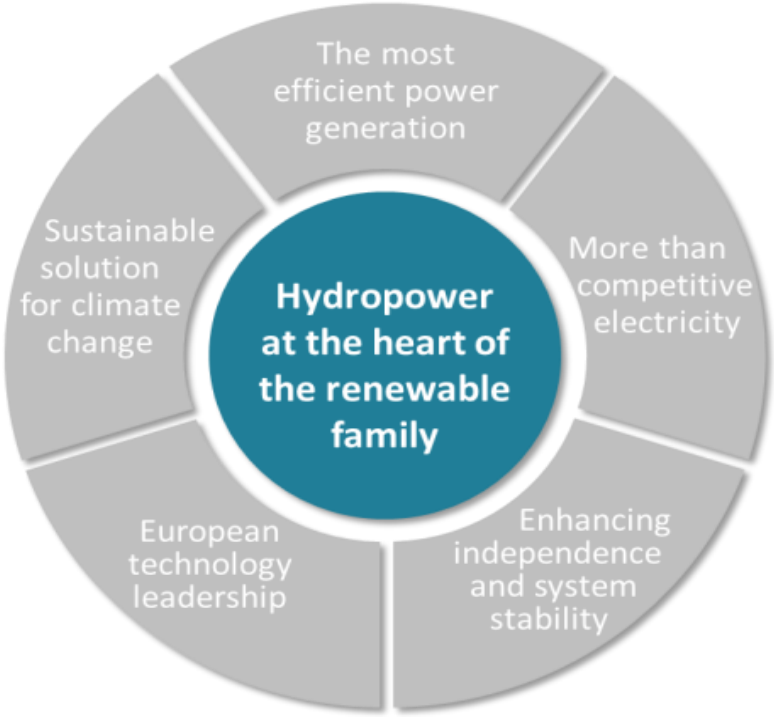
A 10% increase in hydropower generation in Europe by 2030 means:

+ 60 TWh renewable electricity
+ 9-11bn € increase in GDP
+ 27.000 – 36.000 new jobs

Europe = EU-28, Norway, Switzerland and Turkey

Source: Study - The Hydropower sector‘s contribution to a sustainable and prosperous Europe, DNV GL 2015

Technology characteristics point out hydropower‘s importance for the renewable energy era.



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.

Hydropower represents both long experience and innovation:

- More than 100 years of experience in Europe
- Tailor-made and innovative system solutions

Hydropower has the highest efficiency rate of all energy technologies:

- 85-95% electricity conversion rate

Hydropower is a major source of electrity generation in Europe today.

215 GW

600 TWh

18 % share of electricity generation in **Europe.**

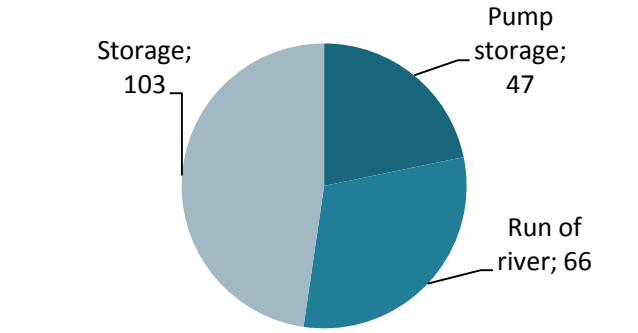
150 GW

380 TWh

13% share of electricity generation in the **EU-28.**

TOP hydropower countries in Europe (Generation in 2013)	
Norway: 129 TWh	Spain: 41 TWh
France: 75 TWh	Switzerland: 40 TWh
Sweden: 60 TWh	Germany: 24 TWh
Turkey: 59 TWh	Romania: 15 TWh
Italy: 52 TWh	Portugal: 15 TWh
Austria: 41 TWh	Finland: 13 TWh

Installed Capacity of hydropower in Europe (GW)

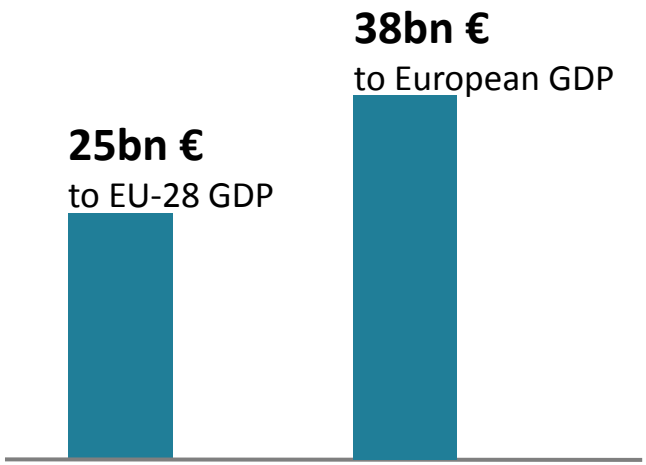


Europe = EU-28, Norway, Switzerland and Turkey

Source: DNV GL 2015

Hydropower‘s contribution to European welfare is significant.

GDP-Contribution of Hydropower per year



Value creation by electricity generation (more than 90%) a**nd exports of hydropower equipment.**

- Overall value creation of hydropower generation and equipment manufacturing amounts to approx. **0,3% of European GDP**, which is comparable to the GDP of Slovenia.
- **Value creation of the sector can be expected to be stable** and is not artificially inflated by short-term effect.
- **Multipurpose functions of hydropower add additional more than 10bn € in value creation per year.**
- **Hydropower contributes to public sector revenues** by taxes, levies and other charges (8,5bn € in EU-28, 14,5bn € in Europe); a **substantial share is paid to local governments, promoting regional economies.** Contribution is much higher than payments to smaller hydropower plants (2,6bn €).
- **More than 25bn € investments by European hydropower companies into new and existing capacity since 2010.**

Source: DNV GL 2015

Hydropower sector ensures high-value employment in Europe.

Employment in the Hydropower sector

EU-28: more than 80.000 jobs	**Direct employment** includes 42.000 FTE* in generation and 5.000 in equipment manufacturing.	**Indirect employment doubles the number of jobs due to hydropower in Europe / EU-28:** DNV GL assumes a similar level of employment in other sectors, who provides external services to hydropower sector, including operations & maintenance, planning, engineering and consulting.
Europe: nearly 120.000 jobs	**Direct employment** includes more than 50.000 FTE* in generation and almost 7.000 in equipment manufacturing.	

*FTE: Full-time-equivalent

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High-value employment:

- **650.000 € annual value creation per employee** (FTE).
- More than **eight times higher than the average** in the EU manufacturing sector.

Source: DNV GL 2015

Hydropower demonstrates European technology leadership & innovation

1.	European hydropower manufacturers have **2/3 global market share.**
2.	European hydropower manufacturers spend **more than 5% of turn-over on R&D**, which is **more than twice as high than economy-wide expenditure and more than the 3% EU-target** (as percentage share of GDP).
3.	**Constant innovation** to maintain global leadership and deal with challenges of renewable integration and environmental challenges.

Focus area of innovation in the European hydropower sector:

- Cost reduction and increased output
- Flexibility for dealing with variable renewables and changing market environment
- Environmental-friendly development
- Tailored design for complex site conditions
- Adaptation to climate change (e.g. solutions for dam safety and safe operations)

Source: DNV GL 2015

Hydropower contributes to security of supply and energy system stability in Europe.

EU's energy security of supply is a main challenge:

- **EU imports 53%** of the energy it consumes.
- **400bn € bill for energy imports** in 2013.
- Rising share of renewables in the electricity market calls for **more flexibility and storage capacity** in order ensure security of supply.

Higher energy independence means greater security, economic growth and welfare.

Contributions to reduce energy dependence:

24bn € avoided imports	• **Up to 24bn € avoided fossil fuel imports to the EU-28 by existing hydropower.** • Equivalent to up to 11% of fossil energy imports.
1bn € fuel savings	• **1bn € of fossil fuel savings for European costumers on account of pump storage.** • Estimated for the year 2013 based on actual production and market prices.

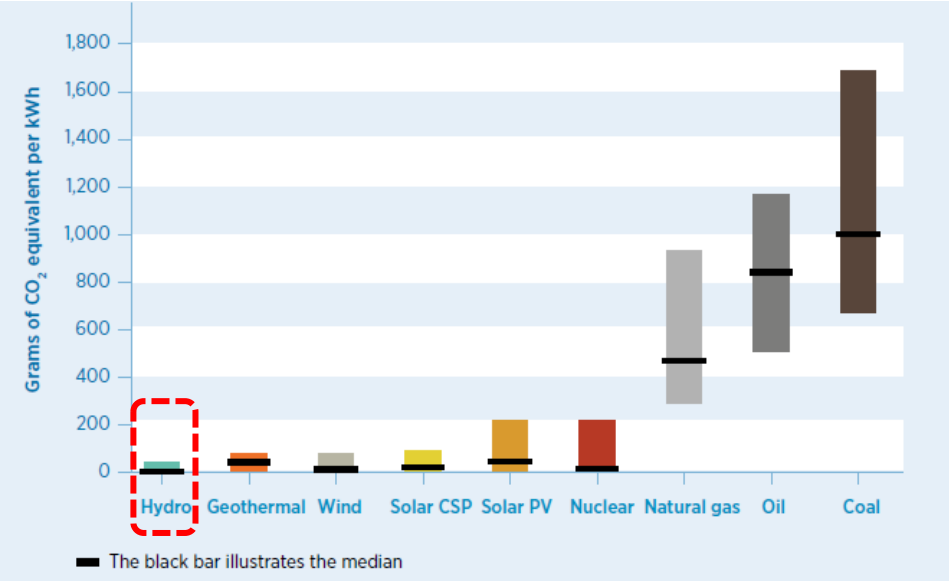
Contributions to energy system stability:

220 TWh storage capacity	• 220 TWh of storage capacity by hydropower in Europe is **equivalent to nearly 25 days of average consumption.** • Hydropower is a firm and dispatachable storage.
Cost-efficient flexibility	• **Hydropwer is a cost efficient provider of flexibility.** It is indispensable for competitive integration of large volumes of volatile renewables.
Firm capacity	• **More than 150 GW of firm capacity**, which is equivalent to supply more than 25% of maximum peak load.

Source: DNV GL 2015

Hydropower is a sustainable solution to combat for climate change.

Life-cycle emission intensity of electricity generation by technology



Source: RETHINKING ENERGY 2014, IRENA (International Renewable Energy Agency) (based on IPPC (2011)
Note: Methane emissions from atypical reservoirs have been registered. The discussion in this respect is an international one, but of minor relevance in the European context.

Best-in-class carbon footprint!

Carbon footprint accounts for the total quantity of GHG-emissions over the lifecycle of a product or process.

A low-carbon footprint is essential for a successful transition to a low-carbon future.

More than 180 Mt of CO_2-emissions are avoided p.a.!

Equivalent to 15% of total CO_2-emissions in the EU-28 power sector.

DNV.GL calculations are based on CO_2-intensity of total electricity generation (excl. hydropower).

Source: DNV GL 2015

Multipurpose functions of hydropower delivers major benefits to society.

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Water supply

- Different purposes and water uses, incl. agriculture, drinking water, industrial processes , cooling water.

Flood mitigation

- Using storage capacity and dikes. Avoiding or reducing damages from flood events.

Navigation

- Transportation of goods using vessels; alternative to other modes of transportation.

Tourism

- Facilitating water sports and other tourist activities at hydropower plants and water reservoirs.

Other

- Various other functions, incl. collection of floating residues, providing water for fire fighting planes, fishery and aquaculture.

More than 10bn € additional annual value creation on account of multipurpose benefits.

Source: DNV GL 2015

Hydropower is a major contributor to a sustainable and prosperous Europe also in the future.

Europe has still considerable scope for expanding hydropower generation:

+7% in EU-28
+ 20% in Europe
…possible by 2030

+19% in EU-28
+ 31% in Europe
…possible by 2050

Potential investments until 2030:
up to 112bn € in EU-28
up to 183bn € in Europe

Potential employment effects:
plus 50.000 jobs in hydropower sector.


Run-of-river


Storage


Pump-storage

- **Investments strongly depend on good market and regulatory framework.**
- Due to the longevity of hydropower plants, European consumers will benefit from sustainable and affordable electricity for many decades.

…additional contributions of hydropower are possible ….
…for a secure, sustainable, competitive and affordable energy supply for Europe.

Europe = EU-28, Norway, Switzerland and Turkey

Source: DNV GL 2015

A 10% increase in hydropower generation in Europe by 2030 would mean…

…plus 60 TWh renewable electricity

…that‘s more than the total elecritity generation in Portugal or in Romania and almost as much as in Finnland or Austria.

…27.000 - 36.000 additional jobs.

…between 9 - 11bn € increase in European GDP.

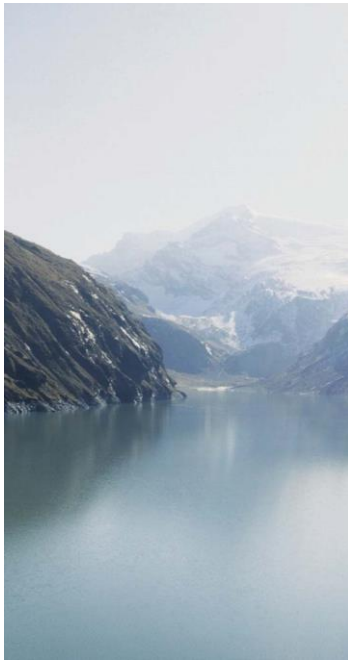
Europe = EU-28, Norway, Switzerland and Turkey

Source: DNV GL 2015

Based on the study results, the European Hydropower Initiative recommends …

„Establish appropriate and consistent framework conditions …
….to guarantee the best possible use of existing and future hydropower…
….in order that hydropower can deliver its valuable contribution…
…for secure, sustainable, competitive and affordable energy for Europe."

1	**Establish a level playing field** in Europe between hydropower and other technologies.
2	**Design the electricity market to reflect the real value of flexible and firm capacity in different time frames.**
3	**Remove remaining obstacles to cross-border trade and strengthen interconnecting infrastructure.**
4	**Avoid double grid fees** for pump-storage power plants.
5	**Align currently conflicting EU policy goals and legislation** in the field of water management, renewable energy generation and climate change adaptation and mitigation.
6	**Use EU R&D and technology programs** as a contribution to facilitate innovation in hydropower, in order **to maintain the hydropower technology leadership in Europe.**



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A European Hydropower Initiative

of Hydropower Companies and Associations.

An European Hydropower Initiative is the group of hydropower companies and associations, who commissioned DNV GL with the study „The hydropower sector's contribution to a sustainable and prosperous Europe".

This macro-economic study of hydropower in Europe was completed in June 2015. The results are disseminated to European and national stakeholders by the European Hydropower Initiative in order to provide additional knowledge about hydropower's contribution to a sustainable and prosperous Europe.

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