



European  
Commission

## Technology factsheet: Competitiveness of clean energy technology – Hydropower and pumped hydropower storage

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### Key emerging technologies & uses

Hydropower is an established sector and the largest and most flexible renewable energy source, with well-known and robust technologies and construction methodologies. Hydropower system-wide TRL is very high. Nevertheless, there are several emerging technologies under development.

#### tech 1

Increasing flexibility (e.g., variable rotational speed of turbines), to better integrate volatile energy sources into the grid and sustainable refurbishment

#### tech 2

New methods for pumped-hydropower storage and hybridization (e.g., using abandoned mines, hydro & batteries, short-circuit operation)

#### tech 3

New methods to increase sustainability (e.g. innovative fish-friendly and environmentally-enhanced turbines, fish passages, hydropeaking mitigation)

#### tech 4

Digital technologies (e.g. for predictive maintenance and reservoir operation)

#### tech 5

Novel operating methods and practices (e.g., sediment control, reservoir operation, hydropeaking control)

#### tech 6

Small-scale turbines to tap hidden hydropower opportunities in existing infrastructures

## Key value chain figures

- **Global employment:** 2.4 million people directly in hydropower sector (IRENA, 2021).
- Europe employment figures vary from 74 000 to 87 000 (EurObserv'ER, 2019); around 89 000 (IRENA, 2021); and 120 000 (JRC). A 10% increase of hydropower in the year 2030 is estimated to create 27 000 jobs in the EU. On the basis of existing installations, IRENA estimates that every 1 MW of community-owned hydropower installed generates ten fulltime equivalent jobs in every year of its operation.
- According to Prognos analysis<sup>1</sup>, turnover of hydropower in the EU was EUR 144 billion in 2021. Top four turnover countries: Italy (EUR 34.4 billion), Germany (EUR 32.8 billion), Austria (EUR 17.3 billion), France (EUR 11.4 billion).



## Key facts



### Fact 1

Hydropower is currently the largest low-carbon and renewable electricity technology, with a global installed power capacity of 1 397 GW and an annual generation of 4 408 TWh in 2022. Hydropower provides, on average, 360 TWh/y in the EU, and a quarter of the global pumped hydropower storage (PHS) installed capacity is in the EU. Europe is home to more than half of hydro equipment manufacturers and large operators of hydropower. More than 95% of energy storage is provided by hydropower (in the EU and globally).

<sup>1</sup>Analysis conducted by Prognos AG and COWI under the project "Assessment of the competitiveness of clean energy technologies (CINEA/2002/OP/0008)" based Eurostat SBS data. Status of the data: March 2024.

## Fact 2

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Traditional hydropower equipment does not use rare or critical materials; it contributes to a resilient energy system thanks to its flexible operation and the storage capacity of reservoirs. This flexibility allows to integrate the volatile energy production from non-dispatchable energy sources (e.g. wind and solar power plants), ensuring grid stability and ancillary services. Therefore, hydropower plays a key role in the long-term decarbonisation scenarios (i.e. the IEA's SDS and NZ2050scenario), contributing to reach the renewable energy targets set in the Renewable Energy Directive (Directive 2009/28/EC) and REPowerEU.



## Fact 3

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Despite the high technical maturity of hydropower, there have been policy developments and several research programmes in the European hydropower sector. Since most suitable sites in the EU have been already exploited or are protected by environmental legislation, and because new greenfield projects can generate environmental impacts, new developments have been often associated to the mitigation of environmental impacts and to the modernisation and optimisation of the existing water and hydro infrastructures. New water reservoirs should be conceived as multipurpose projects.

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on hydropower and pumped hydropower storage

