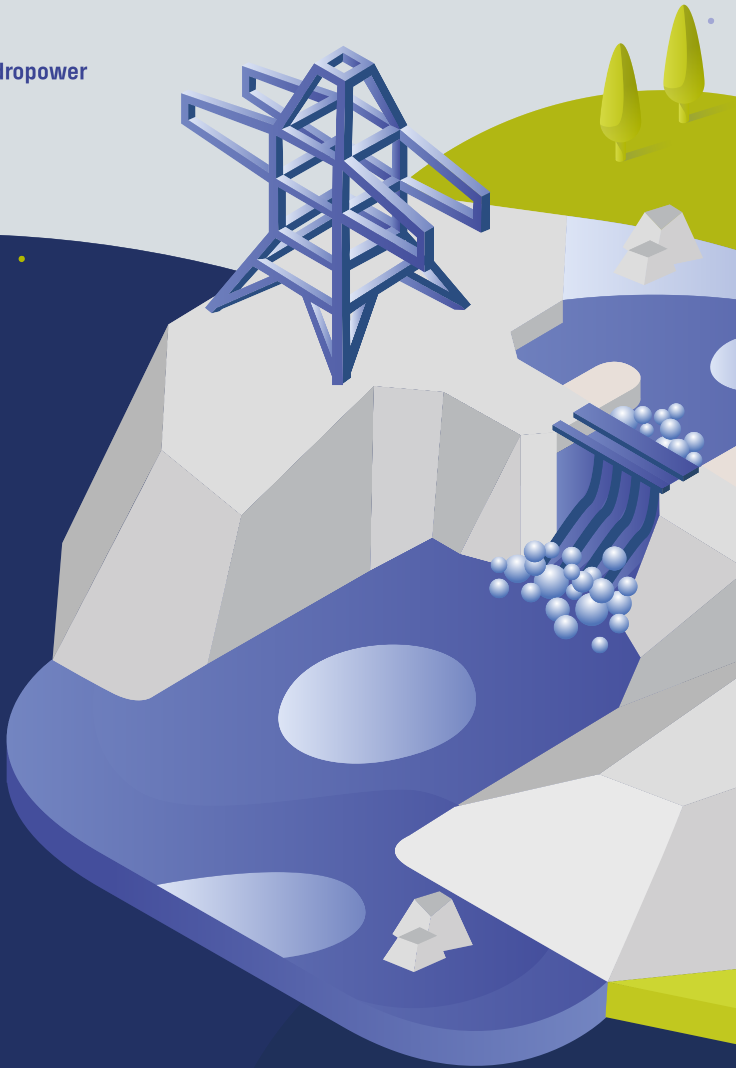
XPRESS

XPRESS LCA FACTSHEET (1/5)

RENEWABLE ENERGY TECHNOLOGIES

The XPRESS project has adopted the LCA attributional modelling approach to look at existing good practice Renewable Energy (RE) technology examples related to past Green Public Procurement tenders found in the TED (Tender Electronic Daily) database.

This factsheet outlines good practices and LCAs related to **Hydropower** technologies.



Hydropower

An assessment of small hydropower potential in Europe was done in 2000 within the BlueAGE Project (Blue Energy for A Green Europe), a "Strategic study for the development of Small Hydro Power in the European Union" carried out under the Fourth Framework Programme. According to this study the remaining potential from small hydropower could be around 2 700 MW of installed new capacity and 11.5 TWh of electricity production annually, while the total production from this Renewable Energy Source (RES) in the EU could lay at 51.5 TWh with an installed capacity of 12 850 MW. The study also pointed that, provided the economic incentives for producers are improved and the environmental constraints from the Water Framework Directive (WFD) of 2000 could decrease, the total contribution from small hydropower in the EU 15 member countries could reach 60 TWh at 2020 – 2030.

In principle, the use of water to gain energy is not ruled out by the WFD. However, the small hydropower potential can be affected by the WFD because this RE technology unavoidably brings important hydromorphological alterations to water bodies.

The typical interventions associated with hydropower include: impoundment and diversion of the water courses, sediment accumulation, impact on water balance and water levels due to storage effects, interruption of biological continuity (impeding upstream and downstream fish migration). Many of these impacts can be mitigated by different measures, but some alterations are so significant that they don't allow the water body to reach a good ecological status.

As the BIUAGE project put it, "the crucial question is how to reach a balance and equilibrated solution between the characteristics of the plant and the ecological quality in the most economically and technologically feasible way". In fact, these delicate compromise solutions and trade-offs are always at the core of sustainability decision-making.

Hydropower is nowadays a fundamental RES in countries like Norway, Sweden and Austria, which meet most of their energy needs, e.g. around 77% of the electricity consumed in Austria.

Due to the barriers mentioned above, the share of electricity generated from hydropower has remained quite similar for the last ten years (Eurostat, 2020), which is around 11% of the total RE primary production in the EU-28 (normalised values to last 15 years to account for meteorological variations), but its share in the total installed capacity has dropped from 20% in 2000 to 15% in 2017.

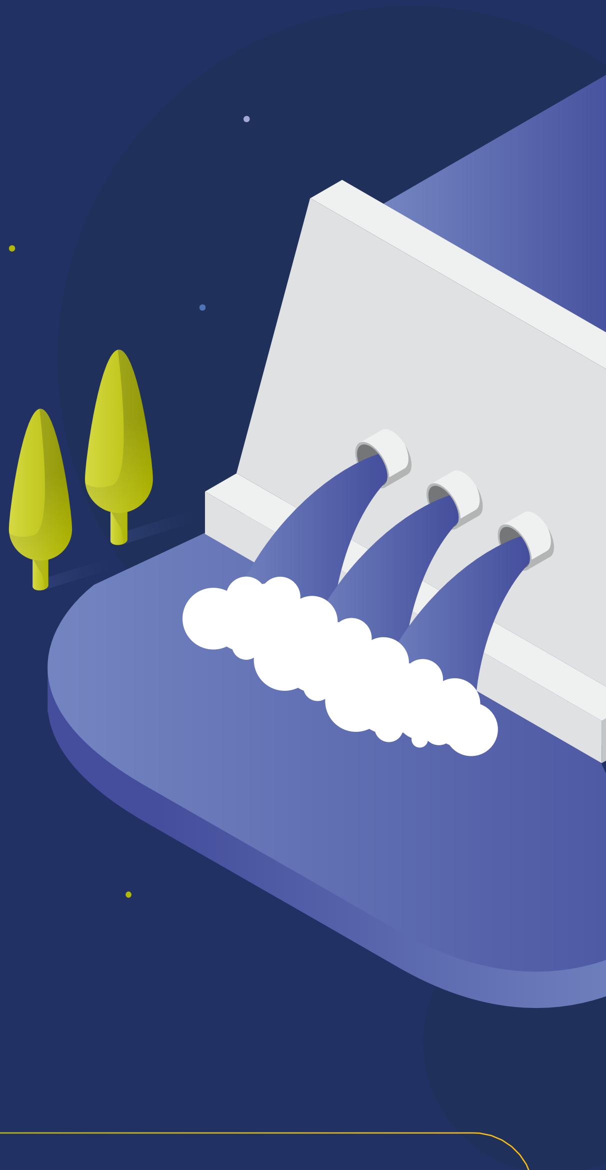
Given the conflicts between these European Directives, and due to the multiple impacts that micro hydropower dams can cause in the biodiversity of small streams and water basins (Premalatha et al., 2014), the present sustainability assessment through LCA will focus on **run-of-river hydropower technology**, which are hydropower plants without important reservoirs or dams.

Run-of-river hydropower

For today's power plants an efficiency of approximately 96% is assumed, modern generators show an efficiency of about 98%. The overall efficiency (current: 0,82; modern: 0,88) is composed of the efficiency of the turbine (current: 0,87; modern: 0,91), the generator (current: 0,96; modern: 0,98) and the transformer (current: 0,98; modern: 0,99).

The calculations are based on the information and data of the following run-of-river power plants (Aegerter et al. 1954): Rupperswil-Auenstein, Wildegg-Brugg, Birsfelden, Donaukraftwerk Greifenstein and Rheinkraftwerk Albbruck-Dogern as well as the new construction of the power plant Ruppoldingen.

The determined specific data was then related to the entire power plant park of Switzerland with an annual net electricity output of 15484 GWh (Ecoinvent database). The lifetime is assumed to be 80 years for the whole infrastructure, while 40 years for the moving parts and auxiliary equipment.



	BE	DE	DK	ES	IT	NO	PT	SE	SK	UK
Annual production potential (GWh)	156	2745	0	22873	15477	NA	6180	3526	725	5727
Suitable locations Mini Hydro	47	960	0	3713	3403	NA	909	751	368	1318
Suitable locations Small Hydro	3	41	0	500	226	NA	133	70	4	124

This European assessment study of the hydropower potential for small (1-10 MW) and mini (0.1 – 1 MW) hydro plants revealed a high variability of the potential of this RES among the considered countries (Bódis et al., 2014). Considering that any hydropower plant will be designed and built according to the productivity potential of each site, taking into account ecological restrictions from the WFD, seasonal variability and long-term fluctuations (15-25 years peaks and lows); considering too, that any installation has gone through technical feasibility and economic viability studies, we present here the theoretical (potential) impact results of an average run-of-river hydropower production of 1 kWh in Europe.

This means that very good sites with abundant water resources all year round will perform better, while poorer sites (with longer periods during the year without any production) will perform worse than the presented resultsbelow. The main difference regarding this RES assessment and the LCA results of run-of-river plants will therefore lay in the overall production potential at the country level.

Impact Category	Unit	Hydropower, run-of- river
Climate change	kg CO2 eq	0.004024
Ozone depletion	kg CFC11 eq	3.41E-10
Ionising radiation	kBq U-235 eq	0.000322
Photochemical ozone formation	kg NMVOC eq	1.97E-05
Particulate matter	disease inc.	4.02E-10
Human toxicity, non-cancer	CTUh	1.25E-10
Human toxicity, cancer	CTUh	1.14E-11
Acidification	mol H+ eq	1.98E-05
Eutrophication, freshwater	kg P eq	1.23E-06
Eutrophication, marine	kg N eq	5.97E-06
Eutrophication, terrestrial	mol N eq	6.44E-05
Ecotoxicity, freshwater	CTUe	0.07266
Water use	m3 depriv.	0.001588
Resource use, fossils	MJ	0.038435
Resource use, minerals and metals	kg Sb eq	3.49E-08

Consortium

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 857831

www.xpress-h2020.eu