

Identifying, quantifying and maximising the multiple benefits of hydropower

A briefing by the International Hydropower Association and the Economic Commission for Africa

Hydropower continues to be a catalyst for growth around the world as it remains the dominant form of renewable energy, having contributed over 16% of the globe's electricity production in 2016. Its role in driving economic development, particularly in countries such as China, Brazil, Norway and Canada where it provides a significant amount of low-cost, resilient and reliable power and energy related services is well documented.

However, often overlooked and under-valued are the multipurpose non-power related benefits that can be created by the construction and operation of a hydropower plant which can't be ascribed to other forms of energy generation. The absence of a widely used and accepted methodology to clearly define and quantify these benefits can, in some cases, impede hydropower development potentially impacting plans for meeting the power needs of developing and emerging economies and the aims set out in the UN Sustainable Development Goals.

The power-related benefits of hydropower include: the capacity to provide both base-load and maximum peak load generation and ancillary services are provided through fast-responding, flexible generation to compensate for load variations over many time scales. In addition, hydropower can provide flexible energy storage to balance intermittent renewable technologies which ensure grid stability and frequency control. Furthermore, it can reduce dependence on imported, often fossil fuel based electricity which can be subjected to periods of great price volatility. Quantifying these power-related benefits can be relatively straight forward as power is generated and sold in a regulated market.

Over and above providing electricity generation, multipurpose hydropower reservoirs can provide additional services through regulating flows for uses such as water supply, irrigation, flood and drought control, environmental management and climate mitigation. The reservoirs themselves can also provide local and regional development through the creation of activities such as navigation, fisheries, recreation and most recently, act as a platform for other forms of energy generation such as floating solar PV.

Hydropower development can enhance and create secondary industries (e.g. related manufacturing activities) while also helping them to integrate within regional and global value chains which further increase employment and training opportunities across a range of skilled and non-skilled areas. Its development can also improve local infrastructure from roads and bridges to even education and healthcare provision in some regions and the benefit often transcend borders.

In West Africa, the 128 MW Sambangalou hydropower interconnection project located on the Gambia River will not only provide Gambia, Guinea-Conakry, Guinea-Bissau and Senegal with sustainable, low-cost electricity but it will have a positive impact on the region's infrastructure, economic connectivity and agricultural sector.

One of the most comprehensive evaluations of the hydropower sector's macroeconomic contribution was conducted by the consultancy DNV GL in 2015.¹ Focusing on Europe, it found that the total value created by the hydropower sector was roughly EUR 38 billion per year with projections of up to 90 billion by 2030. The sector also supports around 100,000 full time jobs across Europe, investing on average between EUR 8 and 12 billion each year. Furthermore, unlike other forms of renewable energy, the report found that the sector contributes EUR 15 billion in annual tax revenues, far outweighing the limited subsidies granted to small hydropower projects.

In addition, the study estimated that the multipurpose benefits of hydropower projects including reservoir functions such as water supply, navigation and tourism contributed a further EUR 10 to 20 billion each year highlighting the significant value of the sector's non-power related benefits to European society. This could be mirrored in other regions of the world where it is currently underutilized such as Africa which has only 34 GW of installed capacity compared to Europe's 223 GW despite having similar hydropower potential. However, it is still an incomplete picture, as the study did not account for a number of additional services such as flood control, noting the complexities involved in quantifying these benefits.

The challenge for the sector is developing practical, reliable and replicable tools that can identify and value all the benefits that the hydropower sector delivers for society both at a system and project level.

For any hydropower project to capture and optimise all the socio-economic and environmental benefits, while reducing any negative impacts, they need to be explicitly integrated in the planning process in close co-ordination with stakeholders.

This not only improves the decision-making process, ensuring that projects are being built in the right place in the right way, but also enhances a plant's risk-reward profile for developers, governments and private sector investors by recognising a project's true value. By ensuring that a project's full value is quantified and recognised, there is also a greater probability of avoiding or mitigating any delays when seeking planning permissions and approvals.

EDF's Value Creation methodology

At a project level, EDF SA, operator of over 450 hydropower installations worldwide and manager of 75% of France's surface water storage, has been actively engaged in assessing the benefits created for stakeholders associated with hydropower reservoirs since 2013. EDF's work has focused on developing a systematic check-list and tool for hydropower operators to identify and analyse the created value of a project's development and operation.

In 2016, EDF finalised its first 'Hydropower Value Creation Guidance' to be used to aid the decision-making process with operators and stakeholders working together to ensure a system-scale approach is taken to the development of projects. The guidance is based around five overarching categories for assessment containing both monetary and non-monetary values and includes: (1) Electricity services, (2) Socio-economic values, (3) Societal values, (4) Environmental values and (5) Risk management. To assess these categories, the EDF methodology provides a nine-step evaluation process which takes into account macroeconomic statistics as well as data collected by the operator. Quantifying the benefits associated with certain categories can be a complex task so further work is to be undertaken to strengthen the methodology. This relates to the environmental impacts and

¹ <https://www.hydropower.org/study-the-hydropower-sector%E2%80%99s-contribution-to-a-sustainable-and-prosperous-europe>

benefits as well as indirect and induced job creation related to hydropower on a very localised project or community scale.

The methodology displays the results in three ways so it can be clearly communicated to operators, decision-makers and stakeholders: (1) synthesized table of main results, (2) a map showing the spatial distribution of values, and (3) a temporal graph of value creation across the different categories.

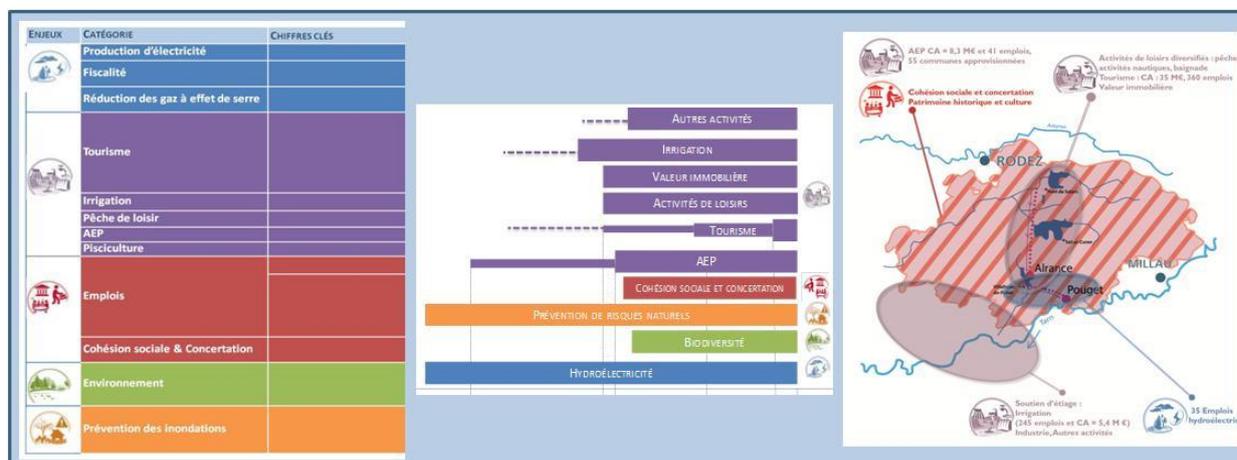


Figure 1: The three ways in which EDF's Value Creation methodology can display results

To date, the methodology has been applied to projects in France, Canada and Laos. In assessing the Durance-Verdon basin, an area with a high density of hydropower in the south-east of France, the methodology confirmed that the non-power benefits associated with the multi-purposes reservoirs were 7 to 9 times higher than the turnover related to the production of electricity. The methodology has also been applied to the world's first tidal power plant in La Rance, Brittany.

In Quebec, Canada, Hydro-Québec is finalizing its assessment of some ten power stations along the Saint-Maurice River by applying EDF's methodology using a complementary scale. The Mauricie region has benefited greatly from the development of hydropower and this assessment is providing a clearer picture of the values created. Even today, the hydroelectric complex contributes to different industries, such as tourism, as well as, navigation activities or environmental activities.

In Laos PDR, the methodology has been applied to the 1,075 MW Nam Theun 2 project, the largest hydropower project in the country which started commercial operation in 2010. The assessment highlighted not only the significant economic contribution it is making to the country through royalties, income tax, job creation but also its positive impacts on poverty alleviation and provision of health and education services. Following this assessment, EDF is seeking to refine the methodology when applying it to developing countries to allow assessment of future value creation at new projects over time, which is often complicated in the absence of reliable public economic and societal baseline data and development scenarios. Further information on the examples cited and how EDF's methodology accounts for the value created can be found at Annex A.

Conclusion

Hydropower plants are highly valuable assets with benefits far beyond power generation, which will be critical to meeting the future climate and water needs of the globe.

Developing a comprehensive methodology to identify, quantify and maximise the multiple benefits of hydropower development will help ensure that its value to society is optimised and not

undervalued. In addition, by applying the methodology in the preparation phase of the project's life cycle as opposed to simply existing projects, it can be used to better engage stakeholders from the onset and also identify and minimise risks to help ensure projects are developed in a sustainable manner. EDF, for example, intends to test its methodology on power projects under development.

Building on the work carried out by EDF, the challenge for the sector is to refine and further develop a practical, replicable and credible methodology that accurately captures all the values (both positive and negative) associated with the development of hydropower across all conditions in a transparent manner. This will require continued collaboration across countries and sectors focusing in particular on how to account for those non-power benefits which are complex to value, such as food security, health impacts and what economic-multiplier could be attached to hydropower development.

With several significant projects either under construction or close to completion such as the 6,000 MW Grand Ethiopian Renaissance Dam and further plans in the pipeline including the Inga III project; hydropower will be an increasingly important component of Africa's energy mix. Having an appropriate methodology in place, which is widely applied across the continent, will help ensure that all the multiple benefits of hydropower are optimised and enjoyed by society.

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Photo: Boating in the Rance estuary, France

ANNEXES

Annex A: Value Creation methodology being applied in Canada, France and Laos.

	La Rance, France	Saint-Maurice, Canada	Nam Theun 2 (NT2), Laos PDR
Electricity Services	<ul style="list-style-type: none"> • Taxes and dividends: €2.5m annually. • ~60 jobs related to electricity production and ship locks. • Reliance on 20 local enterprises for generation & maintenance. 	<ul style="list-style-type: none"> • Installed capacity: 2,052 MW. • Goods and services purchased in 2015: CAD 127m • Hydro-Québec (HQ) jobs in the Mauricie region: 973 in 2015. 	<ul style="list-style-type: none"> • ~8.5% of Laos' domestic electricity in 2016. • Royalties, income tax and dividends USD 210m managed through a revenue management mechanism for poverty reduction.
Socio-economic Values	<ul style="list-style-type: none"> • Sailing and tourism activities in and around the estuary; 3rd most visited site in Brittany, 2 companies organizing cruises. • Fishery of St Jacques scallops, mussels oysters, cuttlefish, shellfish & clams. 	<ul style="list-style-type: none"> • Adjustable water level management to clean up the river following log • Driving instream flow pilot project for nautical activities. • Sharing of water data. • Involvement in multi-user roads and infrastructure. 	<ul style="list-style-type: none"> • Concession Agreement increased awareness in Laos for environment and safety issues; contributed to economic development; aspects of NT2 inspired other hydro projects. • The Nakai District was declared out of Poverty in 2013 (97% of affected communities achieved the Household Income Target – 3% remaining directly supported by Social Safety Net). • 120 km of access road increasing transportation links and economic development. • Fisheries values: estimated average contribution of USD 989,000 per year (2009-2016) on the Nakai plateau.
Societal Values	<ul style="list-style-type: none"> • Construction cost of an estuary bridge avoided since the dam serves as a road. • Contribution to the economic development and appeal of the region. • First tidal power plant built worldwide. 	<ul style="list-style-type: none"> • Industrial heritage: HQ initiated the Cité de l'énergie (one-of-a-kind in North America) and is also a partner /restoration of historical buildings. • Donations and sponsorships: CAD 287k in 2016. 	<ul style="list-style-type: none"> • Health improvement (2 health centers, underweight children has been reduced by one-third). • Education (32 schools, school enrollment tripled with 90% of school enrollment among children 5-9 years old after resettlement). • Empowerment of women (36.8% seats in village committees) and youth in the communities. • 11 community-based organizations in each hamlet
Environmental Management	<ul style="list-style-type: none"> • Avoidance of 235,000 – 534,000 tons of CO₂. 	<ul style="list-style-type: none"> • Pioneer in the study of GHG emissions from 	<ul style="list-style-type: none"> • Creation of the largest National Protected Area

	<ul style="list-style-type: none"> • After initial impacts on the estuary’s ecosystem, good recovery and protection of many species. • Estuary siltation management and valorization of sediments in dune restoration and agriculture. • Increased environmental knowledge on estuary siltation processes. 	<p>reservoirs. Avoidance of 4.2 million tons of CO₂.</p> <ul style="list-style-type: none"> • Reinstating ecological habitats by putting in place fish spawning grounds, wetlands, and other mitigation measures. • Contribution to local projects related to the conservation and protection of biodiversity. • Environmental data collecting and studies regarding the biophysical and human environments, thousands of datasets and hundreds of reports relating to the Saint-Maurice River contributed to the Environment and Communities Documentation Center. 	<p>hosting the largest wild elephant population in Lao PDR (~130 individuals)</p> <ul style="list-style-type: none"> • Environmental knowledge created and strengthened in the region for better resource management (rivers and reservoir) and shared with local stakeholders. • Increased waste management awareness.
<p>Risk Management</p>	<ul style="list-style-type: none"> • Protection against estuary floods, damage control by keeping the reservoir at an agreed level. 	<ul style="list-style-type: none"> • HQ respects water levels with regard to operations. Thresholds and alerts are identified before critical levels are reached. In emergency situations, HQ communicates with Sécurité civile, which coordinates actions with municipalities. 	<ul style="list-style-type: none"> • Creation of a 7,000 ha safe zone, cleared from 25,000 unexploded bombs. • Creation of a hydro-safety framework among the 3 districts.