Hydro Energy is Really a "Clean" Energy?
Ecological Problems Generated by Hydropower Plants

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Abstract: Hydraulic energy is the ability of a physical system (running water, generally speaking river) to perform a mechanical work when flowing from a higher position to a lower position. Thanks to the water circuit in nature, maintained by the Sun's energy, hydraulic energy is a type of renewable energy. This form of energy is utilized through hydropower plants. Some of the hydroelectric plants are very large, such as the Roman-Serbian border Porţile de Fier I (Iron Gates I, in english) (the largest on the Danube) and the Portţile de Fier II (Iron Gates II). Other hydroelectric plants are medium but also very small, such as those installed on the small rivers in the Făgăraş Mountains, such as the rivers Capra, Buda, Topolog etc., some even in the Natura 2000 protected areas; more than 500 micro-hydropower plants after National Geographic. But there is a contradiction: the ecological quality of the rivers must increase, but we also need to increase the percentage of renewable energy. With their negative environmental impact, hydropower plants of any size, does not generate a so "green" energy just as it desires. Solving the discrepancy between the economically and ecologically interests, is the key to sustainable development in the Danube area.

Keywords: ecological exploitable potential; environmental impact of hydropower plants; green energy

Introduction

Given the large demand and the increasing production of electricity at global level (Fig.1), especially due to the economic development of emerging countries and due to the increase of the population, it is very important to analyze the impact of various electricity production methods on the environment.

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Though, in many places in the world, subsequently to the construction of larger or smaller hydropower plants, after the beginning of their exploitation, their influence on the environment has been proved to be harmful, sometimes earlier than expected and with higher amplitude.

Practically, any reservoir built on a river flow represents, from the ecologic and hydrologic perspective, a significant change of its previous statuses; a natural ecosystem is destructed and it is replaced by another ecosystem, an artificial lake. Things would be quite simple if they would only be limited to these issues, but it is not the case. The consequences of anthropic changes are much more extended and much higher are never strictly limited to the geographical area of the hydropower plant, the dam and the lake.

Even from the middle of the XXth century, as a consequence of building large dams and reservoirs on some rivers in the world, one has started noticing the ecological results and also the economic results of some changes in certain ecosystems.

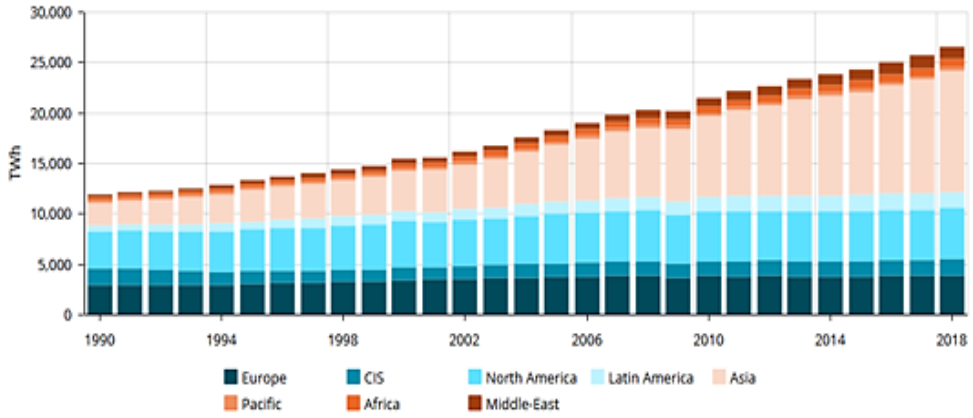

Figure 1. World electricity production; trend over 1990-2018

Source: https://yearbook.enerdata.net

Ecological and Economic Costs Generated by Hydroelectric Plants

A series of emerging countries, such as China, have based their electricity production on coal power plants, due to the large deposits of lignite it owns, the associated level of pollution being high, the environmental costs being also high. In fact, China is ranked first on the Globe regarding the coal-based electricity, as 70% of the total electricity is produced based on coal (www.worldatlas.com). Other countries, especially the ones with high development degree, started choosing more and more

electricity producing technologies which, in their opinion, have a reduced impact on the environment, the so called "green energy". Most also include the hydropower plant based electricity in this category. Going back to the case of China, this country also owns another interesting record: first place on the hydropower plant based electricity ranking (https://ceoworld.biz). This data is not contradictory, as China tries by all means to satisfy its huge growth of the energy consumption, which has been needful to a sustainable economic development during the last decades.

Within the EU, the directive 2009/28/CE has implemented some mandatory targets for all member states, so that by 2020 to increase the percentage of the energy resulted from the so called renewable sources. Thus, this type of energy has had a considerable development, as it has doubled its percentage in the final gross energy consumption between 2012 and 2016, reaching approximately 17% in 2016 (https://ec.europa.eu/eurostat). Hydro power is also included in this category.

If we analyze other recent data for the European states issued by the previously mentioned source (Table 1), we notice that the percentage of the renewable sources in the internal gross energy consumption in 2016 is different from a country to another. We observe two interesting things here: by far, we can observe the situation of Norway, with a high percentage of hydro power (44.2%), followed by only several countries that reached at least 10%: Albania (29.5%), Iceland (20.8%), Montenegro (16%), Sweden (10.8%) and Austria (10.1%). Considering that, the conclusion that could be taken is that the hydro power is incompletely harnessed in nearly all states and that their percentage could significantly grow as a result of some massive investments in hydroelectric arrangements.

Table 1. Share of Renewables in Gross Inland Energy Consumption, 2016

	Renewable energy	of which: Biofuels & renewable wastes [2]	Hydro power	Wind power	Solar energy	Geothermal energy
EU-28	13.2	8.6	1.8	1.6	0.8	0.4
Belgium	6.8	5.4	0.1	0.8	0.5	0.0
Bulgaria	19.7	7.2	1.9	0.7	0.8	0.7
Czech Republic	10.3	9.3	0.4	0.1	0.5	0.0
Denmark	29.7	21.7	0.0	6.3	0.7	0.0
Germany	12.3	8.2	0.6	2.1	1.2	0.1
Estonia	25.5	14.7	0.0	0.5	0.0	0.0
Ireland	7.5	3.4	0.4	3.6	0.1	0.0
Greece	19.9	4.6	2.0	1.5	2.2	0.0
Spain	14.3	5.6	2.6	3.4	2.6	0.0
France	9.9	6.6	2.1	0.7	0.3	0.1
Croatia	28.3	15.1	6.9	1.0	0.2	0.1
Italy	16.8	8.5	2.4	1.9	1.4	3.6
Cyprus	6.3	2.1	0.0	0.5	3.3	0.1
Latvia	37.0	31.8	5.0	0.3	0.0	0.0
Lithuania	29.5	19.7	0.5	1.4	0.1	0.0
Luxembourg	5.3	4.0	0.2	0.2	0.3	0.0
Hungary	11.7	10.5	0.1	0.2	0.1	0.5
Malta	3.4	1.3	0.0	0.0	2.1	0.0
Netherlands	5.7	3.5	0.0	0.9	0.2	0.1
Austria	29.7	17.3	10.1	1.3	0.8	0.1
Poland	8.8	7.4	0.2	1.1	0.1	0.0
Portugal	24.2	12.4	5.8	4.6	0.7	0.7
Romania	19.1	12.0	4.8	1.7	0.5	0.1
Slovenia	16.5	9.7	5.7	0.0	0.5	0.7
Slovakia	9.5	6.9	2.3	0.0	0.3	0.1
Finland	30.7	26.0	3.9	0.5	0.0	0.0
Sweden	37.1	23.6	10.5	2.7	0.0	0.0
United Kingdom	8.1	5.7	0.7	1.7	0.5	0.0
Iceland	82.7	0.3	20.5	0.0	0.0	61.6
Norway	50.1	5.3	44.2	0.7	0.0	0.0
Montenegro	33.7	17.6	16.0	0.0	0.0	0.0
Former Yugoslav Republic of Macedonia	14.2	7.5	6.1	0.4	0.1	0.2
Albania	42.0	11.9	29.5	0.0	0.6	0.0
Serbia	13.1	7.0	6.1	0.0	0.0	0.0
Turkey	12.3	2.2	4.1	1.0	0.7	4.3
Bosnia and Herzegovina	15.6	8.4	7.2	0.0	0.0	0.0
Kosovo[1]	14.3	13.5	0.8	0.0	0.0	0.0

eurostat

(1) This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.
(2) The category 'Biofuels and renewable wastes' includes wood and solid biofuels, liquid biofuels, biogas and renewable wastes.

Source:https://ec.europa.eu/eurostat

By enlarging the study area at global level, other researchers (Zhou, 2015) notice the significant potential of hydropower (Fig. 2); authors talk about "a total global potential of gross, technical, economic, and exploitable hydropower" and estimate these potential categories "to be approximately 128, 26, 21, and 16 petawatt hours per year" (1 petawatt = 10^{15} watts).

Figure 2. The Top-100 Hydropower Potential Countries (Hydropower and Electricity Demand are in Log Scale and the Number on the Bar is Exploitable Hydropower Potential)

Source: Zhou, 2015

At first glance, in this case also, at global level, we notice the same phenomenon, namely an under usage of hydro power.

Though, if we make a more complex analysis on the situation, if we study the impact on the environment and even the economic consequences of implementing hydropower plants, either small or large, we reach conclusions which show that hydropower is not as green as it seems after a superficial study. In these cases this phrase is valid, too: "*In many cases, after a while, the benefits brought by a certain economic activity (for which an ecosystem had to be changed or even destroyed) are far lower than the loses*" (Turtureanu, 2018).

We firstly debate over older cases that support our arguments and which represent study cases in ecology (Botnariuc & Vădineanu, 1982). Hence, the building of the Asuan (Egypt) dam has been finalized in the second part of the XXth century, in 1970; the associated hydropower plant generates electricity, the agricultural production in the area has significantly grown, the course of the Nile has regularized and the navigation is much safer. By building the dam, floods were avoided. As a result of the water resource, the region developed unseen fields such as industry,

fishing, tourism and agriculture. We obviously consider them as "benefits". There are many controversies regarding the ecological effects and also economic effects of this dam. Though some reports accentuate the positive economic effects (Biswas, 2002), other studies conclude that the effects on the environment are so serious that the economic damage is much larger than the benefits, recommending the destruction of the dam, as many scientist analyze the phenomena from more perspectives. To this extent, the recent volume (2019), *Grand Ethiopian Renaissance Dam Versus Aswan High Dam. A View from Egypt (editors:* Negm & Abdel-Fattah) expresses the various opinions of more scientists. Amongst the negative effects of the dam's appearance, one can see: the coast erosion generated by the retention of the sediments in the lake, as only a small volume of sediments pass over the dam; the saturation of soils, due to the water evaporation used for irrigations; the collapse of the ecosystems in the eastern part of the Mediterranean Sea, as the role of the sediments transported by the Nile and spilled in the sea are vital to a multitude of marine organisms. As an effect, the fishing in the area has suffered much. Moreover, sediments that used to be transported by the Nile originated in the erosion generated by the tributary rivers of the Nile that were draining the Ethiopian Plateau, with volcanic origins; in fact, sediments originated in the very fertile volcanic ashes that were cemented in volcanic tuff (Dorobăţ, 2012). We know that, from immemorial times that the Nile flooded several times a year and naturally fertilized its meadows, leading to agricultural productions that could support the civilization that built the pyramids. Alongside the construction of the dam, the retention of sediments behind the dam and the impossibility of the Nile to naturally flood the meadows, have led to the decrease of the fertility and to the needing that what was once made by nature to be compensated through artificial fertilizers, less assimilated, with all associated costs and insufficiencies. Moreover, the stagnated water in the lake led to the development of mosquitos which spread malaria, contaminating and killing people (Botnariuc & Vădineanu, 1982). According to many scientists, the damages generated by the dam are far more than the so called advantages. Nor the construction of the hydropower plants on the Danube, Porţile de Fier I and II does not lack economic and ecologic costs; alongside the well-known benefits, we must also include in this chapter the same problem related to the retention of sediments in the Black Sea and the erosion of the coast area, south of the Romanian shore. The environmental problems are the result of the impossibility of some fish species to spawn upstream, on the Danube, in traditional locations, sometimes reaching even Wien (www.wwf.ro). The shortage of this area to only 863 km has exposed some valuable species, such as the Danube mackerel (*Alosa immaculata*), sturgeons

(producing caviar) to the danger of extinction; sturgeons are currently some of the most endangered animals on the IUCN endangered species list,they appeared 200 million years ago, four of the five species of sturgeons in the Danube are in danger of extinction (www.wwf.ro).

The reports regarding the sturgeon catch (*Acipenser gueldenstaedti*, *Huso huso*) have indicated significant decreases, even 10 times lower compared to the period right after the finalization of Portile de Fier I (www.wwf.ro). The Portile de Fier reservoirs aren't equipped with special technique that would act as side trips designed to easy the migration of fishes; there are technical solutions that would allow the modification of the building, but they are very expensive; organisms such as WWF, the International Commission for the Protection of the Danube River recommend the building of these side trips. A famous case of cross-border problems was also the dam that was to be built in Nagymaros (Hungary)-Gabcikovo (Slovakia), for hydropower production (Galambos, 1993). Hungary gave up on the construction claiming environmental issues, in 1989, and the litigation between the states was solved through international courthouses. An eventual construction of another dam in Turnu Măgurele-Nikopole area would drastically reduce the chances of these species to survive. There are similar cases all over the world, as there is no area with minor environmental problems. The recent appearance of some hydro technical buildings, large dams in China, on Huang He or Yangtze rivers, have led to similar issues signaled by various authors (e.g. Li et al, 2017; www.mtholyoke.edu/~lpohara/Pol 116/enviro.html; Kong et al, 2016), by organizations such as Wordwatch Institute (www.worldwatch.org) or even by National Geographic Society. If in the case of Asuan, one can claim that at the moment, few was known about ecology, about what environmental problems could be generated, in subsequent cases, one could not use this excuse any more.

Not only hydropower plants' building on large rivers generates serious environmental problems. In numerous literature studies, attention was drawn on the fact that these micro hydropower plants that were built or are to be built in Romania, 550 by 2020 (www.wwf.ro) seriously damage the environment and lead to both ecologic and economic damages in time. We can give some examples of published alarm signals. In our numerous travels through Făgăraş, in Capra, Otic, Buda etc areas, we witnessed the intervention, the arrangement of some mountain riverbeds, designed for the construction of micro hydropower plants. Alongside the environmental impact in the moment of the micro hydropower plants' finalization (very large debit fluctuations, very large fluctuations of water temperature; obstacle

for the migration of living creatures; the destruction of some ecosystems etc.) (www.natgeo.ro/; https://peterlengyel.wordpress.com). We also notice another significant problem which isn't approached by many: the impact on the environment of the hydropower plants construction process and the pipelines themselves. Though the impact study does not mention such issues, it practically supposes the installation of excavators, bulldozers in the river bed, excavations and the usage of the gravel from the riverbed, which is ecologically dangerous and totally forbidden and obviously, not mentioned by the construction companies. The riverbed is deviated in most of the cases, leading to the total extinction of the bioderm (Bleahu, 2004; Truță Vlăduțu, 2006; 2008), the ecological barbarously reaching its peak. Also, pipelines were installed in many cases modifying the banks. Obviously, the authorities in charge of sanctioning such acts are absent. They shouldn't have even authorized the construction of such micro hydropower plants, which shows that the impact studies were extremely superficial and poorly issued. Things are interesting if we also consider the fact that companies that exploit the micro hydropower plants, which benefit from the electricity production, do not support environmental costs, the damages on the environment. This is why one cannot summon the lack of precedence, the lack of knowledge regarding the environmental impact, because, in this area too, on the Vâlsan, as an effect of hydropower buildings, an endemic element, the *Romanichthys valsanicola* fish species, has almost extinct (Truță Vlăduțu, 2005). The biodiversity, the conservation of natural capital are endangered (Turtureanu et al., 2018b).

At a certain moment, this species was endemic for Argeş, Doamnei and Vâlsan Rivers. Hydrotechnical arrangements on Arges, many of which useless, have almost eliminated this species, as well as on Doamnei River. The last area where this species maybe still survives, is represented by only several km on the course of Vâlsan River.

Considering all of the above, we propose that alongside the potential of gross, technical, economic, and exploitable hydropower concepts, used by Zhou et al (2015), the introduction of another concept"ecological exploitable potential". The calculation of such a parameter is still a very challenging, complex and difficult tryout.

Conclusions

Electricity produced in hydropower plants, irrespective of their size, is not green energy, whose production would have an insignificant impact on the environment. On the contrary, in many cases, the impact is devastating, irreversible, also leading to not only ecologic, but also economic losses, which make the benefits lower than the losses.

It is necessary to consider the potential of ecological exploitable hydropower of the rivers, any other parameter leading to ecologic errors with serious economic results.

The environmental impact study in the case of hydropower plants construction must be very complex, interdisciplinary, not to be limited only to the area of the reservoir or of the dam, but also to identify and approach the effects on a wider geographical area and on a larger period of time.

Hydropower is an energy source only as long as the impact on the environment doesn't pass over its supportability capacity.

Hydropower is an economically viable clean energy source as long as the environmental costs are lower than the benefits and as long as these benefits, as costs, are equally distributed from the social perspective, at the level of the socio-economic system.

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