ASSESMENT OF SHP'S EFFECTS ONTO ENVIRONMENT

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The promotion of renewable energy sources is placed high on the priority list of the EU, both for their ecological characteristics and the benefits deriving from their use. In this regard the most significant document is the 2001/77/EC Directive on the promotion of electricity produced from renewable energy sources, which sets out the target shares of renewable energy sources in electricity generation of 22% in 2010.

Based on the above mentioned guidelines, but also taking into consideration Romania's renewable sources potential, a target for the generation of 33% of the overall electricity consumption from renewable sources by the year 2010 was established (including large hydropower plants as well). Also, in 2001 Romania ratified the Kyoto Protocol and committed itself to reduce greenhouse gas (GHG) emissions by 8% in the first commitment period 2008-2012 comparing with the base year (1989).

When referring to the use of renewable energy in Romania, one actually speaks of hydropower, as the other sources are poorly represented (a small number of wind, solar, biomass and geothermal projects have been implemented in the country). Regarding the hydro development, Romania has a long history: the first SHP's are recorded at the end of 19th century, some of them being up to now under operation. Still, the opportunities for hydro development are very good, around 5000 locations in Romania being identified as favourable for small HPPs. In the development of new SHP's, beside the energy production assessment (the estimation of the water available, the flow rate and the head, which allow the evaluation of the energy production) and economic appraisal (based on the estimated annual energy production, an estimation of the annual income can be made), the effects onto environment must be examine as well, even if it is well known that properly designed small hydro schemes are easily integrated into local ecosystems. This paper presents the main aspects regarding the environmental effects of small hydro development. Some specific effects identified in several operational SHP's are described.

Keywords: renewable energy, small HPPs, the environmental effects

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1. Introduction

At the "Third Conference of the Parties to the United Nations Framework Convention on Climate Change" held in Kyoto in December 1997, the European Union has accepted the urgent need to tackle the climate change issue. A target to reduce greenhouse gas emissions by 8 % by 2010 from 1990 levels has been also adopted. A very important step in the reduction of CO2 emissions is the development of energy from renewable resources

Therefore the EU Council and Parliament has brought forward Directive 2001/77/EC for the promotion of electricity produced from renewable energy resources.

Electricity production from hydropower has been, and still is today, the first renewable source used to generate electricity. Nowadays hydropower electricity in the European Union - both large and small scale – represents, according to the White Paper, 13% of the total electricity generated, so reducing the CO2 emissions by more than 67 million tons a year.

The main disadvantage of conventional hydro is the requirement of large areas of land flooding, with its consequential environmental and social issues. In this context, the properly designed small hydro schemes are easily integrated into local ecosystems.

When referring to the use of renewable energy in Romania, one actually speaks of hydropower, as the other sources are poorly represented (a small number of wind, solar, biomass and geothermal projects have been implemented in the country).

Regarding the hydro development, Romania has a long history: the first SHP's are recorded at the end of 19th century (the first one was commissioned in 1898, on the Sadu River, with an installed power of 1,28MW), some of them being up to now under operation.

Even if Romania is rich in water resources, this type of energy resources have been ignored for a long time, due to the existence of readily available fossil fuels. The evolution of the total installed hydropower capacity has a higher rate of development was registered in 1960 – 1990, while after 1990, hydropower development stagnated due to small investment funds from the public budget.

Nowadays, the Romanian government is strongly encouraging the private capital investment in the development of SHPP's, given the fact that about 5000 locations in Romania were identified as suitable for the construction of SHP's. A great pressure results also from the agreement with the EU objectives of ensuring 12% from our energy production with renewable by 2010.

2. The Environmental Impact Assessment

The environment is the complex of physical, chemical, and biotic factors (as climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival.

As any other man-made developments, small hydropower plants greatly affect the surrounding environment, having both negative and positive effects, which can be summarized as follows:

a) With regard to the part of environment in which the effects are manifesting:
   - functional effects: which result from the main purpose of the development (water flow regulation, water supply, energy generation, flood prevention, water quality improvement);
   - ecological effects: which refers to the direct or indirect action upon various living species;
   - geophysical effects: which refers to the changes in the abiotic environment (changes in the geological, hydrological, hydrogeological, seismic, morphologic features and so on);
   - economical and social effects: are expressing the effects onto the antropic environment (modification of landscapes quality and destination, displacement of persons, appearance of new localities, modification/alienation of archaeological, cultural and historical heritage, development of tourist activities);

b) With regard to the quality of the effects:
   - positive effects;
   - negative effects;
   - indifferent effects;

c) With regard to the manifestation probabilities of the effects:
   - sure effects;
   - probable effects;
   - uncertain effects;
   - unknown effects;

d) With regard to the period of manifestation:
   - permanent effects: their action is manifesting continuously over time;
   - temporary effects: their action in time is limited;

e) With regard to the moment of manifestation:
   - Immediate effects;
   - Medium term effects;
   - Long time effects**;**

f) From the quantitative and qualitative significance:

- Important effects, which essentially modify the pre-existent situation;
- Medium value effects;
- Minor value effects.

Thus, the Environmental Impact Assessment is a very important step to be undergone by the government and SHPP beneficiary. The impact studies must provide the relevant authorities with all the necessary elements to take a decision.

Therefore, the study must contain, stated in a scientific way, all the effects of the project on the environment.

As a decision process, an Environmental Impact Assessment is significant when is present a multiplicity of alternatives among which a choice is possible: different project and design alternatives must be taken into consideration (including the so called "zero alternative" - that is no small hydropower plant realization), and the relevant impacts must be analyzed.

Impacts of hydropower schemes are highly location and technology specific.

During the design, construction and operation stages, the environment can be affected by: **vegetation cutting** – which is important for the impoverishment of the forests, for the disfigurement of the landscape caused by visual impact, for the riverine erosion; **excavation work** – which is a very important aspect in the case of protected areas, is necessary to find a place for the excavated rock and its reuse, it influence the groundwater regime, the stability of slopes, the dusts, and so on; **temporary diversion of rivers**, which can be made in different ways (by a temporary earth dam, by a pipe system, and by many other ways depending on the particular site situation) and the negative effects depend on the diversion system used and refers to the aquatic life (it heavily affects the riparian life), the bed load transport regime and the water surface elevations upstream (major risk of inundation during flood events in the construction phase) and downstream (significant reduction of water levels till to complete drying up; one method for the limitation of its negative impact is the guarantee of minimal flow downstream of the diversion works); **water courses dredging** - the action has a great impact onto aquatic life, but positive aspects can appear especially in the case of rivers with large amounts of alluvial material deposited; in this case the dredging can be a way for the river "maintenance"; **reservoir construction** - is created by damming the watercourse and, as effects, in addition to the loss of ground, excavation works, the construction and opening of construction roads, and even - depending of the dam size- concrete manufacturing plants, can be mentioned the modification induced to the river regime (water velocities, the levels upstream and downstream of the dam, the sediment transport and so on) and, consequently, the whole environment around (vegetation, fauna) and the landscape; the main positive effects (even it is unlikely to meet large reservoirs in SHPP schemes) is the possibility of producing energy at times of low flow or increased demand and with the regulation of flow rates and the reduction of peak flows during flood events; **the construction of water intakes, open channels, penstocks, tailraces, powerhouses etc.** - the impacts generated by the construction of these structures are: noise affecting the life of the animals; danger of erosion due to the loss of vegetation consequent to the excavation work and affecting the turbidity of the water; downstream sediment deposition, etc.; **road construction, enlargements of small roads and road traffic** - depending on the particular situation, those can have negative impacts (tree cutting, the perturbation of animals, traffic emissions, possible road accidents) or positive effects (the economy of the area increase, with the consequent benefits for local people, better access to the area, jobs created); **temporary displacement of persons, roads** - the realization of small hydropower plants doesn't require displacement of person because they do not involve large basins; the temporary displacement or interruption of roads is frequent, especially where penstock is installed under the roads to minimize the final visual impact, but even if the action refers to temporary situation, the negative impact can be relevant and must be taken into consideration; **transmission lines** – they affects mainly by visual intrusion; the transmission lines in SHPP schemes are 66kV or lower, so they can not be perceived like a threat to human health due to electromagnetic field generation; **noise and vibrations** – the sources of noise from a small hydroelectric plant may be numerous: trash rack cleaner, trash conveyor, generator, gearbox, turbine, transformer, but noise comes mainly from the hydroelectric unit and, when used, from the speed increasers; the allowable level of noise depends on the local population or isolated houses near to the powerhouse; in the case of high mountain diversion scheme, the direct coupling of turbine and generator is possible, so the component responsible for most of the vibrations is eliminated; also, this effect is meet during the design stage, when the geological survey is carried out and during the construction stage, when the area is very affected from this point of view; **landscape impact**: each of the components that comprise a hydro scheme has potential to change the visual impact of the site by introducing contrasting forms, lines, colors or textures; the design, location, and appearance of any one feature may well determine the level of public acceptance for the entire scheme and appropriate measures bust be taken, like painting the structures in non-contrasting colors and textures to obtain non-reflecting surfaces, which will blend with or complement the characteristic landscape.

3. Specific Environmental Effects of SHPP

The Belareca – Cerna hydroelectric development is situated on the Cerna River Basin, in Caras Severin County, and has a surface of 454 km^2. It contains 2 heads: the Herculane Head, commissioned in 1988, and the Belareca Head, not commissioned yet.

The development has a great negative impact with regard to the temporary displacement of population. On the other hand, the development leads to a raise of the economy in the area, improvements in water supply and irrigation, development of tourist activities with the consequent benefits for local people. The afore mentioned lakes prevent the riverine areas from flooding, and by the water storage realised, the minimum flow of water downstream all over the year is assured, maintaining the flora and the fauna. The regime of groundwater has been modified, the groundwater levels being influenced, in the upstream and downstream as well. The river flow modification and the rise in water temperature lead to the invasion and migration of some of the crustacean species and cause even the disappearance of few invertebrate species.

The area is situated in the neighbourhoods of the Domogled-Valea Cernei National Park, one of the most important parks in the country regarding the geological originality and momentousness. Due to the limestone soils, unique ecosystems are encounter and the urge of protecting and conserving them is rising. The following protected vegetation can be mentioned: Nigritella rubra, Trollius europaeus, Rhododendron kotschyi, Iris graminea, Crocus moesiacus, Sorbus borbassi, Colchicum haynaldi. There is also a very important invertebrate's fauna, 45% from the Romania's Lepidoptera fauna being located in this area.

The fauna of vertebrates is very rich also, which includes a lot of species protected by law like: the chamois (*Rupicapra rupicapra)*, the Eurasian Lynx (*Lynx lynx*), the brown bear (*Ursus arctos*), the bats (*Chiroptera*), the Common Kestrel (*Falco tinnunculus*), the Golden Eagle (*Aquila chrysaetos*), the Common Buzzard (*Buteo buteo*), the Lammergeier (*Gypaetus barbatus)*, the Egyptian Vulture (*Neophron percnopterus*), the Griffon Vulture (*Gyps fulvus),* the Eurasian Black Vulture (*Aegypius monachus*), the Capercaillie (*Tetrao urogallus*), the Tawny Owl (*Strix aluco*), the Common Raven (*Corvus corax*), the *horned viper(Vipera ammodytes),* the Aesculapian Snake (*Elaphe longissima* or *Zamenis longissimus*), the Hermann's Tortoise (*Testudo hermanni*), the grayling (*Thymallus thymallus*), the Danube salmon (*Hucho hucho*).

The Cerna – Motru – Tismana Major Development. The Cerna – Motru – Tismana Major Development is located in the Gorj County, in the mountain and subcarpatic area of Godeanu Mountain and Mileanu Mountain, on the Motru River, Tismana River and Bistrița River. The hidroenergetic system contains 5 lakes (Cerna, Motru, Vâja, Clocotiş and Downstream Tismana), 4 hydroelectric power plants (Motru, Tismana, Clocotiş and Downstream Tismana) and 3 headraces (Cerna-Motru, Motru-Tismana şi Bistrița-Clocotiş-Tismana). The system contain 2 small hydropower plants: Clocotis HPP and Tismana Downstream HPP.

Considering the fact that both of the SHPP are part of the Cerna – Motru – Tismana Major Development, their impact over the surface water quality can not be treated separately from the one produced by the hydroenergetics system.

The construction of dams and reservoir heavily affected the waters of Bistrita River. The river regime is modified in the upstream and downstream area of the dams.

In the upstream area, the reservoir construction determines low water velocities and high water depths due to the dam construction. In the downstream area the river regime is highly pulsatory and variable, depended on the water turbinated by the HPP. None of the lake has undergone major changes in water quality (like eutrophication and lacustrian vegetation growth). It must be mentioned the wave apparition at the lake surface, which contribute to the lakeside erosion.

The alluvial transport is the major effects produced by the HPP developments. There are many negative effects since the dynamic equilibrium of the river is extremely damaged: the lakes are clogged (Tismana Downstream Lake is 40 – 50% clogged; Motru Lake is clogged just in the 5 cm at the dam and 20 cm at the lake end; Vaja Lake is not presenting an important clogging phenomenon). In the downstream area of the dams, the alluvial transport is almost nonexistent, contributing this way to the river sides erosion. Due to the rocky soil structure, the river sides' erosion is not very severe, excepting the Tismana River sides, on 17.8 km length, where the soil is formed by sand, gravel, and marl clay. In this area the rivers sides were consolidated. Also, in Arjoci Village, Godinesti Commune, Gorj County, a SHPP will be constructed, having as effect flow water regulation of Tismana River on 8 km length, and the river sides' erosion decrease.

In Cerna - Motru – Tismana development, due to the geographical position and geomorphologic structure of the area, the groundwater are not very affected. Only in the Motru storage area is reported a rising of the groundwater level and consequently, a bigger spring flow and even new springs appeared.

The climate is not affected at all.

With regard to the river water quality, the geographic position and the rivers slope assures high water velocities which allow a good water aeration and autopurification as well. The water quality in Cerna River is of good quality – with respect to the organic matter and mineral content the water is in the first quality category (excepting the total phosphorus, phenols and zinc) and, from the specific toxic indicators, is in the second quality category.

The specific indicators for the eutrophication in Cerna Lakes showed the following: the water saturation in oxygen is above 70 % and the suprasaturation phenomenon was not enregistered, values which underline the lake's oligotrophy;

the organic matter mineralization capacity, expressed by CCO_{Mn} (mg O/l) and dizolved oxygen concentration, varies between 31- 76 %, which sugest the lake's mesotrophy; nutrients concentration were 0,220 mg N/l for the total mineral nitrogen (reflecting the lake's oligotrophy) and 0,019 mg P/l for the total phosphorus (reflecting the lake's mesotrophy). Concluding, the above values reveals that Valea lui Iovan Lake waters are first quality waters, as well as Tismana Lake waters, while the trophic state of Valea lui Iovan Lake can be characterized by a oligotrophic - mezotrophic level whereas Tismana Lake by a oligotroph level.

Regarding the impact onto the biologic environment, Cerna-Motru-Tismana hydroenergetic complex has significantly effects. The Cerna Lake assures the proper condictions for trout and Eurasian minnow (*Phoxinus phoxinus*), which is a good indicator of the quality and oxygen content of streams and rivers. Unfortunately they are endangered by poaching, which already cause the disappearance of Danube salmon from Cerna River. One piece of European eel was fish from the Cerna River, which is a very curious thing regarding the fact that European eel spent part of the life cycle in the sea and part in freshwater rivers, being often common on the shore.

With respect to water use, the hydroenergetic complex, which purpose is, beside the electricity generation, the water supply for the Jiu Basin consumers as well, assures a rise of the average flow with 9,5 m^3/s now, and the value will be of 10,5 m^3/s, when the complex will be fully functional, and will assure the water for irrigation for 34 000 ha.

The area is now economically developed, and tourist activities can be performed. Only Tismana Monastery (1385), which is one of the oldest monasteries in Romania, can be mention as cultural and archaeological heritage.

The main tourist attractions in the area are the Tismana Monastery and the Domogled-Valea Cernei National Park.

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