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Hydropower production from bridges in urban or suburban areas

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A new technology for hydropower production from rivers crossing urban or suburban areas is proposed, based on the use of Cross-Flow turbines having its axis horizontal and normal to the flow direction. A large part of the river cross-section could be covered by the turbine cross-section and this would generate a small, but consistent jump between the water levels of the inlet and the outlet sections.

The turbine should be anchored to a pre-existing bridge and the total length of its axis should be of the same order of the bridge length. Due to the large axis extension, it should be possible to easily attain a gross power similar to the power produced with a more traditional installation, based on weirs or barrages, if single jumps of few tens of centimeters were added over a large number of bridges. If the bridges were set in urbanized areas, the production of electricity would be located close to its consumption, according to the smart grid requirements, and the hydrological basin at the bridge section (along with the corresponding discharge) would be greater than the basin of traditional plants located in more upstream locations.

The maximum water level to be attained in the upstream section of the bridge should be the minimum among the following ones: 1) the level corresponding to the maximum flood allowed by the surrounding infra-structures, 2) the level corresponding to the maximum force allowed by the bridge structures. The resulting upstream water level hydrographs should be compatible with the river suspended and bed load equilibrium and with the requirement of the aquatic living population. The system should include a mechanism able to raise the turbine completely out of the water level, if required, for maintenance or other purposes. The complete lifting of the turbine could be used to: a) reconstruct the natural river bed profile during floods, b) allow the navigation or fish movements during some periods of the year, or even some hours of the day.

A possible technology which would allow the accomplishment of the proposed targets is the use of a Cross-Flow turbine, arranged according to the scheme of Fig.1, where:

- the position of the rotating wall (r_w) is set according to the pressure measured at its top, so that a small but constant falling discharge (Q_2) is guaranteed. This falling discharge allows the transition of floating objects and hid the all machinery, with an obvious skyline improvement.

- the average distance d is set in order to guarantee in the confined channel below the turbine an average velocity V similar to the original one existing in the river.

Fig.1 - Scheme of the river Cross-Flow turbine.

Observe in Fig.2 the results of a CFX simulation, carried on with the following input data for a large rectangular section per unit width:

ho (m)	**h_1(m)**	**h_2 (m)**	***d*(m)**
1.5314	**1.99**	**0.082**	**0.1021**
Q_2(m^2/s)	**Q_3(m^2/s)**	**w (r.p.m.)**	**V_0(m/s)**
0.04	**0.267**	**27**	**2.61**

Table 1. Input data for the CFD simulation.

Simulation have been carried out using ANSYS code, with a computational domain divided using both tetrahedral and prismatic elements.

The mechanical power estimated at the rotational shaft was of 4.84 KW/m and the hydraulic power of the water stream was of 7.25 KW/m. Thus the turbine efficiency was of about 49.97 %.

Fig.2 - Vectors velocity water field close to the Cross-Flow turbine domain.

From the environmental point of view the turbine constitutes nonetheless a physical barrier that moving organisms will have to negotiate on their movements through the blades, particularly larger ones such as fish. Also, the hydraulic environment of the river will be modified, e.g. turbulence, shear stress, pressure and flow patterns, affecting as well the smaller organisms. While developing the turbine, a thorough appraisal of its environmental consequences for aquatic ecosystems has to be done, in order to develop an environmentally-friendly structure, embedding mitigation aspects.

Furthermore, the structure itself will be subject to colonization on its surfaces by a biological matrix including microbial organisms but also filamentous algae and aquatic macrophytes, either anchored of clogging to the structure while drifting downstream. When developing the turbine, the side-effects of such epibiosis have to be evaluated, given the evidence already existing in rivers and canals, of harmful vegetation interfering with irrigation and transport structures.