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ON THE ADVANTAGES OF THE UNDERWATER TURBINES COMPARED TO WIND TURBINES: ECOLOGICAL ASPECT

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As it is widely known, wind energy is one of the most promising options for transitioning to clean, renewable energy harvesting processes. At the same time, this method of generating electricity also has quite negative aspects, which are discussed below in comparison with underwater systems for collecting clean ocean energy.

First of all, the main direction of development of wind power plants is associated with the creation of giant blades (more than 100 meters long [1]), the only manufacturing option for which is the use of composite materials, which are extremely difficult to recycle after the blades have been used. It is well known that at the moment, used blades are simply buried in the ground in the hope that in the future the necessary recycling technologies will appear. It should be noted that underwater turbines using do not involve the construction of giant installations, and existing projects are focused on creating arrays of small turbines (of modular design, as for example it is proposed in [2]). In this case, the blades can be made from easily recyclable steels or modern plastics (particularly it may be realized with using modern 3D printers and appropriate plastics types as it is shown in [3]).

The second extremely negative environmental aspect of wind energy is the direct mechanical impact of the blades rotating at high speed on birds, which often causes their death. As it is estimated in [4], there are over than 1.17 millions of birds' deaths caused by wind turbines every year only in US. Taking the wind turbine rotation frequency equal even to the next underestimate value [5]:

$$f = 0.1 \text{ rate per second},$$

for the angular velocity we get:

$$\omega = 2\pi f = 0.628 \text{ rad/sec},$$

and for the linear velocity of the hundred-meter blade tip we get:

$$V = \omega R = 62.8 \text{ m/s or } 226 \text{ km/h}.$$

Considering that the maximum speed that birds can reach in flight almost never exceeds 100 km/h, it is obvious that it is impossible for them to avoid a direct collision with a massive blade, and at such a speed an impact will most likely lead to their death. To the contrary, underwater turbine blades are to be rotated at significantly lower speeds (which is compensated by the water 800 times higher density than the air) and have much more smaller sizes. A similar calculation for a blade with a radius of 1 meter and a rotation speed of 0.5 rate per minute, gives the velocity of 0.052 m/s which is equal only to 5 cm per second. This value is much less than the maximum speed of most fishes which in most cases equals to the hundreds of centimeters per second.

Thus, it can be argued that turbines rotating underwater (which means: at low speeds) are practically safe for most marine inhabitants, while high-speed wind turbines, on the contrary, are dangerous for all birds without exception.

Also it should be noted that underwater turbines create virtually no noise pollution in the surrounding area, unlike wind farms, for which the noise they create is an important problem.

Additionally, it can be said that in most cases, wind farms are installed on land, which requires the alienation of significant areas, often of high value for agriculture or other purposes. The installation of underwater turbines obviously does not have this disadvantage. Of course, the use of arrays of underwater turbines also requires some alienation of the underwater zone (for example, areas on the shelf), but in general they are significantly less valuable in comparison with onshore areas.

Results. Thus, it is possible to conclude that underwater turbines can be considered significantly more environmentally friendly in several respects compared to popular wind options. Accordingly, the development of underwater turbine projects is quite promising and requires practical steps in the near future.

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