The Innovation

The Betz law considers a system where the air flow is not compressible. In reality the air is compressible. The air flow reflects from the blade and partially mixes with the incoming air flow. Therefore, the air density changes in the vicinity of the blade.

The Betz law says that the speed of the air flow behind the "actuator" disk cannot be zero as it can result in dramatic increase of air density. In the Betz model the air flow is symmetrical and goes through the entire disk. This flow is continuous and the air particles continue the same trajectories (during some short time) behind the disk. The air flow remains symmetrical, only its diameter increases. In the real model, the air flow changes its direction immediately after collision with the blade. The reflected air flow has two components, the first component is directed in opposite direction to the rotation of the blade in the plane of rotation and the second component is oriented perpendicular to the plane of rotation. The Betz law is not working here because the second component can be very small and no dramatic air density increase happens. The reflected air flow can move entirely aside from the blades and leaves the physical system before the next blade arrives in the same position. Principle of conservation of mass is working, but within a local volume there can be variations of air density as the system is not isolated from the surrounding atmosphere. Variations of density occur very fast, in the millisecond scale. Ability of the air system to return to an average density is an important part of the physical process. It assumes that the air flow is compressible.

In our model, it's important that in the same position we have two physical states: the blade is in the space position and no blade is in the same position. The second physical state (no blade is in the position) is used for removing the reflected air flow from the system by incoming air flow. Suppose the change of the physical state happens after 1 sec. During this time the air flow can go 5 to 10 meters. This distance is sufficient to remove the reflected air flow from the system. The next interaction of the air flow with the blade in the same position is an independent event.
In the Betz model, all the air flow sections are correlated to each other during the whole process. This actually creates the well-known limit.

In Betz law, a mechanism of transferring the kinetic energy is based on conservation of momentum. The energy transfer is the same across the disk. In the real model, rotation of the blades is described by physics of conservation of angular momentum of the system. The larger the angular momentum, the bigger energy can be generated. The angular momentum is decreased when a turbine is working. The air flow produces the torque that increases the angular momentum compensating for that decrease. It is well known that the same force can produce different torques. Therefore, the blades should be long enough. Geometry of the blade and its moment of inertia is very important in this physical mechanism. The Betz theory does not include rotational mechanics at all. The disk in the Betz theory has zero mass. This does not work in rotational mechanics at all.

The Betz model considers continuous interaction between the disk and the incoming air flow. The disk remains in its static position. Our model is a dynamic one. The incoming air flow is changing during rotation of the blades. Once the blade has changed its position, it interacts with a new air flow in a different place. This new air flow has little connection to the previous air flow because the reflected air particles move in the opposite direction relative to the movement of the blade. Practically, the blade separates the reflected air flow and the new incoming air flow.

Weight of the blades. A curved sheet metal is an ideal material for producing stiff and light structures. Moreover, our philosophy is interconnection of few differently shaped thin metal structures together. We can decrease the weight of the blades by using thinner sheet metal and making larger openings. However, it is not our purpose to make the blades extremely light because we need a reasonably large moment of inertia to produce a large angular momentum. The load and dynamic load are dependent on the ability of the system to produce and maintain the large angular momentum. The large angular momentum allows us to deal with bigger loads in a wider range.

Fatigue of the structure may occur during continuous and repetitive mechanical deformation of the structure. In our design, thin metal structures of different shapes have different deformation directions. Therefore, possible deformation of one structure is compensated by stiffness of other structures in that deformation direction. There are a few bars (hollow metal square profiles) in the structure compensating the possible deformation and twisting at most critical positions.

The mechanical design for production is ready. We have thought carefully about integration of all parts. The optimal process of bending of template flat sheet metal and the assembling procedure have been developed to be simple and cost effective. There are local metal manufacturing companies that can produce the parts of our system.

Dr. Andrei Pavlov
Founder and CEO
APLAB Oy
Tel. +358 44 2447746
e-mail: andrei.pavlov1@gmail.com
www.aplab.fi