

Introduction

Ladies and gentlemen.

As we know, transformational research is the research to find out the errors of the current scientific foundation and build the correct scientific foundation to replace it. But it is often hindered by forces that benefit from the wrong scientific foundation. For example, Copernicus's heliocentric system took 282 years, the discovery of HP bacteria took 12 years to be recognized.

Transformation research: The formula for calculating power for wind turbines, finding the scientific foundation of wind turbines is the wrong Betz law and building a replacement formula. Introduced since 2014, but not yet interested, continued to be perfected until now. Would like to introduce to you to bring wind turbines to a new era, manufactured according to scientific principles, to produce wind power at the cheapest cost. Will bring hundreds of billions of USD in profit each year for the wind power industry & reduce billions of tons of CO2 emissions each year for the whole world.

The author sincerely thanks you for your attention, comments and cooperation.

FORMULA FOR CALCULATION OF WIND TURBINE POWER

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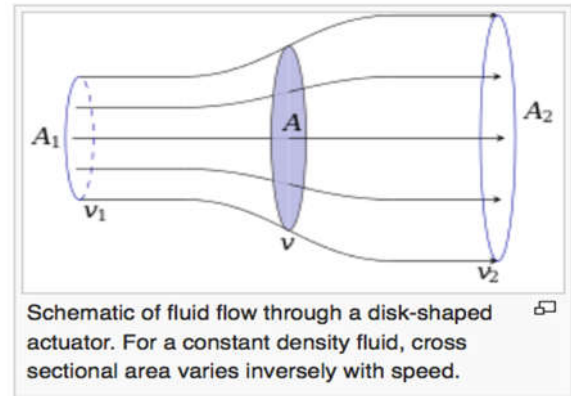
Ha Noi, VIET NAM. 09/05/2014. Complete 25/09/2025.

I. THE CURRENT CALCULATION OF WIND TURBINE POWER IS WRONG

Wind turbines are very important renewable energy production equipment. However, until now (2025), the capacity of wind turbines is still calculated according to the formula of Betz's law but Betz's law has a very serious error, due to the wrong application of 3 physical laws. As we can see:

1. Betz's law is wrong from the beginning when it ignores the phenomenon behind the turbine, all wind elements move chaotically, and in the turbine area, wind elements can collide with the blades or not, to draw a diagram of the wind passing through the turbine is a flow tube diagram, then apply the law of conservation of mass to the control volume and establish the continuity equation:

$$\dot{m} = \rho A_1 v_1 = \rho S v = \rho A_2 v_2$$



Linear wind velocities v & v_2 do not exist, so all calculations of Betz's law and other studies on wind turbines using the quantities v & v_2 are wrong.

2. Betz's law is wrong again when it considers the rotor's force acting on the wind to be equal to the mass of the air multiplied by its acceleration: $F = ma$. This is the equation of Newton's second law. Wind is a fluid, not a point object to apply this equation.

3. Betz's law is wrong again when it applies the formula: $dE = F \cdot dx$ calculating the work of linear motion to calculate the work of rotation of the turbine.

Misapplying 3 physical laws, the entire research paper does not have a single correct calculation, so Betz's law is seriously wrong, the formula for calculation of wind turbine power according to Betz's law is meaningless:

$$P = C_p \frac{1}{2} \rho S v_1^3$$

(ρ is air density; S is the swept area of the turbine blade; v_1 is the wind field velocity; C_p is the power coefficient (Betz coefficient)).

The formula of Betz's law cannot calculate the power of the wind turbine at all.

In this formula, only the blade length is the physical quantity of the wind turbine hidden in the swept area of the blade, so it has spread the wrong scientific knowledge into the human perception that: Just increase the blade length to increase the swept area, then the power of the wind turbine has increased. Leading to the current capacity of the wind turbine is announced corresponding to the swept area of the blade, as the criteria for manufacturing wind turbines, causing the wind turbine blades to be manufactured incorrectly, with very low power.

Since around 2018, published wind turbine specifications have not included the Betz coefficient. However, they still follow Betz's law. For example, a wind turbine published:

- Rated power $P = 4 \text{ MW}$;
- Swept area of the blade $S = 13275 \text{ m}^2$;
- Rated wind speed $v_I = 12 \text{ m/s}$;
- Power density 1&2 is 301 W/m^2 & $3,3 \text{ m}^2/\text{KW}$.

Power density 1&2 is the same, calculated by the Weibull function, which is equal to the power density of the wind flow with a speed of 6-7m/s multiplied by 2, it has no physical meaning and is not related to the wind turbine power, so it is meaningless.

The wind turbine power in the above example is only suitable when the meaningless formula of Betz's law is applied to calculate as we see:

$$4\text{MW} \approx \frac{1}{2} \rho \times 13275 \times (12)^3 \times C_p (\text{W});$$

Therefore, the Betz coefficient is: $C_p = 0,285$. Thus, this declared wind turbine power value is meaningless.

Wind turbines are currently published with specifications as in the example above. Therefore, the declared wind turbine power is meaningless.

If we measure the power directly or have a formula to calculate the power of a wind turbine correctly, we will see how disastrous wind turbines are due to exploiting the nonsense of Betz's law.

Therefore, it is necessary for genuine science and technology leaders, genuine scientists to research and speak up to remove Betz's law from the system of scientific knowledge, together build a formula to accurately calculate the wind turbine power and create a scientific basis for manufacturing wind turbine blades with the most reasonable length, area, tilt and configuration, for the highest capacity.

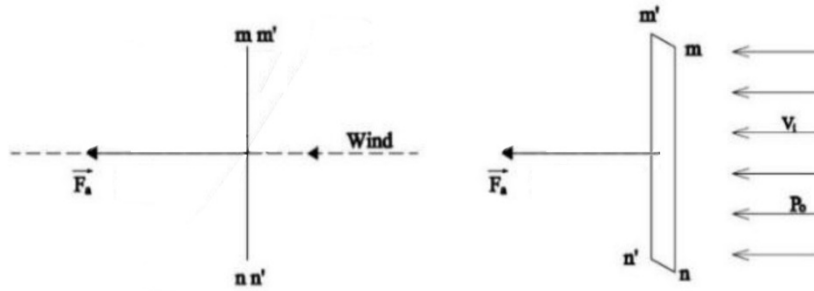
The following is a study to build a formula for calculation of wind turbine power. Please review and give comments for practical application.

II. FORMULA FOR CALCULATION OF THE POWER OF THE WIND TURBINE

2-1. Wind force - Frontal resistance.

Standing in front of the wind, holding a positive mm'n'n board forward, the wind will move chaotically behind the board, we will see the force of the wind pushing the board backwards.

The force of the wind acting on the board $\vec{F}_a$ is the frontal resistance. (Picture 01).



Picture 01

In fluid mechanics, there is a law of frontal resistance F_a when vortices appear behind the object. The formula for calculating the force F_a is:
$$F_a = \frac{C_x}{2} \rho S v^2 \quad (2-1)$$

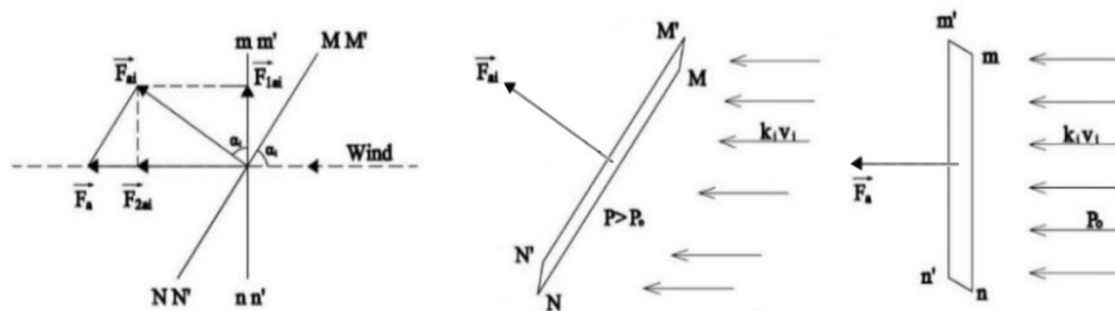
In which: C_x is the frontal resistance coefficient; S is the cross-section perpendicular to the wind direction; v is the wind velocity. ρ is the air density.

The values of C_x for objects of different shapes are in the table:

$C_x = 1,32$	1,12	0,34	0,24	0,04
Disk	Half spheres	Sphere	Cone	

(Excerpt from page 22/28 & 23/28 Chapter 8 FLUID MECHANICS by Professor Duong Hieu Dau)

The diagram analyzes the frontal drag force acting on a vertical board and an inclined board blocking the same wind flow:



a. Analyze the forces on the two boards. b. Force acting on the inclined plane. c. Force acting on the vertical plane.

Picture 02

When replacing the thin plate $mm'n'n$ with a thin plate $MM'N'N$ with area S_c and blocking the wind with cross-section S as above and inclined to the wind direction at an angle α . The frontal resistance force acting on the thin plate $MM'N'N$ is $\vec{F}_{ai}$ perpendicular to the surface $MM'N'N$;

$\vec{F}_{ai}$ is the projection of $\vec{F}_a$ on the perpendicular to the surface $MM'N'N$ (Picture 02).

The magnitude of the frontal resistance force $\vec{F}_a$ is: $\overline{F_{ai}} = \overline{F_a} \sin \alpha$

With $S = S_c \sin \alpha$; From (2-1) we have the magnitude of the wind force acting on the stationary inclined plate as:

$$\overline{F_{ai}} = \frac{C_x}{2} \rho S v^2 \sin^2 \alpha \quad (2-2)$$

Plate $MM'N'N$ is qualified to be considered as a wind turbine blade element.

2-2. Summary of wind velocity acting on the blades when the turbine rotates

2-2-1. Concept: Wind velocity reduction coefficient in front of the turbine.

When an object is placed in a wind field, the wind velocity before acting on the object will be reduced compared to the wind field velocity, which is a natural phenomenon.

This reduction is called the "wind velocity reduction coefficient in front of the turbine", denoted as k , ($k < 1$).

The wind velocity reduction coefficient k needs to be determined experimentally by investment science agencies.

The wind field has a velocity v , then the wind velocity before acting on the turbine blades is: kv .

When the ratio of blade area to swept area is less than 1/7, we can choose $k \approx 1$

2-2-2. Synthesis of wind velocity acting on the blade when the turbine rotates

We know that the sailboat runs in the direction of the wind, then the synthesis of wind velocity acting on the sail is equal to the wind velocity minus the boat velocity.

The turbine blade is tilted to the wind direction at an angle of $0^\circ < \alpha_i < 90^\circ$ and rotates perpendicular to the wind direction. We need to determine the synthesis of wind velocity acting on the blade.

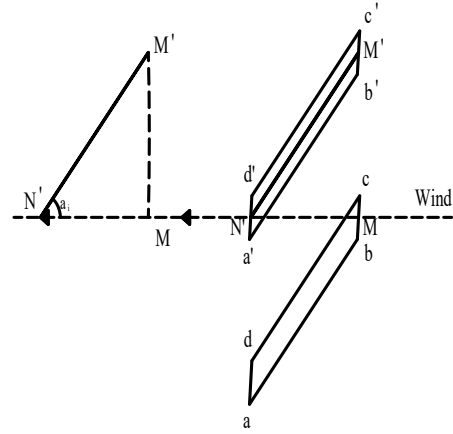
Choose a rectangular blade element i (abcd) lying horizontally on the blade, thin, short and flat (Picture3), at the i time:

- The blade element surface is inclined to the wind direction at an angle α_i ,
- The blade element center is a distance r_i from the center of rotation;
- The turbine rotation speed is ω_i ;
- The wind field velocity is v_i ;
- The wind velocity reduction coefficient is k_i

We consider the wind flow acting on the i -th blade element, which is a set of wind rays with the velocity of the wind elements being $k_i v_i$.



a A wing segment.



b Action point motion diagram

(Picture3),

Consider a wind ray, starting to act on point M located at the front edge of the blade element, the turbine rotates evenly, the point of action of this wind ray on the blade element surface, will move on the blade surface, along the line MN' lying horizontally on the blade and exit the blade element at point N', located at the back edge of the blade element, after a period of time t .

In the same period of time t , point M moves to position M' along the trajectory of arc MM'. Consider arc MM' as straight and the movement of M to M' is uniform, with the linear velocity of point M being: $r_i \omega_i$.

$$\text{We have: } t = \frac{MM'}{r_i \omega_i}$$

With r_i long enough and MM' short enough. We consider M'MN' as a right triangle at M; angle M'N'M equals α_i ;

$$\text{We have: } MN' = MM' \cot \alpha_i;$$

* During the same time period t , in the direction of the wind ray (Wind), the point of action of the wind ray on the blade element moves uniformly from point M to N' with a velocity called v_{Ci} .

$$\text{We have: } v_{Ci} = \frac{MN'}{t} = \frac{MM' \cot \alpha_i}{\frac{MM'}{r_i \omega_i}} = r_i \omega_i \cot \alpha_i$$

* The total velocity v_{Si} of the wind jet (Wind) acting on the turbine blade element surface is the velocity of the wind jet minus the velocity v_{Ci} of the point of action:

$$v_{Si} = k_i v_i - v_{Ci} = k_i v_i - r_i \omega_i \cot \alpha_i$$

All wind jets act on the blade element as the wind jet (Wind). We have the total velocity of the wind acting on a turbine blade element as:

$$v_{Si} = k_i v_i - r_i \omega_i \cot \alpha_i \quad (0^\circ < \alpha_i < 90^\circ). \quad (2-3)$$

If $v_{Si} < 0$ then the wind particles are sucked away faster, the turbine loses energy.

If $v_{Si} = 0$ then the wind particles do not act on the blade surface, it does not capture wind energy.

If $v_{Si} > 0$, the wind elements will collide with the blade element face, creating a high pressure area in front, creating a vortex behind and creating a force acting on the turbine blade. That is the condition for a turbine blade element to collect wind energy and is stated in the law of **Wind velocity synthesis acting on a turbine blade element**.

A turbine blade element only collects wind energy when the wind velocity synthesis acting on it is equal to the wind velocity in front of it minus the product of the rotation radius with the rotation speed and the cotangent of its pitch angle, greater than 0

Represented by the inequality: $k_i v_i - r_i \omega_i \cot \alpha_i > 0$; (with: $0^0 < \alpha_i < 90^0$).

In which: k_i is the wind velocity reduction in front of the i -th blade element; v_i is the wind field velocity at the i -th time; r_i is the distance from the center of rotation to the i -th blade element; ω_i is the rotational velocity of the turbine at the i -th time; α_i is the pitch angle of the i -th blade element.

2-3. The force of the wind on a turbine blade element:

Currently, the force of wind acting on turbine blades is misunderstood to be similar to the Zhukovski lift force acting on aircraft wings. There is a formula for calculating this force, but there is no formula for calculating the power of a wind turbine based on this force.

The turbine blade rotates perpendicular to the wind direction. When the turbine rotates or stands still, we imagine that there is always the same wind flow with the same cross-section blowing into the turbine blade. The turbine blade resists the movement of this wind flow, so the force of the wind on the turbine blade is the frontal resistance force.

We divide the turbine blade into n elements, with a width equal to the blade width, a length according to the blade length and short enough to be considered flat. Each blade element is considered as a thin plate $MM'N'N$ in (Picture 02). Consider the i -th blade element with:

- area S_{Ci} ,

- the angle of inclination with the wind direction is α_i ($0^0 < \alpha_i < 90^0$),
- the center of the blade element is a distance r_i from the center of rotation,
- the turbine rotates with an angular velocity at time i is ω_i ,
- the wind field velocity at time i is v_i ,
- the wind velocity reduction coefficient in front of the i th blade element is k_i ,

As we know, the total wind velocity acting on the i th blade element is:

$$v_{Si} = k_i v_i - r_i \omega_i \cot \alpha_i \quad (2-3);$$

We only consider the cases where $v_{Si} > 0$.

According to (2-2), the i-th blade element is subjected to the frontal resistance force

$$\vec{F}_{ai} \text{ as: } \overline{F}_{ai} = \frac{C_x}{2} \rho S_{Ci} (k_i v_i - r_i \omega_i \cot \alpha_i)^2 \sin^2 \alpha_i$$

Force $\vec{F}_{ai}$ is analyzed into two component forces:

The component parallel to the wind direction and turbine axis (Picture 01) has the effect of pushing the turbine $\vec{F}_{2ai}$ down, with the magnitude of:

$$F_{2ai} = F_{ai} \sin \alpha_i = \frac{C_x}{2} \rho S_{Ci} (k_i v_i - r_i \omega_i \cot \alpha_i)^2 \sin^3 \alpha_i \quad (2-4)$$

The component tangential to the rotational path (Picture 01) has the effect of making the turbine blades rotate, $\vec{F}_{1ai}$, with the magnitude of:

$$F_{1ai} = F_{ai} \cos \alpha_i = \frac{C_x}{2} \rho S_{Ci} (k_i v_i - r_i \omega_i \cot \alpha_i)^2 \cos \alpha_i \sin^2 \alpha_i \quad (2-5)$$

2-4. Moment of force

As in section 3., we have divided the turbine blade into n segments, each segment i has its center at a distance r_i from the turbine axis, the tangential component to the rotational trajectory of the frontal resistance force acting on the blade element i is F_{1ai} , as calculated in (2-5); this force will create a moment of force M_i , whose magnitude is equal to the product of the magnitude of the force F_{1ai} with the lever arm r_i .

$$\text{We have: } M_i = F_{1ai} r_i = \frac{C_x}{2} \rho S_{Ci} r_i (k_i v_i - r_i \omega_i \cot \alpha_i)^2 \cos \alpha_i \sin^2 \alpha_i;$$

The total torque M_C of the wind acting on a wind turbine blade is:

$$M_C = \frac{C_x}{2} \rho \sum_{i=1}^n S_{Ci} r_i (k_i v_i - r_i \omega_i \cot \alpha_i)^2 \cos \alpha_i \sin^2 \alpha_i$$

The total torque M of the wind acting on a wind turbine with number of blades a is:

$$M = \frac{C_x}{2} \rho a \sum_{i=1}^n S_{Ci} r_i (k_i v_i - r_i \omega_i \cot \alpha_i)^2 \cos \alpha_i \sin^2 \alpha_i; \quad (2-6)$$

2-5. Formula for calculating power for propeller wind turbines.

From (2-6) the turbine has a rotation speed at the i-th time ω_i , we have the power of the wind turbine at the i-th time equal to the product of the total torque and rotation speed, we get the formula for calculating the power of the propeller wind turbine as:

$$P_i = \frac{C_x}{2} \rho a \omega_i \sum_{i=1}^n S_{Ci} r_i (k_i v_i - r_i \omega_i \cot \alpha_i)^2 \cos \alpha_i \sin^2 \alpha_i \quad (2-7)$$

(With the condition: $(k_i v_i - r_i \omega_i \cot \alpha_i) > 0$ & $(0^\circ < \alpha_i < 90^\circ)$).

In which: P_i is the turbine power at the i-th time;

C_x is the front drag coefficient;

ρ is the air density;

a is the number of wind turbine blades;

ω_i (rad/s) is the turbine rotation speed at the i -th time;

$S_{Ci}(m^2)$: is the area of the i -th blade segment;

$r_i(m)$ is the distance from the center of rotation to the i -th blade segment;

k_i is the wind velocity reduction before the i -th blade element;

v_i (m/s) is the wind velocity at the i -th time;

$\alpha_i(0^\circ)$ is the inclination angle of the i -th blade segment.

“FORMULA FOR CALCULATION OF WIND TURBINE POWER” Power calculation formula for propeller wind turbine” has all the physical factors, it allows to calculate the power of the wind turbine accurately.

2-6. The relationship between power and pitch angle.

From “Power calculation formula for propeller wind turbines” we have the formula for calculating the power of a blade segment:

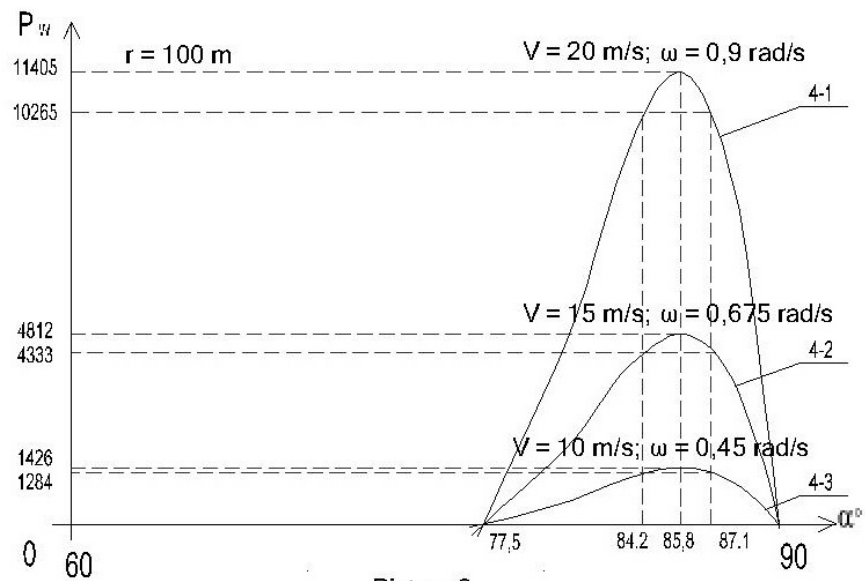
$$P_i = \frac{1}{2} C_x \rho \omega_i S_{Ci} r_i (k_i v_i - r_i \omega_i \cot \alpha_i)^2 \cos \alpha_i \sin^2 \alpha_i$$

We can draw a graph showing the relationship between the power and the tilt angle of the blade segment with area $S_{Ci} = 12m^2$ and the parameters at (Picture 3;4;5)

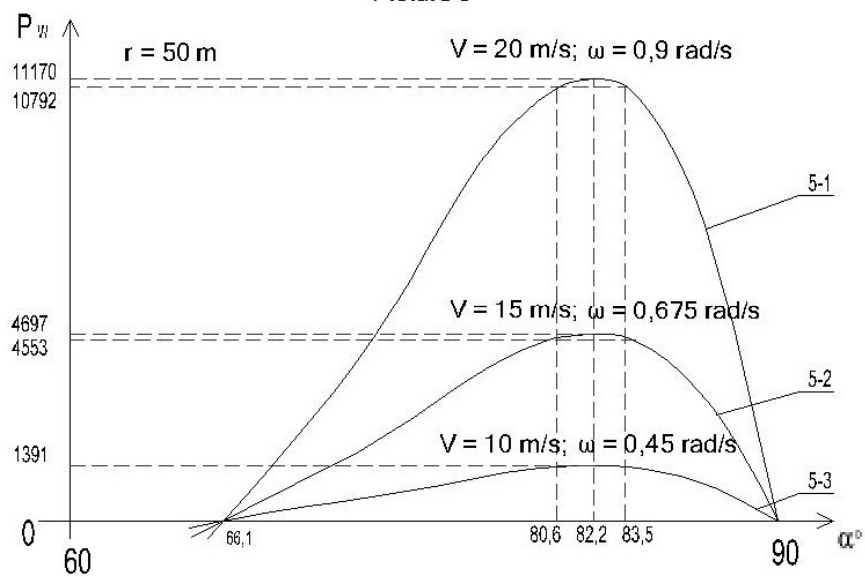
r is the distance from the blade segment to the center of rotation;

v is the wind speed at the i -th time;

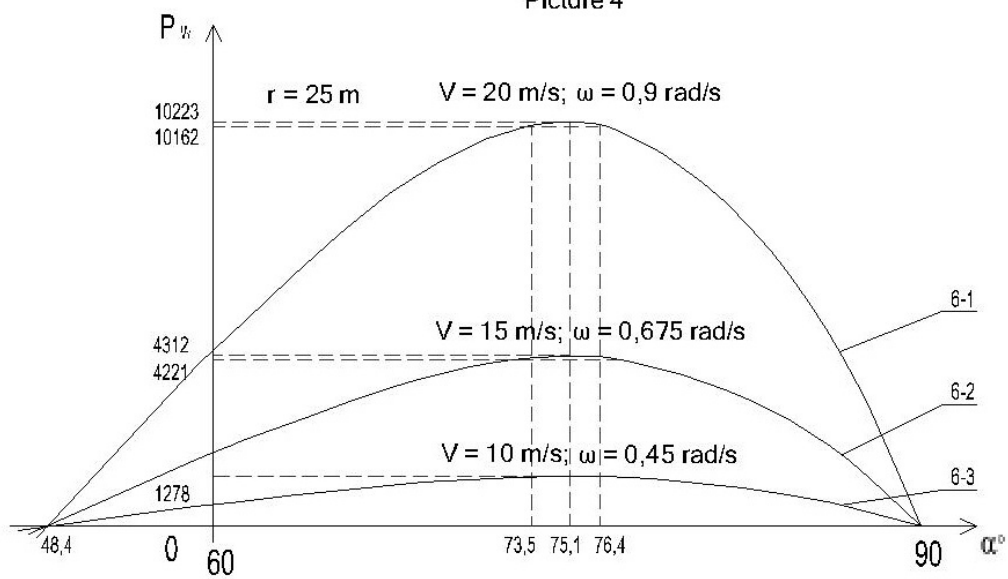
ω_i (rad/s) is the rotation speed of the turbine at the i -th time.



Picture 3



Picture 4



Picture 5

Surveying the blade elements of wind turbines by graph, we see:

- Each blade position has only one optimal tilt angle for maximum power. Power decreases very quickly when the tilt angle leaves the optimal position.
- The blade configuration must be thin and flat to have the largest C_x for maximum power.
- At all wind speeds, on average, each m^2 of turbine blade can only collect a maximum power equal to 18% of the power density of the wind flow acting on it.

This conclusion is to quickly calculate the maximum power a wind turbine can achieve at any wind speed, by multiplying the blade area by the power collection capacity of $1m^2$ of blade according to the following table.

v (m/s);	Power density (W/m ²);	Maximum power collection capacity of 1m ² of blade (W)
6	132	23
7	212	37
8	316	56
9	450	80
10	612	110
11	815	146
12	1058	190
13	1345	269
14	1680	336
15	2067	413
16	2508	501
17	3009	601
18	3572	714
19	4201	840

EXAMPLE: A wind turbine has 3 blades 65m long, assuming the blade width is 5m, the total blade area is 900m². If it has a reasonable tilt angle and configuration, it will have a maximum capacity at a wind speed of 12m/s:

$$900m^2 * 190W/m^2 = 171000W.$$

Worldwide, up to now (2025), wind turbines with blades 65m long, (swept area of about 13270 m²), have been announced to have a capacity of 4 MW at a wind speed of 12m/s, which is about 23 times higher than the preliminary calculated capacity.

In reality, because large wind turbines today do not have optimal configuration and tilt angle, their announced capacity is often about 25-30 times larger than the actual capacity, which is easily verified in practice. **This is a huge mistake in science & technology of mankind.**

When calculating the power for a wind turbine according to the "FORMULA FOR CALCULATION OF WIND TURBINE POWER", assuming the turbine has flat blades, reasonable tilt angle, calculating the power according to the blade area, we will see:

- The highest power of a wind turbine usually reaches about 25% of the declared power at a wind speed of about 21m/s.
- The power of a wind turbine usually reaches less than 5% of the declared power at a wind speed of 12m/s.

Directly measuring the power of this wind turbine, we also have similar results. Thus, if we use the declared power to calculate the electricity output to the national grid and to calculate the CO2 emission reduction index, it will be more than 4 times higher than the actual, causing very serious harm to the economy and the environment.

When the research on transformation: FORMULA FOR CALCULATION OF WIND TURBINE POWER is popularized, all large wind turbines need to change the blade set. Wind farm manufacturers and installers have suffered huge losses. The author hopes that countries will not hold wind turbine manufacturers accountable, so that they can have funds to replace wind turbine blades. You can contact the author to get the technology to manufacture wind turbine blades with the best capacity, increasing investment efficiency by about 4 times. Will bring hundreds of billions of dollars in profits each year to the wind power industry & reduce billions of tons of CO2 emissions each year worldwide.

Therefore, it is necessary to comprehensively change wind turbines from the scientific foundation to the creation of new inventions. In order to bring wind turbines to a new era, producing the cheapest wind power, serving economic development and combating climate change.

We invite genuine scientists to read, comment & spread, to bring "Formula for calculating capacity for propeller wind turbines" to the wind energy industry. Bring it to wind energy policy makers to make the economy develop and the environment be protected.

We invite wind turbine manufacturers & traders to read to produce transparent wind power, for high income & benefit humanity.

The author sincerely thanks.

Ba At Lai