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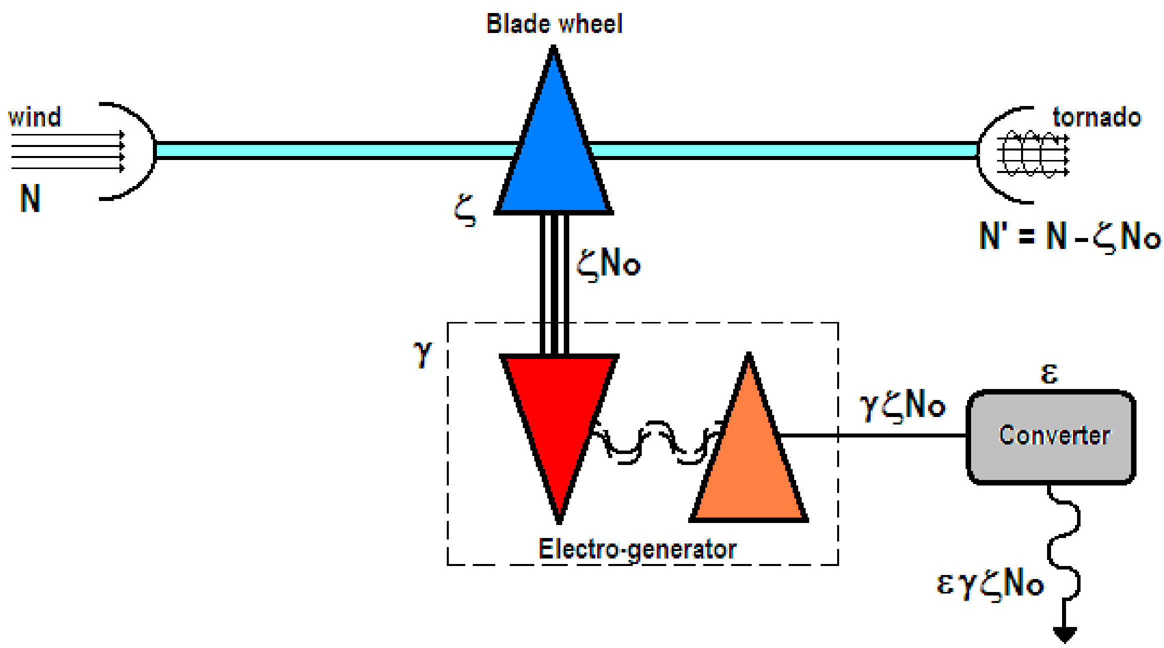
The Truth About Wind Electro Generators (WEGs)

I. Efficiency of ideal WEG.

Following ***Qualitics*** let us consider *the equivalent graph* of wind electro-generator (WEG) of series "Cyclopes":



This graph schematically reflects all three attributive processes in any WEG, which are the following:

1. Wind with natural intrinsic power N blows into an entrance (a nozzle, if it is implemented), rotates the blade wheel, and through some exit (a nozzle, if it is implemented) moves out, back into the atmosphere, carrying on some intrinsic power N'. In this process the conversion of some part of wind's kinematical power into a rotational power of blade wheel occurs. In other words, any WEG has to consist of some device that converts *available kinematical power* of the straightforward motion of wind

into a kinematical energy of rotation of blade wheel. ***The available kinematical power*** is only a part of the entire intrinsic power of *the working fluid body* (in our case – wind of air) in any stream process. It was found that ***the available kinematical power,*** No, is only **0.386** part of the intrinsic power of *the working fluid body,* N, i. e.

$$No = 0.386\ N$$

(Details see in "The Qualitics", book available on *thequalitics.com*)

Therefore, the blade wheel, at interaction with wind with efficiency ζ, will gain power ζNo.

2. The blade wheel through some driving mechanism passes its gained power ζNo to some electro-generator, EG, making rotation of some magnets (or coils) into this generator. The functionality of EG is clear – to convert mechanical power of rotation into a power of the electric current. Let us assume that EG performs this functionality with some efficiency γ. Thus on the exit of EG there will be available power γζNo, carried by the generated electric current.

3. To be useful, the generated electric current has to be converted into the one, which is standard and can be adopted by the common greed. This job should be done by special Converter, which does it with some efficiency ε. Therefore, the consumer will receive power equal to εγζNo.

As one can see, three independent physical processes are attributively involved in work of any WEG:

- Conversion of wind's energy into energy of rotation of the blade wheel;
- Conversion of energy of rotation of blade wheel into energy of some electric current;
- Conversion of generated electric current into the generally accepted current of common greed.

Each of these three processes has its own specifics, is using different physical phenomena, and obeys specific laws of Nature. *Ergo*, any WEG is producing power

$$N^* = 0.386\ \varepsilon\gamma\zeta N$$

Thus, WEG has efficiency

$$k = 0.386\ \varepsilon\gamma\zeta$$

The typical values of k are shown in Table 1 for some of WEGs.

Table 1

Model	Source	N* in W	R in m	V in m/s	No in W	N*/No
ARE 110	AbundantRE.com	2500	1.8	11	3329	75%*
ARE 442	AbundantRE.com	10000	3.6	11	13317	75%*
Bergey XL.1	bergey.com	1000	1.25	11	1606	62%
Bergey 1500	bergey.com	1500	1.6	12	3415	44%
Bergey Excel	bergey.com	10000	3.5	13	20777	48%
1.5s	gewindenergy.com	1500000	35.25	13	2107490	71%*
1.5se	gewindenergy.com	1500000	35.25	13	2107490	71%*
1.5sl	gewindenergy.com	1500000	38.5	14	3139951	48%
1.5sle	gewindenergy.com	1500000	38.5	14	3139951	48%
1.5xle	gewindenergy.com	1500000	41.25	12.5	2565637	58%
Air Breeze	windenergy.com	200	0.57	12.5	490	41%
Proven 0.6	solarwindwork.com	600	1.275	12	2169	28%
Proven 2.5	solarwindwork.com	2500	1.750	12	4085	61%
Proven 6	solarwindwork.com	6000	2.750	12	10088	59%
Proven 15	solarwindwork.com	15000	4.500	12	27014	56%
Enercon E-126	Wikipedia	6000000	63	14	8407803	71%*
Repower 5M	Wikipedia	5000000	63	14	8407803	59%

*- projected values.

II. Efficiency of ideal blade wheel of WEG.

Considering the blade wheel as a stream device, the functionality of which is a conversion of the power N of the straightforward flow of air into the power of rotation of said blade wheel, one should define its efficiency as ratio

$$\zeta = N_{rot}/0.386\ N$$

where N_{rot} is the actual power of rotation of the considered blade wheel that it actually provides. This index of efficiency differs from index

$$eff = N_{rot}/N$$

because ζ contains knowledge of fact that in any stream process only 0.386 part of power of straightforward motion of working fluid stream, N, is available for transformation into other types of power.

That is the reason why in the book "*The Qualitics*" was suggested to call as "*the quality index*" of the blade wheel, keeping the name "efficiency index" for eff.

It is well known, that the efficiency of blade wheel of WEG, ζ, significantly depends on its design: how many blades are there and what shapes and sizes they have. Less known is the facts that this efficiency very strong depends also on shapes and sizes of channels that are foregoing and following this blade wheel.

Poor design of entrance nozzle can cut efficiency ζ significantly: there are known cases when poor design of entrance into turbojet engine has created so called "*air-corns*" that were preventing air of going into engine, at all.

Poor design of exit nozzle or/and transport channel also can cut ζ significantly: the shapes of these elements do define the scale of turbulization of the discharged air, and consequently, increasing the aero-resistance of the entire device.

It is important to recognize that the commonly used three-blade rotary wheel of many of the contemporary models of WEG, *a priory*, have very poor efficiency ζ. The reason is very clear: *at three blades on the rotary wheel a lot of wind simply is passing through device between blades without interaction with them, at all.*

However, there is one more, the major, reason why any build WEG reveals poor efficiency: *high aero-resistance of these WEGs*.

Indeed, even if stream of working fluid media affront of any blade wheel is stationary, uniform, laminar, and purely straightforward, behind said wheel it already is non-stationary, non-uniform, turbulent and twirled. Each of just emphasized features, which stream gains after passing the blade wheel, significantly contributes in the aero-resistance of device, and consequently, spends some of available power of stream, No = 0.386 N, not for N_{rot}, but for "parasitic" types of motions of fluid that are decreasing ability of stream to flow straightforward, giving a place for incoming portions of working stream ahead the blade wheel to interact with this wheel. In other words, these features do increase the aero-resistance of blade wheel.

III. The main idea of WEG "Cyclopes".

There is no way to influent somehow the formation of any of abovementioned features in the stream that has passed the usually build rotary blade wheel. But we can artificially restrict some of those features to appear, if we will surround blade wheel by some, appropriately formed, jacket. The functionality of this jacket should be **the provision of a laminar twirled discharge of air after it accomplished an interaction with blades of the considering blade wheel**.

But there is known the only one exact solution of the Navier-Stockes equations for a laminar twirled discharge stream – **the stationary regular tornado solution**, which was found in G. I. Kiknadze, Y. K. Krasnov, Doklady Akademii Nauk. USSR, 1986, No.6, p. 5.

Moreover, it appears that this solution has **solid-rotating core**, what exactly is the same as the rotation of air stream just after it lives a rotating blade wheel of any WEG. Therefore, surrounding blade wheel by jacket that has shape of streamlines of the appropriate stationary regular tornado, we will force stream of air after it leaves the blades of blade wheel to flow as a core of such tornado – as a laminar, solid-body like rotating discharge flow.

Namely this idea led to construction of WEG that Qualitics, Inc. is calling as “Cyclopes”. And namely this idea allows us to declare Cyclopes to be the most efficient solution for WEGs.

IV. Efficiency of electro-generator (alternator).

As we know, the blade wheel of any WEG through some driving mechanism passes its gained power ζNo to some electro-generator, EG, forcing some magnets into this generator to rotate. The functionality of EG is clear – to convert mechanical power of rotation of blade wheel into a power of the electric current into some chain of coils.

The simplest way of passing power of rotating blade wheel to rotating magnets is to attach those magnets directly on the ends of blades, so that magnets will pass over some chain of static coils synchronically with said wheel. We call such solution as *S-generator*.

Let us assume that EG performs its functionality with some efficiency γ. Thus on the exit of EG there will be available power γζNo, carried by the electric current, which will be generated in proper chain of static coils.

The principles of phenomena in S-generator are well known (the Faraday Effect, Joule heating of coils by electric current, and Om’s Law) and there are no problems with provision of a high efficiency of said generator. But the case of WEG has its own specifics of implementation of S-generators. These specifics are rising of nature of WEG’s work: its blade wheel is driven by the very variable wind, whose speed may vary between 0 (fully steel weather) and up to hundreds km/hr (hurricanes). Therefore, magnets of S-generator may rotate sometimes with very high speed. In one hand, it may cause very high voltage and current into coils that might destroy them. In other hand, chosen S-generator (its magnets and/or chain of coins may not be able to adopt all power of rotation to convert it into electric current at some values of speed of wind). Thus, the new characteristic of S-generator – *the capability index* – becomes important for applications of WEG. The capability index, χ, is the ration of maximal power of current that can be generated in chosen closed circuit by the given S-generator, to the maximal available power of wind, i.e.

$$\chi = \text{Max } N_{electric} / 0.386 \text{ N}$$

Good WEG should have $\chi > 1$ into entire range of speeds of wind, in which the given WEG is implemented to work.

V. Electro-magnetic friction.

The very significant specific of S-generators is that they create significant electro-magnetic friction, which decreases speed of rotation of the blade wheel. This friction appears as a reaction of coil on the action of passing over magnet. The force of this friction, F_{em}, which acts on the moving magnet, is strongly depending on the speed of magnet relatively to coil, i. e. in our case – on the angular velocity of the rotation of the blade wheel, Ω.

It is obvious that $F_{em} = 0$ when $\Omega = 0$. As bigger Ω is, as stronger F_{em} becomes, and therefore, as stronger the electro-magnetic friction restricts the rising of speed of the blade wheel.

Thus, one can conclude that generators have a very important feature – they provide force, which acts against changes of the rotation speed of the blade wheel.

S-generators that are used in WEGs of series “Cyclopes” are designed in a way to provide automatic over speed protection of the blade wheel.

VI. Efficiency of convertor.

Although the rotating magnets generate a harmonic current in chain of coils of S-generator, this current can not be passed to general domestic electric grid because it has characteristics that do not match to those of current in this grid. Therefore, any WEG with S-generator has to have some Converter, which would have functionality to convert current of S-generator into current with a standard characteristic: frequency 60Hz and amplitude 110V.

For small WEGs (with power under several kW) such Converter can be build as a purely electronic device and there are a lot of ways to build it not jeopardizing its high efficiency.

VII. Performance of WEG.

- *How WEG should be characterized?*

Because the driving force of any WEG is the wind, the performance of WEG strongly depends on behavior of wind that actually is blowing on WEG in each given moment. Therefore, each customer of WEG should recognize those real conditions at which WEG will work: average speed of wind that is commonly blows in the area of WEG's placement, and most important – what is the spectrum of wind, that is specific for this area (how often and long in time the gusts of wind are in this area, how big speeds they have).

Indeed, even at small average speed of wind (which defines so called "speed zone" of a given area), there are not very long in time, but powerful enough gusts of wind. Because performance of WEG (the generated power of electric current) depends on speed of wind V as V^3, namely those gusts will define average generated energy of the produced electricity, not the average wind. Therefore, the customer should recognize also to what "wind power zone" the location of WEG belongs.

Knowledge of "speed zone" is important, because, for instance, even very efficient WEG with start-up value of wind speed V will be very much useless in speed zone with average speed of wind that is less than V. And that is why WEGs with lower start-up speed of wind are commercially more competitive than ones with higher start-up wind speed values.

But useful performance of WEG is defined by wind power zone. Therefore, it is customer-friendly to accompany each WEG with table of performance in each wind power zone.

- *WEG with what rated power is enough?*

The instant power of WEG generated electric current is defined by the instant speed of wind. Therefore, it is customer-friendly to accompany each WEG with table or graph that is shown as performance of WEG depends on speed of wind.

Currently WEG are characterized by rated power of the generated current at rated speed of wind. For example, Specification of WEG says: "Rated power of WEG is 400W at rated wind speed V = 12.5 m/s (27.7 mph)". Such information is good enough for comparison of abilities of different WEGs, but is insufficient to help customer to answer his main question: "*Is this WEG good for resolution of my problem?*" And the main customer's problem usually is a need of WEG that will provide some given energy E kW-hr per month (day, year, etc.) For example, WEG should provide energy that will be enough for work of some water pump in the field a given number of hours during each month. To answer abovementioned customer's main question, each WEG has to be accompanied with table or graph of performance in each wind power zone.

VIII. Why "Cyclopes" is very perspective solution of WEG?

As it was said in paragraph III, the body of "Cyclopes" provides a laminar tornado-type discharge of air after it accomplished an interaction with blades of the considering blade wheel. Consequently, it provides a possibility to have a minimal aero-resistance of WEG that is allowed by the nature of flows of a viscose fluid, particularly – an air.

Proposed *internal* shape of body of "Cyclopes" is chosen on the ground of the theoretical analysis of flows of an ideal fluid through the axial-symmetric bodies having a hole inside with a boundary surface in the form of surface of streamlines of the potential discharge part of the regular stationary tornado.

In the same time, proposed *external* shape of body of "Cyclopes" is chosen on the ground of the theoretical analysis of streamlining of bodies by an ideal fluid.

The tornado-like discharge of air from "Cyclopes" provides several useful features besides said main one – provision of a possibly minimal aero-resistance. Let us consider some of these features.

- Tornado-like exhausting stream suppresses some of excitations of WEG under side-blows of wind, making WEG more stable against vulnerable wind; just as any gyroscope does.
- Tornado-like exhausting stream is very stable formation and can be destroyed by the wind on much larger distances from an exhaust cross-section of WEG, than straightforward exhausting stream; it prevents WEG against disturbance by the back-born turbulization of the exhaust stream of air.
- Tornado-like exhausting stream

Proposed shape of body of "Cyclopes" allows reliable attachment of many of useful auxiliary devices as tail, wings, covering patterns and so on.

Proposed shape of body of "Cyclopes" allows placement of many of useful auxiliary devices as S-generator, converter, controlling probes, etc. inside WEG.

Proposed shape of body of "Cyclopes" allows reliable attachment of WEG to the many types of mounts, like poles, flat or beveled roofs, etc.

IX. Economics: small TWEGs versus gigantic 3-blades WEGs.

Read about this comparison on Qualitics, Inc website at:

http://www.thequalitics.com/pdf/WEproposalWEG.pdf

X. Efficiency of electro-generator (alternator).

In respect of this issue there are many of curious statements in practice of WEG. For instance, Chinese company has announced new model of three blades WEG, Air X, which has length of blades R = 0.575m and produces power of N* = 400 W at rated speed of wind v = 12.5 m/s. According theory of WEG, the maximal wind power that is available for any stream process is equal to $No=0.386*d*\pi R^2*v^3/2 = 466W$ at density of air $d=1.19\ kg/m^3$. It means that they are claiming WEG with efficiency k = N*/No = 86%, what seems too unbelievable for 3-blades WEG, especially if one will compare this with efficiencies other known WEGs, as it is shown in the following table.

Model	Source	N in W	R in m	V in m/s	No in W	N/No	N/No in %
ARE 110	AbundantRE.com	2500	1.8	11	3329	0.751	75.1%
ARE 442	AbundantRE.com	10000	3.6	11	13317	0.751	75.1%
Bergey XL.1	bergey.com	1000	1.25	11	1606	0.623	62.3%
Bergey 1500	bergey.com	1500	1.6	12	3415	0.439	43.9%
Bergey Excel	bergey.com	10000	3.5	13	20777	0.481	48.1%
1.5s	gewindenergy.com	1500000	35.25	13	2107490	0.712	71.2%
1.5se	gewindenergy.com	1500000	35.25	13	2107490	0.712	71.2%
1.5sl	gewindenergy.com	1500000	38.5	14	3139951	0.478	47.8%
1.5sle	gewindenergy.com	1500000	38.5	14	3139951	0.478	47.8%
1.5xle	gewindenergy.com	1500000	41.25	12.5	2565637	0.585	58.5%
Air Breeze	windenergy.com	200	0.57	12.5	490	0.408	40.8%
Proven 0.6	solarwindwork.com	600	1.275	12	2169	0.277	27.7%
Proven 2.5	solarwindwork.com	2500	1.750	12	4085	0.612	61.2%
Proven 6	solarwindwork.com	6000	2.750	12	10088	0.595	59.5%
Proven 15	solarwindwork.com	15000	4.500	12	27014	0.555	55.5%
Enercon E-126	Wikipedia	6000000	63	14	8407803	0.714	71.4%
Repower 5M	Wikipedia	5000000	63	14	8407803	0.595	59.5%