Electron Wind Generator

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Abstract

Author offers a new method of getting electric energy from wind. A special injector injects electrons into the atmosphere. Wind picks up the electrons and moves them in the direction of wind which is also against the direction of electric field. At some distance from injector a unique grid acquires the electrons, thus charging and producing electricity. This method does not require, as does other wind energy devices, strong columns, wind turbines, or electric generators. This proposed wind installation is cheap. The area of wind breaking may be large and produces a great deal of energy. Although this electron wind installations may be in a city, the population will not see them.

Keywords: *wind energy, utilization of wind energy, electronic wind electric generator, EABG, Bolonkin.*

Introduction

Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electrical power, windmills for mechanical power, wind pumps for water pumping or drainage, or sails to propel ships.

Large wind farms consist of hundreds of individual wind turbines which are connected to the electric power transmission network. Offshore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms provide electricity to isolated locations. Utility companies increasingly buy surplus electricity produced by small domestic wind turbines.

Wind power, as a viable alternative to fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation and uses little land. The effects on the environment are generally less problematic than those from other power sources. As of 2011, Denmark generates more than a quarter of its electricity from wind and 83 countries around the world are using wind power on a commercial basis. In 2010 wind energy production was over 2.5% of total worldwide electricity usage, and growing rapidly at more than 25% per annum. The monetary cost per unit of energy produced is similar to the cost for new coal and natural gas installations.

Worldwide there are now over two hundred thousand wind turbines operating, with a total nameplate capacity of 282,482 MW as of end 2012. The European Union alone passed some 100,000 MW nameplate capacity in September 2012, while the United States surpassed 50,000 MW in August 2012 and China passed 50,000 MW the same month.

Some Information about Wind Energy. The power of wind engine strongly depends on wind speed (to the third power). Low altitude wind (H = 10 m) has the standard average speed of $\boldsymbol{V}$ = 6 m/s. High altitude wind is powerful and practically everywhere is stable and constant. Wind in the troposphere and stratosphere are powerful and permanent. For example, at an altitude of 5 km, the average wind speed is about 20 M/s, at an altitude 10 - 12 km the wind may reach 40 m/s (at latitude of about 20 - 35^0 N).

There are permanent jet streams at high altitude. For example, at H = 12-13 km and about 25^0 N latitude, the average wind speed at its core is about 148 km/h (41 m/s). The most intensive portion has a maximum speed of 185 km/h (51 m/s) latitude 22^0, and 151 km/h (42 m/s) at latitude 35^0 in North America. On a given winter day, speeds in the jet core may exceed 370 km/h (103 m/s) for a distance of several hundred miles along the direction of the wind. Lateral wind shears in the direction normal to the jet stream may be 185 km/h per 556 km to right and 185 km/h per 185 km to the left.

The wind speed of V = 40 m/s at an altitude H = 13 km provides 64 times more energy than surface wind speeds of 6 m/s at an altitude of 10 m.

This is an enormous renewable and free energy source. (See reference: *Science and Technology, v.2*, p.265).

Economy of conventional utilization of wind energy. Current wind power plants have low ongoing costs, but moderate capital cost. The marginal cost of wind energy once a plant is constructed is usually less than 1-cent per kW·h. The estimated average cost per unit incorporates the cost of construction of the turbine and transmission facilities, borrowed funds, return to investors (including cost of risk), estimated annual production, and other components, averaged over the projected useful life of the equipment, which may be in excess of twenty years. Energy cost estimates are highly dependent on these assumptions so published cost figures can differ substantially. In 2004, conventional wind energy cost a fifth of what it did in the 1980s, and a continued downward trend is expected as larger multi-megawatt turbines were mass-produced. A 2011 report from the American Wind Energy Association stated, "Wind's costs have dropped over the past two years, in the range of 5 to 6 cents per kilowatt-hour recently.... about 2 cents cheaper than coal-fired electricity, and more projects were financed through debt arrangements than tax equity structures last year.... winning more mainstream acceptance from Wall Street's banks.... Equipment makers can also deliver products in the same year that they are ordered instead of waiting up to three years as was the case in previous cycles.... 5,600 MW of new installed capacity is under construction in the United States, more than double the number at this point in 2010. Thirty-five percent of all new power generation built in the United States since 2005 has come from wind, more than new gas and coal plants combined, as power providers are increasingly enticed to wind energy as a convenient hedge against unpredictable commodity price moves."

A British Wind Energy Association report gives an average generation cost of onshore wind power of around 3.2 pence (between US 5 and 6 cents) per kW·h (2005). Cost per unit of energy produced was estimated in 2006 to be comparable to the cost of new generating capacity in the US for coal and natural gas: wind cost was estimated at $55.80 per MW·h, coal at $53.10/MW·h and natural gas at $52.50. Similar comparative results with natural gas were obtained in a governmental study in the UK in 2011. A 2009 study on wind power in Spain by Gabriel Calzada Alvarez of King Juan Carlos University concluded that each installed MW of wind power led to the loss of 4.27 jobs, by raising energy costs and driving away electricity-intensive businesses. The U.S. Department of Energy found the study to be seriously flawed, and the conclusion unsupported. The presence of wind energy, even when subsidized, can reduce costs for consumers (€5 billion/yr in Germany) by reducing the marginal price, by minimizing the use of expensive peaking power plants.

In February 2013 Bloomberg New Energy Finance reported that the cost of generating electricity from new wind farms is cheaper than new coal or new baseload gas plants. In Australia, when including the current Australian federal government carbon pricing scheme their modeling gives costs (in Australian dollars) of $80/MWh for new wind farms, $143/MWh for new coal plants and $116/MWh for new baseload gas plants. The modeling also shows that "even without a carbon price (the most efficient way to reduce economy-wide emissions) wind energy is 14% cheaper than new coal and 18% cheaper than new gas." Part of the higher costs for new coal plants is due to high financial lending costs because of "the reputational damage of emissions-intensive investments". The expense of gas fired plants is partly due to "export market" effects on local prices. Costs of production from coal fired plants built in "the 1970s and 1980s" are cheaper than renewable energy sources because of depreciation.

Programs for Developing Wind Energy. Wind is a clean and inexhaustible source of energy that has been used for many centuries to grind grain, pump water, propel sailing ships, and perform other work. Wind farm is the term used for a large number of wind machines clustered at a site with persistent favorable winds, generally near mountain passes. Wind farms have been erected in New Hampshire, in the Tehachapi Mountains, at Altamont Pass in California, at various sites in Hawaii, and may other locations. Machine capacities range from 10 to 500 kilowatts. In 1984 the total energy output of all wind farms in the United States exceeded 150 million kilowatt-hours.

A program of the United States Department of Energy encouraged the development of new machines, the construction of wind farms, and an evaluation of the economic effect of large-scale use of wind power.

The utilization of renewable energy ('green' energy) is currently on the increase. For example, numerous wind turbines are being installed along the British coast. In addition, the British government has plans to develop off-shore wind farms along their coast in an attempt to increase the use of renewable energy sources. A total of $2.4 billion was injected into renewable energy projects over the last three years in an attempt to meet the government's target of using renewable energy to generate 10% of the country's energy needs by 2010.

This British program saves the emission of almost a million tons of carbon dioxide. Denmark plans to get about 30% of their energy from wind sources.

Unfortunately, current ground wind energy systems have deficiencies which limit their commercial applications:

1. Wind energy is unevenly distributed and has relatively low energy density. Huge turbines cannot be placed on the ground; many small turbines must be used instead. In California, there are thousands of small wind turbines. However, while small turbines are relatively inefficient, very huge turbines placed at ground are also inefficient due to the relatively low wind energy density and their high cost. The current cost of wind energy is higher than energy of thermal power stations.
2. Wind power is a function of the cube of wind velocity. At surface level, wind has low speed and it is non-steady. If wind velocity decreases in half, the wind power decreases by a factor of 8 times.
3. The productivity of a wind-power system depends heavily on the prevailing weather.
4. Wind turbines produce noise and visually detract from the landscape.

While there are many research programs and proposals for wind driven power generation systems, all of them are ground or tower based. The system proposed in this article is located at high altitude (up to the stratosphere), where strong permanent and steady streams are located. This article also proposes a solution to the main technologist challenge of this system; the transfer of energy to the ground via a mechanical transmission made from closed loop, modern composite fiber cable.

The reader can find the information about this idea in [1]-[2], a detailed description of the innovation in [3]-[6], and the wind energy in references [7]-[8], new material used in the proposed innovation in [9]-[13]. The review of last airborne concepts in [14]-[17].

Description of Innovation

One simplest version of the offered electron wind generator (EABG) is presented in fig.1. Installation contains: electron injectors 2 established in column 6 and electron collector (net) 4 having the conductive leaves 5 (metallic foil, for example, aluminum foil). They have a large surface which helps to collect the electrons from big area. Network connects with the electron injectors through a useful load 7.

Work of EABG. The EABG generator works the following way: injector injects the electrons into air, the wind catch them and moves to collector (network) 4. Network 4 has negative charge, electron injector has positive charge. The electric field breaks the electrons (negative ions) and decreases the wind speed. But the electric ion speed is less than wind speed and electrons when they reach the collector settle into collector and increase its negative charge. Those additional charges (electrons) return through the electric load 7 and make the useful work.

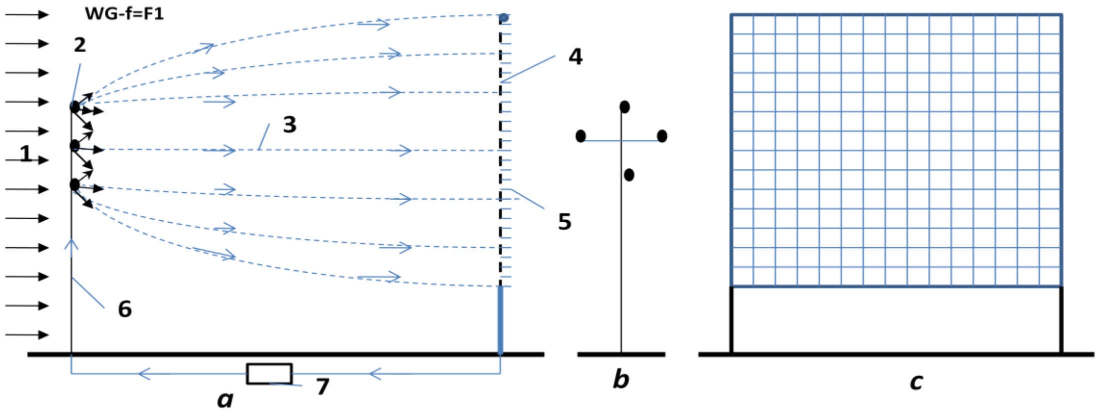

Fig.1. One version of Electron Wind Electric Generator (EABG). ***a*** – side view of the installation; ***b*** – front view of the electron injector column; c – front view of the collect net. *Notations:* 1 is wind; 2 is electron injector; 3 is trajectories of electrons; 4 is net collecting the electrons; 5 is conductive leaves (metallic foil, for example, aluminum foil); 6 is column (post) for supporting of the electron injectors; 7 is the outer electric load.

In the city any building may be used as an electron collector (fig.2). This building must be colored by a conductive paint. This layer of paint must be isolated from the Earth and connected to the injectors via useful electric load. The injectors may be located in other buildings or any electric, lamp, or telephone posts.

The injectors are located around the building and get wind energy regardless the directions of wind.

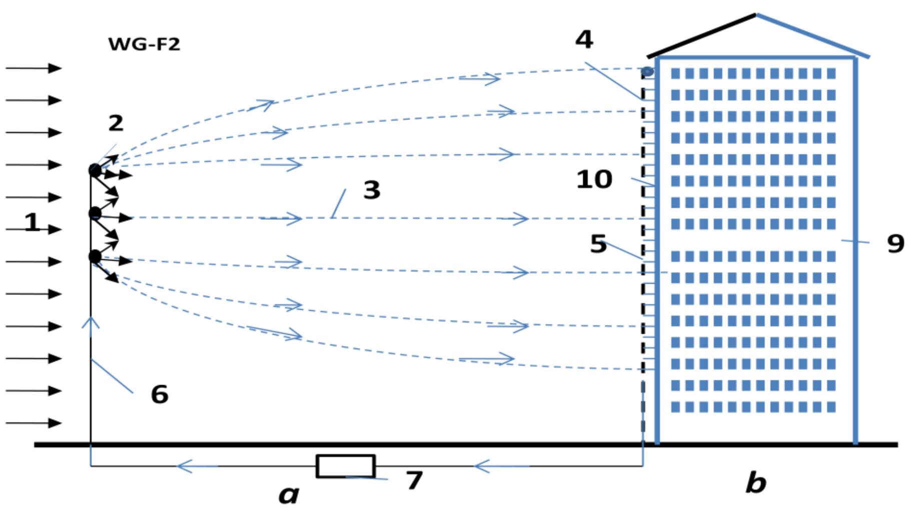

Fig.2. Using the building walls as the collector (net) for electrons.

In places where there are no buildings, the collector is located on the Earth surface (fig.3). The injectors may be up on a mast (fig. 3a) or located also on earth surface (fig. 3b). The efficiency of these will be different. The surface collector is conductivity film 11 (fig.3) (for example, aluminum foil), isolated from Earth. For increasing the efficiency of collector we can (optionally) place under collector the isolated positive charge 12 (or positive electrets) (fig. 3).

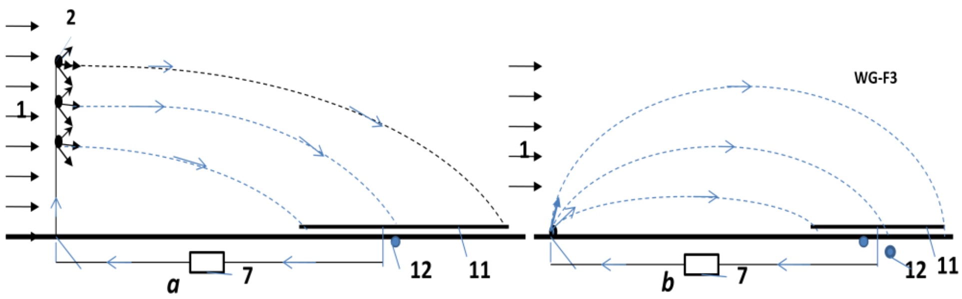

Fig.3. The horizontal conductivity film as collector of electrons. ***a*** – injectors in column; ***b*** - injectors at Earth surface. *Notations:* 11 - conductivity film (for example, aluminum foil); 12 (optional) positive isolated charge (for example, electrets).

If we want to use wind energy at high altitudes, a special parachute can be used. Two versions of these designs are shown in fig.4. In the first version the electron injector is supported by wing 13 (fig.4a), in the second version (fig.4b) the electron injector is supported by a unique parachute 15 which creates also the lift force. Special parachute is net containing the conductive leaves as 5 in fig.1.

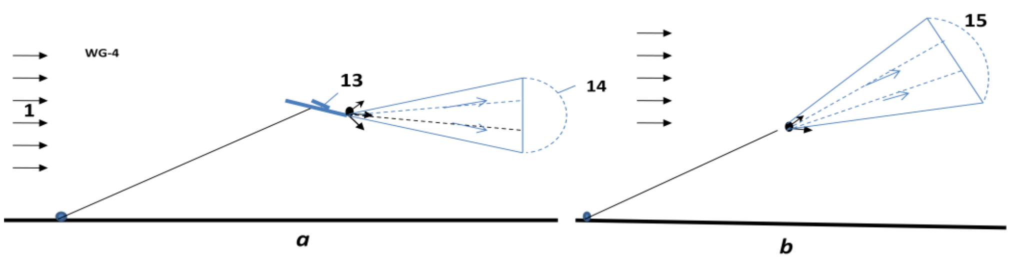

Fig.4. Airborne (flight) high altitude Electron wind generator. ***a*** - wing support; ***b*** – wind parachute support. *Notations:* 13 is wing; 14 is parachute; 15 is parachute having lift force.

Advantages of the proposed electron wind systems (EABG) in comparison with the conventional air wind systems.

The suggested new principle electron wind generator (EABG) has the following advantages in comparison with conventional wind systems used at present time.

Advantages:

1. Offered installations are very simple.
2. Offered system is very cheap (by hundreds of times). No tower, propeller, magnetic electric generator, gear box.
3. Offered system can cover a large area and has enormous power.
4. Offered installations are suitable for city having many high rise building.
5. The EABGs are invisible for population.
6. Offered installations produce high voltage direct electricity. That is advantage if energy is being transferred long distances.
7. Offered system is very suitable for airborne wind installation, because it is very light and produces high voltage electricity.
8. Offered system may be used as brake and can supply power to the electric system of aircraft.

Estimations and Computation

1. **Power of a wind** energy N [Watt, Joule/sec]

$$N = 0.5\eta\rho AV^3 \quad \text{[W]} \; . \qquad (1)$$

The coefficient of efficiency, η, equals about 0.2 ÷0.25 for EABG; 0.15 ÷ 0.35 for low speed propeller rotors (ratio of blade tip speed to wind speed equals $\lambda \approx 1$); η = 0.45 ÷ 0.5 for high speed propeller rotors (λ = 5 - 7). The Darrieus rotor has η = 0.35 - 0.4. The gyroplane rotor has 0.1 ÷ 0.15. The air balloon and the drag (parachute) rotor has η = 0.15 - 0.2. The Makani rotor has 0.15 ÷ 0.25. The theoretical maximum equals $\eta \approx 0.6$. Theoretical maximum of the electron generator is 0.25. A - front (forward) area of the electron corrector, rotor, air balloon or parachute [m^2]. ρ - density of air: ρ_o =1.225 kg/m^3 for air at sea level altitude H = 0; ρ = 0.736 at altitude H = 5 km; ρ = 0.413 at H = 10 km. V is average annually wind speed, m/s.

Table 1. Relative density ρ_r and temperature of the standard atmosphere via altitude

H, km	0	0.4	1	2	3	6	8	10	12
$\rho_r=\rho/\rho_o$	1	0.954	0.887	0.784	0.692	0.466	0.352	0.261	0.191
T, K	288	287	282	276	269	250	237	223	217

Issue [6].

The salient point here is that the strength of wind power depends upon the wind speed (by third order!). If the wind speed increases by two times, the power increases by 8 times. If the wind speed increases 3 times, the wind power increases 27 times!

The wind speed increases in altitude and can reach in constant air stream at altitude H = 5 – 7 km up V = 30 – 40 m/s. At altitude the wind is more stable/constant which is one of the major advantages that an airborne wind systems has over ground wind systems.

For comparison of different wind systems of the engineers must make computations for average annual wind speed V_0 = 6 m/s and altitude H_0 = 10 m. For standard wind speed and altitude the maximal wind power equals 66 W/m^2.

The energy, E, produced in one year is (1 year ≈ 30.2×10^6 work sec) [J]

$$E = 3600\times24\times350N \approx 30\times10^6 N, \quad [\text{J}]. \qquad (2)$$

2. Electron speed. The electron speed about the wind, gas (air) jet may be computed by equation:

$$j_s = qn_-b_-E + qD_-(dn_-/dx)\,, \qquad (3)$$

where j_s is density of electric currency about jet, A/m^2; $q = 1.6\times10^{-19}$ C is charge of single electron, C; n_- is density of injected electrons (negative charges) in 1 m^3; b_- is charge mobility of negative charges, m^2/sV; E is electric intensity, V/m; D_- is diffusion coefficient of charges; dn_-/dx is gradient of charges. For our estimation we put dn_-/dx = 0. In this case

$$j_s = qn_-b_-E\,, \quad Q = qn\,, \quad v = bE\,, \quad j_s = Qv\,, \qquad (4)$$

where Q is density of the negative charge in 1 m^3; v is speed of the negative charges about wind, m/s.

The negative charge mobility for normal pressure and temperature T = 20^{o}C is:

In dry air b_- = 1.9×10^{-4} m^2/sV, in humid air b_- = 2.1×10^{-4} m^2/sV. (5)

If the air pressure is from 13 to 6×10^6 Pa, then the mobility follows the law bp = const, where p is air pressure. When air density decreases, the charge mobility increases. The mobility stregnth depends upon the purity of gas.

For normal air density the electric intensity must be less than 3 MV (E < 3 MV). Otherwise the electric breakdown may be.

If $v > 0$, the electrons accelerate the air ($E > 0$ and installation spends energy, works as ventilator). If $v < 0$, the electrons beak the wind ($E < 0$ and the correct installation can produce energy, works as electric generator). If $v = 0$ (electron speed about installation equals wind speed V), the electric resistance is zero.

3. Optimal regime of work the electron generator. Let us to find the maximal power of electron generator.

The specific power of electron generator P [W/m^2] is

$$P = Tv = 0.5\rho(V-v)^2 v \quad , \qquad (6)$$

where T is air trust, N/m^2; V is wind speed, m/s; v is electron speed about air in opposed direction, m/s.

This function has maximum when relation

$$v/V = 1/3. \qquad (7)$$

That means the optimal electric intensity is (see (2) – (3))($b = 2\times10^{-4}$):

$$v = bE, \; E = v/b = V/3b = 1.67\times10^3 V , \quad [\text{V/m}] \qquad (8)$$

where V is wind speed, m/s.

The optimal voltage and electric currency aproximatly is:

$$U \approx EL , \; I = N/U , \qquad (9)$$

where U is voltage, V; L is distance between injector and collector, m; I is electric currency, A.

4. Electron injectors.

There are some methods for generating electron emissions: hot cathode emission, cold field electron emission (edge cold emission, edge cathode), photo emission, radiation emission, radioisotope emission and so on. We consider only the hot emission and briefly the cold field electron emission (edge cathodes).

The **hot cathode** emission computed by equation:

$$j_s = BT^2 exp(-A/kT) , \qquad (10)$$

where B is coefficient, A/cm^{2}K^2; T is catode temperature, K; $k = 1.38\times10^{-23}$ [J/K] is Bolzmann constant; A is thermoelectron exit work, eV. Both values A, B depend from material of cathode and its cover. The "*A*" changes from 1.6 to 5 eV, the "*B*" changes from 0.5 to120 A/cm^{2}K^2. Boron thermo-cathode produces electric currency up 200 A/cm^2. For temperature 1400 ÷1500K the cathode can produce currency up 1000 A/cm^2. The life of cathode can reach some years [19]-[20].

The edge cold emission. The cold field electron emission uses the edge cathodes. It is known that the electric intensity E_e in the edge is

$$E_e = U/a . \qquad (11)$$

Here a is radious of the edge. If voltage between the edge and nears net (anode) is $U = 1000$ V, the radius of edge $a = 10^{-5}$ m, electric intensity at edge is the $E_a = 10^8$ V/m. That is enough for the electron emission. The density of electric current may reach up 10^4 A/cm^2 . For getting the required currency we make the need number of edges.

5. Airborne wind Turbine.

The drag of the vertical collector/rotor equals

$$D_r = N/V, \quad [\text{N}]. \qquad (12)$$

The lift force of the wing, L_w, is

$$L_w = 0.5 C_L \rho V^2 A_w, \quad [\text{N}], \qquad (13)$$

where C_L is lift coefficient (maximum $C_L \approx 2$ - 2.5); A_w is area of the wing, m^2.

The drag of the wing is

$$D_w = 0.5 C_D \rho V^2 A_w, \quad [\text{N}], \tag{14}$$

where C_D is the drag coefficient ($C_D \approx 0.02 \div 0.2$).

The air drag, D_c, of main cable and air drag, D_{tr}, of the transmission cable is

$$D_c = 0.5 C_{d,c} \rho V^2 H d_c \ , \quad D_{tr} = 0.5 C_{d,r} V^2 H d_{tr}, \quad [\text{N}], \tag{15}$$

where $C_{d,c}$ - drag coefficient of main cable, $C_{d,c} \approx 0.05 - 0.15$; H is rotor altitude, m; d_c is diameter of the main cable, m. $C_{d,r}$ - drag coefficient of the transmission cable, $C_{d,r} \approx 0.05 - 0.15$; d_{tr} is diameter of the transmission cable, m. Only half of this drag must be added to the total drag of wind installation:

$$D \approx D_r + D_w + D_d + 0.5 D_c + 0.5 D_{tr}, \quad [\text{N}] \tag{16}$$

If the wind installation is supported by dirigible, the lift force and air drag of dirigible must be added to wing lift force and total of system. The useful specific lift force of dirigible is about 5 N/m^3 (0,5 kg/m^3) at $H = 0$ and zero at $H = 6$ km. Full lift force is:

$$L = L_w + L_d - Mg - 0.5g(m_c + m_{tr}) \ , \quad [\text{N}]. \tag{17}$$

Here M is total mass of installation (electron injectors + parachute/collector + half of cable and wires weight), kg; $g = 9.81$ m/s^2 is Earth acceleration. Lift force of dirigible $L_d \approx 5U_d$ [N], where U_d is dirigible volume, m^3.

The mass of main and transmission cable are:

$$m_c = \gamma_c S_c L, \ m_{tr} = 2\gamma_{tr} S_{tr} L, \ [\text{kg}], \tag{18}$$

where γ_c is specific weight/density of cables, kg/m^3, $\gamma_c \approx 1500 \div 1800$ kg/m^3; S_c is cross section area of cables, m^2; L is length of cable, m.

The average angle α of connection line to horizon is

$$\sin\alpha \approx L/D, \tag{19}$$

The annual energy produced by the wind energy extraction installation equals

$$E = 8.33N \quad [\text{kWh}]\,. \tag{20}$$

Project

Let us assume: on the wall of a seven story building is installed electron collector $A = 30\times60$ m $=1800$ m^2. The wall of this building may be colored by conductive paint. The electron injectors are installed in front of wall (collector), in the distance of $L = 30$ m. Wind is perpendicular to the collector and has standard average permanent speed $V = 6$ m/s. The electron generator in optimal regime has the following data:

The power in efficiency $\eta = 0.25$:

$$N = 0.5\eta\rho AV^3 = 0.5\cdot0.25\cdot1.225\cdot1800\cdot6^3 \approx 100 \text{ kW}\,. \tag{21}$$

Optimal intensity of electric field:

$$E = 1.67\cdot10^3 V = 1.67\cdot10^3\cdot6 \approx 10 \text{ kV/m}. \tag{22}$$

Voltage and electric currency:

$$U = FL = 10\cdot30 = 300 \text{ kV}, \quad I = N/U = 100/300 = 0.333 \text{ A}. \tag{23}$$

Produced voltage is high, but a special electric capacitor converts the high voltage in low voltage.

Conclusion

Relatively no progress has been made in wind energy technology in the last years. While the energy from wind is free, its production is more expensive than its production in conventional electric power stations. Conventional wind energy devices have approached their maximum energy extraction potential relative to their installation cost. Current wind installations cannot significantly decrease a cost of kWh, provide the stability of energy production. They cannot continue significantly increase the power of single energy units.

The renewable energy industry needs revolutionary ideas that improve performance parameters (installation cost and power per unit) and that significantly decrease (by 5-10 times) the cost of energy production. The electron wind installations delineated in this paper can move the wind energy industry from stagnation to revolutionary potential.

The following is a list of benefits provided by the proposed new electron wind systems compared to current grown installations:

1. The produced energy is at least 0 times cheaper than energy produced in conventional electric stations which includes current wind installation.
2. The proposed system is relatively inexpensive (no expensive tower), it can be made with a very large collector thus capturing wind energy from an enormous area (tens of times more than typical wind turbines).
3. The proposed airborne electron installation does not require large ground space.
4. The installation may be located near customers.
5. Neither noise nor marring the landscape ruining the views.
6. The airborne energy production at high altitude is more stable because the wind is steadier. The wind may be zero near the surface but it is typically strong and steady at higher altitudes. This can be observed when it is calm on the ground, but clouds are moving in the sky. There are a strong permanent air streams at a high altitude at many regions of the USA and World.
7. The high altitude installation can be easy relocated to other places.
8. Offered installations are suitable for city having many high rise building.
9. The EABGs are invisible for population.
10. Offered installations produce high voltage direct electricity. That is advantage if energy is transferring in long distance.
11. Offered system is very suitable for airborne wind installation, because it is very light.
12. Offered system may be used as break and short power electric system of aircraft.

As with any new idea, the suggested concept is in need of research and development. The theoretical problems do not require fundamental breakthroughs. It is necessary to design small, cheap installations to study and get an experience in the design electron wind generator.

This paper has suggested some design solutions from patent application [2]. The author has many detailed analysis in addition to these presented projects. Organizations or investors are interested in these projects can address the author (http://Bolonkin.narod.ru , aBolonkin@juno.com , abolonkin@gmail.com).

The other ideas are in [1]-[6].

Acknowledgement

The author wishes to acknowledge Professor Shmuel Neumann for correcting the English and offering useful advices and suggestions.

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(Reader can find part of these articles in WEBs: http://Bolonkin.narod.ru/p65.htm, http://www.scribd.com(23); http://arxiv.org , (45); http://www.archive.org/ (20) and http://aiaa.org (41) search "Bolonkin").

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