A MAJOR INNOVATION: THE VORTEX TOWER POWER STATIONS (SELF SECURE VORTEX TOWERS)

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Received: 6 Dec 2007; accepted: 6 Jan. 2008

The Vortex Tower Power Stations relates to a continuously mass-producing electric power station without pollution, greenhouse gas emission, consumption of limited natural resources, wastes and independently of irregularity of wind conditions. The invention is embodied in the form of a hollow tower-shaped structure flared at the base thereof, surrounded by a greenhouse area and is optimised in order to combine several natural forces and effects: chimney effect, greenhouse effect, Coriolis force, Venturi effect and wind. The inventive plant comprises, in particular curved structures for activating an artificial and self-sustaining vortex, peripheral flap shutters for involving a wind quantity and pools optimised for storing calories supplied by sun and optionally by effluents of nuclear power plants, different industrial activities or geothermal waters. The production capacity of the inventive power plant is of several hundreds of MW and the production cost of one kW·h could be substantially low.

Alain Coustou

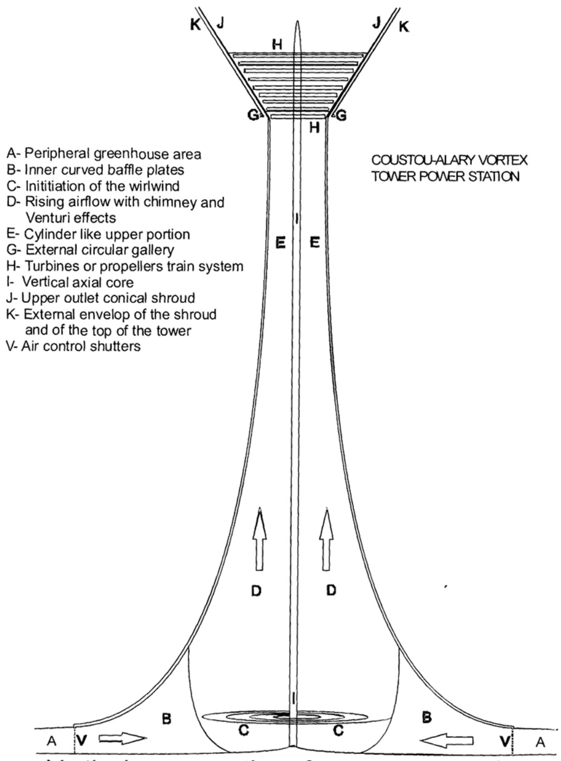
Born in France on 1940, Alain Coustou is lecturer in Bordeaux University. PhD in Economics and university degree of Demography, he is member of the scientific council of the University and officer of the "palmes académiques", a high decoration granted par the French Ministry of Education.

He has been one of the main founders of the Douala University Center (Cameroun) and the founder − and during seven years the first director − of the Economic and Business Sciences School (ESSEC) of Douala, from 1977 to 1984.

Actually, his main scientific interest topics are energy, climate change and sustained development. So, his two major scientific projects research are concerning the vortex towers power stations and the climatic risks.

His most recent publication is "Le réchauffement climatique, un risque majeur" (climate change, a major risk), an important paper published in the "Cahiers de la Security" (Security Journal, No. 3. P. 38-50, France, January 2008).

He is also the author of a book titled "Terre, fin de partie? La dérive climatique, un risque majeur" (Earth, end of game? The climate drift, a major risk) (205 pages, Eons Editions, France, September 2005).



Vertical cross-section of a vortex tower plant

Introduction

The Vortex Tower Power Stations or Self Secure Vortex Towers ("Tours Aérogénératrices" or "Tours Vortex à Sécurité Intrinséque" in french) are an innovative solution for continuous mass production of electrical energy at a low cost, without the emission of greenhouse gas, without the use of scarce natural resources, without waste, and without being adversely affected by the irregularity of wind conditions.

These towers are neither wind turbines nor ordinary solar chimneys, but they belong to the family of the vortex towers, whose geometry is intended for the obtaining and the permanence of a controlled artificial twister (vortex).

Origin of the vortex towers and environmental concerns

The first example of this type of project has been developed forty years ago by the french engineer and precursor Edgard Henry Nazare, who named it "Artificial Cyclone Generator" (1964)[1] or "Aerothermal

[1]French patent No. 1439849/PV 983953, registered at INPI (National Institute of Industrial Property), August 1964.

Power Station" (1982)[2]. The others projects of vortex towers were the one presented in 1975 by the Canadian engineer Louis Marc Michaud (Vortex Power Station)[3] on one hand, and two projects very close to the invention of Nazare on the other hand. The first of them has been proposed in the ex-USSR by Georges Mamulashvili in 1985[4]. A demonstration model of the second is actually experimented by the French engineer François Maugis and the Sumatel Corporation[5].

Meanwhile, in comparison with Nazare's project and with all that have succeeded it, the Vortex Tower Power Stations bring about substantial changes. These changes concern at once the number of the used natural forces and effects, the variety of the heat sources under consideration, numerous structural details, the characteristics of the peripheral greenhouses and of the calories storage system, an unfailing security guaranteed by the absolute control of the artificial twister generated in the structure and, finally, a probably better efficiency than the one of the rival projects.

Those towers have been conceived by the author of the present article, lecturer at the University of Bordeaux (France), energy, climate and sustained development specialist, and by the french computer scientist Paul Alary. They are patented in thirty countries in Europe, America and Asia[6].

Combined with the classic nuclear or thermal power stations, the Self Secure Vortex Towers could at first increase their energy efficiency by a substantial increase of the electric production. So the oldest or the less safe nuclear plants and the most polluting thermal power stations could be shut down quickly.

In addition, the Vortex Tower Power Station can also function in total self-contained operation with only renewable energy supplies, or recover the heat energy lost by the cooling effluents of the industry, while reducing their thermal impact on the environment. And that, whatever the latitude or the climate of the concerned country.

Later, they finally could take the place of the last thermal power stations and guarantee a soft substitution for the nuclear energy.

In the present world, more than the 2/3 of the electricity is generated by the thermal power station, burning coal, oil or gas. Such a situation contributes to intensify dramatically a greenhouse effect, whose the consequences threaten to be beyond all control. In addition, with the oil prices rise, the production costs of thermal electricity often tend toward an increasing, to the detriment of all the users, companies and citizens.

So the creation of really no polluting power stations, capable of producing a low cost kW·h, is a fundamental target towards the aim of a sustained development. All the more because the hydroelectricity is near of its limits, the solar and wind energies at once suffer of a high cost kW·h and a low average availability in the day and the biomass can supply no more than a minor contribution. For its part, the nuclear power is questioned because of the involved worries, particularly about the reprocessing and the long-term safety of the storage of its waste.

A solution happily exists for a short time: the one that's proposed with the Vortex Tower Power Station project, presented in this article. This invention has been patented in France after a demand deposed in 2004[7]. On august 2005, a request for patent has been registered in about thirty others countries.

We expose here the general principles, the description, the functioning, and some of the multiples advantages of this invention.

General principles

The invention is in the form of a hollow tower-shaped structure flared at its base and optimised to combine four and even five forces and natural effects:

− The chimney effect.
− The greenhouse effect.
− The Coriolis force (or effect).
− The Venturi effect.
− Optionally, the wind can add additional energy, without being necessary to the functioning of the tower.
− Lastly, it is possible – and even recommended – to exploit the recovery of heat energy, even low calories, from industry, nuclear power stations, great incinerators or from geothermic, otherwise often needlessly lost.

Description of the structure and functions of the different parts of the plant

The detailed description, the plans and the text of the international patent may be consulted on the Vortex Tower Power Station designer's site[8].

Optimum envisaged measurements

The tower has a minimum height on the order of one hundred meters, and preferably a height on the order of 300 m, not including the outlet shroud. However, it is possible to apply the principle to towers of different sizes. The tower has a base diameter on the order of 150 to 200 meters (for 300-meter tower) and an internal diameter at the base of the conversion means 18 (cylindrical or quasi-cylindrical portion) on the order of 25 to 30 meters (estimation for a 300-m tower).

Summary of the optimum measurements:

− Height: 300 meters.
− Base diameter: 200 meters.

[2]French patent No. 8205544 (publication No. 2524530), registered at INPI, Mars 1982.
[3]US patent No. 2004/0112005A1, belatedly registered in USA. June 2004.
[4]Ex-URSS invention certificates No. 13119654 and 1526335.
[5]SUMATEL, Allée Les Perce-neiges, 73540, La Bathie (France).
[6]International demand No. PCT/FR2005/050659, August 2005.
[7]French patent No. 0408809000, registered at INPI, August 2004.
[8]Http://groups.msn.com/ToursAerogeneratrices2/

− Top internal diameter, at the level of the lower turbine: 25 to 30 meters.
− Greenhouses area, all around the base of the plant: 3 to 5 square kilometers in totally self-contained functioning, infinitely less when combining natural forces and effects with the recovery of industrial cooling calories, or other renewable calories (geothermic).
Lower sizes are conceivable, according to the available calories and the needs, the concept operating effectively with all heights equalizing or exceeding one hundred meters. The concept is valid for different dimensions, with heights exceeding one hundred meters and tours over 300 meters being capable of being envisaged.

Description, from the base to the top

The tower includes, in the lower portion, a plurality of air inlets with baffle walls curved so as to cause the air to rotate and to generate in the tower a whirlwind phenomenon maintained and amplified by the Coriolis force, upstream of the air inlets means for heating the air suctioned into the tower by a chimney effect, means for converting the kinetic energy of the air column into electrical energy, said tower being flared at its base and gradually shrinking so as to accelerate the air by the Venturi effect.
The flared base, which provides perfect stability for the assembly, is painted black. Air inlets are arranged around the periphery of this base and can be screened to prevent the accidental ingress of birds or the suctioning of debris brought by the wind.
Between each of the inlets is an inner and/or outer baffle plate. The inner plates, which may be extended to the outside under the windows, simultaneously have a structural frame function and are interrupted at the central portion of the structure. The inner baffle plates have a curved (plan) form, so as to initiate a rotation movement of the air suctioned in the tower, which rotation (vortex) is amplified in a spiral revolution from the base to the apex and maintains itself by the Coriolis force.
A vertical core is placed in the axis of the tower and ensures the symmetry of the rotation of the air column. This core can join the axis of the turbine or propeller system 18. If necessary, it can be held in the axis of the tower by stretched cables. This core can consist of a hollow structure with a round cross-section, in which the use of cables, a lift and/or an emergency escape is possible.
The base of the tower is surrounded by greenhouses hanging over an area of different type, if the structure is constructed in a region having water resources or not.
In a region having hydraulic resources, communicating basins with a hexagon or quadrangle shape act as relative heat reservoirs for the night. Each basin may be equipped with a black floating cover, intended to prevent evaporation.
In dry or desert areas, a ground surface covered with bitumen or black painted concrete provides the same functions.
In both cases, the area considered is on the order of several km^2 (2 to 3 km^2, for example, in a very sunny area) for a self-contained tower, over which glazing hang. This area can, however, be very substantially reduced when combined with a source of industrial heat energy (nuclear power plants, iron and steel works, etc.).
The diameter of the tower shrinks gradually from the base. This specific feature should cause a considerable acceleration in the rising airflow by a combination with the chimney effect and the Venturi effect.
The upper portion of the tower to the base of the turbines or propellers has a shape similar to a cylinder, possibly slightly truncated or conical, preferably painted a light colour, such as white.
A device for converting the energy of the air column into electricity, capable of being constituted by turbine or propeller stages, controlled by sensors and managed by a computer program, is installed just before the apex of the structure. This device may be accompanied by a flare of the tower at its level so as to better evacuate the air column in spite of the conversion of a large portion of its kinetic energy. This device can optionally be preceded by one or more compressor and discharge valve stages in order to remove any excess pressure.
This cylindrical, quasi-cylindrical or flared portion can be covered by a shroud at the turbine outlet so as to optimise their efficiency and reduce any sound disturbances.

Functioning

Greenhouse effect

In the self-contained operation of the system, the ambient air around the base of the tour, which is generally naturally warmer than that at the apex, is increased in temperature by the greenhouse effect created by the glazings surfaces.
A heat energy reserve is created by the heating of the bitumen ground or black-tinted concrete-covered ground, or, better yet, water basins with a hexagon shape (optimal configuration) or any other shape allowing for regular tessellation of the ground. The capacity for diurnal storage of heat energy is much higher in the case of basins than in the case of bitumen or concrete.
These intercommunicating basins can each be equipped with a floating cover, preferably rigid or semi-rigid. This cover is black, which enables it to absorb solar heat. It would be used as needed to prevent evaporation, depending on the availability of water, which is variable according to the site and possibly the period. Its use would also limit the appearance of a vapour plume at the top of the tower.
To complement the solar heating of the air, the flared base of the tower can itself be painted black and insulated with windows on the portion of which the slope is less than around 60°.
The black absorption and heat energy reserve area surrounding the base of the structure (i.e. an envisaged area on the order of several km^2 of basins and/or bitumen

or concrete) is covered by glazings. The air circulates under them, which air is thus heated before being suctioned by the base of the tower.
This glazing area is encircled by a system of electronically controlled shutters, in order to optimise the use of the heated air according to the possible wind. It is thus possible to obtain a slight overpressure capable of reinforcing the chimney effect. The shutters are normally open in the portion facing the wind and closed in the opposite portion. The opening of these shutters or these valves can be modulated if there is too violent wind, in order to prevent an excess overpressure.
The placement of the tower on the site of a nuclear or classic power plant should enable the use of low heat energy of the water of the external cooling circuit of the power station. In winter, this water would be diverted toward the basins relatively close to the tower, from which it would spread closer and closer to the outer basins. In summer, the process would be reversed, with the water coming from the plants supplying the outer-most basins.
A classic or nuclear plant could thus provide a surplus of energy to one or more towers, surplus varying with the type of plant and with the temperature of the recovered effluents. This solution would have the dual advantage of substantially reducing the area of the greenhouses (therefore reducing the investment cost) and recovering the heat energy unnecessarily discarded into the environment with a hydraulic flow that is often high.
The evaporation would then ensure an evacuation of the heat energy making it possible at least partially to do away with the cooling towers of the plant while increasing the energy of the whirling air, which would increase in humidity. This phenomenon is well known to meteorologists in the case of natural tornadoes, which are often strong above the ocean and weaken or disappear after reaching solid ground.
If the recovered water is hot enough, it may be cost-effective to provide a system for transferring the heat energy from the water to the air that is more effective than the simple interface between the surface of the basins and the suctioned air. Three alternative solutions, among others, may be chosen, optimising the availability of a volume of hot water that is sometimes very large, on the order of some dozens of m^3/second with regard to nuclear power plants in which the cooling is not done in a closed circuit, but uses water from a stream or from the sea.
According to a first solution, a network of more or less narrow pipelines, or even actual radiators, is traversed by the air suctioned by the base of the tower and in which the water circulates, providing heat energy, before it is evacuated into the basins or toward the outside.
According to a second solution, there is a system of cascades from the apex of the greenhouses to the basins. These cascades would constitute water curtains coming from the plant and supplied from pipelines placed under the windows of the greenhouses. An alternative of this solution could consist of creating one or more water jets above each basin or the surface for receiving and discharging water.
According to a third solution, in the ideal case in which the water is available under pressure and/or at a high enough temperature, it could be sprayed directly into the air of the greenhouses (fogging), above the basins or the surface for receiving and discharging water.
In addition, the area of the greenhouses could be further reduced, which would make it possible to envisage the use of double glazings without excessive additional costs. It could even be possible to totally do away with the greenhouse effect if enough hot water is available, and to replace the windows by any material with good mechanical qualities, in which the covered space would then be intended solely to guide the outside air toward the base of the tower while allowing it to be heated by the heat energy extracted from the water.
Finally, it is possible to envisage reducing the flow of the cooling circuit by pumping less water out of the streams, which would be less disruptive for the environment and, by reducing the dilution of the heat energy coming from the plant, would be capable of providing a warmer water flow to the wind turbine tower. In every case, this placement of the towers should allow for a considerable reduction in the cost of the kW·h.
Other activities, such as iron and steel works, cement works, smelting works, incinerators, and so on, produce a flow of heat energy that is often wasted. This heat energy could also be recovered so as to significantly increase the energy production of the towers. Indeed, even low-calorie liquid or gaseous effluents can increase the energy production of the tower with respect to what is possible in a self-contained operation. This production does depends not on the absolute temperature of the air at the base, but on the difference between said temperature and the temperature of the air outside the apex of the plant.
Similarly, it is possible to use a thermal spring or geothermics to provide the basins with comparable advantages at the level of the preheating of the basin water. In every case, even a spring with a temperature lower than that desired for the air at the base of the tower can be advantageous, since its temperature is greater than that of the outside air. The greenhouse then has only to contribute to a complement of the heating, which reduces the number of basins and the windowed area needed.

Combination of chimney effect, Coriolis force and Venturi effect

Chimney effect

The warm air trapped under the greenhouses area and under the flared base of the tower rises in the hollow structure by the chimney effect. This well known phenomenon by itself would not be enough to ensure the efficacy of the device for a tower of which the height is only one to a few hundred meters. A tower using only the chimney effect and the greenhouse effect should reach a prohibitive height of around 500 to 1000 meters in order to be effective, presenting serious problems of placement, construction and cost.

It is here that the very specific architecture of the device of the invention is involved, making it possible to maximise and concentrate the energy produced by using two other complementary natural effects, the Coriolis force and the Venturi effect, and possibly to take advantage of an overpressure effect due to the wind.

Coriolis force (or effect)

The air that enters the base of the tower is guided by curved baffle plates that activate its rotation, this movement being maintained by the Coriolis effect or force. The internal plates, which are formed between each air inlet recess, can also perform a structural frame function. The axial core of the tower contributes to support the alternators and turbines and it is intended to ensure satisfactory symmetry of the air rotation in spite of any variations when it is suctioned into the tower.

A whirlwind (vortex) phenomenon is thus triggered, and is maintained and amplified by the Coriolis effect. In this way, we obtain a captive and self-maintained twister. The warm air no longer needs to rise, but is animated by a rapid rotational movement in the same direction as that set for the turbine stages.

Venturi effect

The Venturi effect is generated by the specific architecture of the tower, flared at the base, with its internal diameter shrinking as the air rises by the chimney effect. This feature causes a considerable acceleration of the rising and rotating airflow, by the Venturi effect. With an internal diameter in the upper portion of the tower equal, for example, to $1/7^{th}$ that of the base, and a temperature difference of some thirty degrees, the speed of the air column can reach several hundred km/h. It is only preferable to prevent this speed from exceeding 0.7 times the speed of sound.

Thus, the energy carried by the air column is considerably concentrated, compared with what would be obtained by the simple chimney effect in a tubular structure with a constant diameter from the base to the apex.

The conversion of the kinetic energy of the air column into electric energy

The energy of the captive and self-maintained air whirlwind is collected in the upper portion of the tower by a train of several turbines or propellers with a variable pitch, with a diameter slightly smaller than the internal diameter of the tower. The blade-span of these turbines or propellers may be on the order of 25 to 30 m for a 300 m height tower. Flaring the highest portion of the tower in the line of the turbine or propeller train, of which the diameter increases from lowest to highest. This increase in the diameter ensures the evacuation of a constant air volume in spite of the disruption of the air column by the turbines, and increases the efficiency of the assembly.

Finally, the upper outlet of the tower can usefully be covered by a shroud intended both to prevent the appearance of turbulence at the outlet of the turbine or propeller train and to minimise any sound disturbances. This shroud has a frusto-conical (truncated) or a progressive shape. It can be a double shroud, intended to cause a cool air suction phenomenon and cool the periphery of the warm air column after it leaves the turbine or propeller train, this solution being capable of effectively reducing the sound disturbances. This double shroud can be extended downward to reach the portion of the tower containing the turbines or propellers. This enveloping shroud would suction a layer of cool air along this portion, which, optionally combined with external radiators, could help to ensure the cooling of the turbines (or any other system for capturing energy. This formula should be particularly advantageous.

The percentage of conversion of the kinetic energy might exceed 75 %. The production of electricity thus obtained is permanent. In particular, it is practically independent of the wind, unlike in conventional wind turbines, limited by the Betz's law. The possible production fluctuations can hardly result from variations in the difference between the temperatures of the air at the base and at the apex of the tower. The wind can nevertheless help to amplify the chimney effect by a double effect of overpressure at the base of the tower and suction at the apex.

The power established can be several hundreds of megawatts for each tower, on the order of 500 MW in optimal activity with some thirty degrees of difference between the air at the base and that at the apex, for a tower 300 m high. The power could be even higher in the case of a vortex tower near a nuclear or thermal power station or a major heat-generating industrial activity. The effluents thereof would ensure the supply of the basins with preheated water and therefore a difference in temperature that is both more stable and greater for the same greenhouse area. They could also be placed directly in contact with the air of the greenhouse area by various methods (spray, cascades, water jets, etc.). According to this hypothesis, it is possible to consider reaching and even exceeding a power on the order of 700 to 1000 MW, reaching the order of magnitude of the power of a nuclear reactor for a particularly low cost.

Certain industrial plants sometimes simultaneously have large electrical energy requirements and a need for cooling water. The placement of a wind turbine tower can in this case both generate the energy needed for the plant and reduce the thermal waste in the environment.

Some bonus and conclusions

Some bonus

Outside, the structure may comprise a station for surveillance, maintenance and/or control, places for antennas, transmitters and retransmitters. The access to the base of the lifts and the tower can be provided underground so as to avoid the need to pass through an overheated greenhouse space.

In regular wind areas, annular wind turbines, wind turbines with vertical-axis cups or other wind turbine devices can optionally encircle the cylindrical or quasi-cylindrical portion of the structure, with the tower constituting the axis of rotation of at least one wind turbine device.

Conclusions

To conclude, the mass production of electrical energy at a particularly low cost (on the order of 2 cents per kW·h in the first estimation) by the new aerothermal power plants, i.e. the Vortex Tower Power Stations, would constitute an extremely beneficial economic advantage.

They would also have the advantage of making it possible to recover the heat energy lost both by the power plants and by other industrial plants and to reduce the thermal disturbances of said plants while supplying them with energy.

They can produce electricity with excellent efficiency from low-temperature sources, since a temperature some thirty degrees higher than room temperature is already enough to allow them to perform very well.

There are no environmental hazards. The artificial whirlwind absolutely cannot escape the tower since it is self-maintained by the specific structure of the plant and most of its energy is converted into electricity. In addition, the tower uses the heat energy available, provided by the Sun, geothermics or an industrial plant, without producing it itself and without generating waste or greenhouse gases.

The power range is relatively broad between the 100 m tower and the over 300 m tower so as to provide a wide variety of uses, and the power of a 300-m tower with preheating by recovery of heat energy is capable of reaching up to several hundred MW, and even approach the power of a nuclear reactor, while improving its overall efficiency and making it economically and environmentally more beneficial.