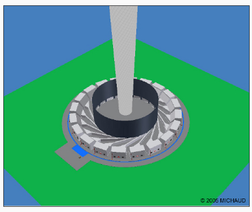
Atmospheric Vortex Engine

English



Mechanical energy is produced when heat is carried upward by convection in the atmosphere. A process for producing an artificial vortex and concentrating mechanical energy where it can be captured is proposed. The existence of dust devils proves that low intensity solar radiation can produce concentrated mechanical energy. It should be possible to control a naturally occurring process. Controlling where mechanical energy is produced in the atmosphere offers the possibility of harnessing solar energy without having to use solar collectors.

The Atmospheric Vortex Engine (AVE) is a process for capturing the energy produced when heat is carried upward by convection in the atmosphere. The process is protected by patent applications and could become a major source of electrical energy. The unit cost of electrical energy produced with an AVE could be half the cost of the next most economical alternative.

A vortex engine consists of a cylindrical wall open at the top and with tangential air entries around the base. Heating the air within the wall using a temporary heat source such as steam starts the vortex. The heat required to sustain the vortex once established can be the natural heat content of warm humid air or can be provided in cooling towers located outside of the cylindrical wall and upstream of the deflectors. The continuous heat source for the peripheral heat exchanger can be waste industrial heat or warm seawater. Restricting the flow of air upstream of the deflectors regulates the intensity of the vortex. The vortex can be stopped by restricting the airflow to deflectors with direct orientation and by opening the airflow to deflectors with reverse orientation. The electrical energy is produced in turbo-expanders located upstream of the tangential air inlets. The pressure at the base of the vortex is less than ambient pressure because of the density of the rising air is less than the density of ambient air at the same level. The outlet pressure of the turbo-expanders is sub-atmospheric because they exhaust into the vortex.

The Atmospheric Vortex Engine has the same thermodynamic basis as the solar chimney. The physical tube of the solar chimney is replaced by centrifugal force in the vortex and the atmospheric boundary layer acts as the solar collector. The AVE needs neither the collector nor the high chimney. The efficiency of the solar chimney is proportional to its height which is limited by practical considerations, but a vortex can extend much higher than a physical chimney. The cylindrical wall could have a diameter of 200 m and a height of 100 m; the vortex could be 50 m in diameter at its base and extend up to the tropopause. Each AVE could generate 50 to 500 MW of electrical power.

The average upward convective heat flux at the bottom atmosphere is 150 W/m^2, one sixth of this heat could be converted to work while it is carried upward by convection. The heat to work conversion efficiency of the process is approximately 15% because the heat is received at an average temperature of 15 C and given up at an average temperature of -15 C. The average work that could be produced in the atmosphere is therefore 25 W/m^2. The total mechanical energy produced in the atmosphere is 12000 TW (25 W/m^2 x 510 x 10^{12} m^2) whereas the total work produced by humans is 2 TW. The quantity of mechanical energy which could be produced in the atmosphere is 6000 times greater than the mechanical energy produced by humans.

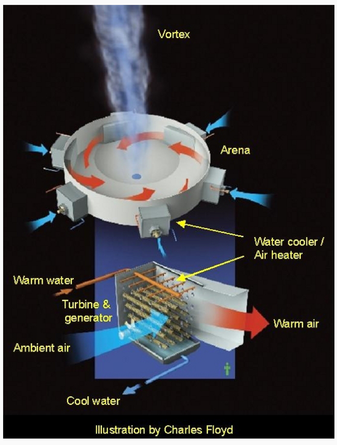
The thermodynamic basis of the AVE is consistent with currently accepted understanding of how energy is produced in the atmosphere. Atmospheric scientists call the mechanical energy that would be produced if a unit mass of air were raised reversibly from the bottom to the top of the troposphere Convective Available Potential Energy (CAPE). CAPE during periods of insolation or active convection is typically 1500 J/kg which is equal to the mechanical energy produced by lowering a kilogram of water 150 m. The vortex would transfer the mechanical energy down to the Earth's surface where it would be captured.

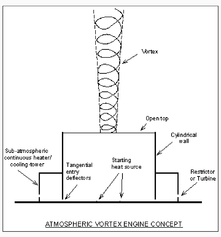
Producing and capturing the work requires that the expansion process be carried out at mechanical equilibrium. Without a mechanism such as a turbo-expander, mechanical energy reverts to heat and is lost. Work is produced when a gas is expanded in a turbine; however, no work is produced when a gas is expanded through a restriction. There must be an expander with a shaft to get the work out of the system. The design of the AVE station compels the expansion to take place at mechanical equilibrium and at a specific location. The quantity of energy which could be produced by the AVE process is far greater compared to the kinetic energy of horizontal winds captured by conventional horizontal axis wind turbines.

The AVE process can provide large quantities of renewable energy, alleviate global warming, and could contribute to meeting the requirements of the Kyoto protocol. The AVE also has the potential of providing precipitation as well as energy.

There is reluctance to attempt to reproduce a phenomenon as destructive as a tornado, but controlled tornadoes could reduce hazards by relieving instability rather than create hazards. A small tornado firmly anchored over a strongly built station would not be a hazard. The AVE could increase the power output of a thermal power plant by 30% by converting 20% of its waste heat to work.

It is estimated that it would be possible to establish a self-sustaining vortex to demonstrate the feasibility of the process with a station 30 m in diameter under ideal conditions. Learning to control large vortices under less than ideal conditions would be a major engineering challenge. Developing the process will require determination, engineering resources; and cooperation between engineers and atmospheric scientists. There will be difficulties to overcome, but they should be no greater than in other large technical enterprises.





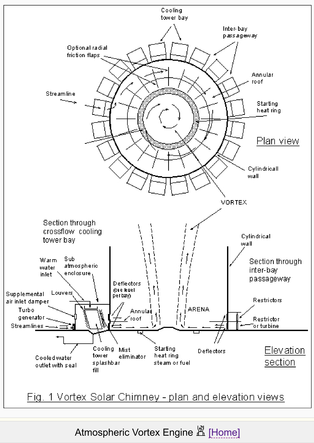


Fig. 1 Vortex Solar Chimney - plan and elevation views