Atmospheric Vortex Engine (AVE)
Technical Overview

AVEtec Energy Corporation, January 2015

The Atmospheric Vortex Engine (AVE) harnesses the energy of the tornado process.

Tornadoes are natural chimneys. In a physical chimney a wall prevents the surrounding cool air from mixing with the warm rising air. In an AVE the physical wall is replaced by centrifugal force; the wall and the rising warm air are one and the same thing.

The artificial tornado is produced by admitting warm or humid air tangentially into a circular area. The draft increases with inlet air temperature and with vortex height. Increasing the draft means more air is drawn in and more power can be produced.

The maximum work that can be produce when air is raised, the ideal work, is equal to:
"The decrease in the enthalpy of the air minus the increase in its potential energy".
The higher the heat content (enthalpy) of the rising air the more work is produced. The heat content can be due to either air temperature (sensible heat) or vapor content (latent heat). Ideal work calculations can account for the energy produced in solar chimneys, in AVE's and in any vortical storm.

Ideal efficiency is: **"One minus the average temperature at which heat is radiated to space divided by the surface temperature"**. Warm air can rise to the top of the troposphere which can have a height of 12 km and an average temperature of minus 18 °C corresponding to an efficiency of 12%. Example: 1 – (255 K / 290 K) = 12 %.

A vortex can extend much higher than a chimney and therefore can produce much more power. The minimum air temperature required to sustain a vortex decreases with vortex height.

The AVE process is unique in using the upper troposphere as the heat sink and as a result can use low temperature heat sources such as warm sea water. Conventional engines need heat at a minimum temperature of 80 °C to be economical; the AVE can make economical use of heat at temperatures as low as 26 °C. The AVE is the only solar energy technology not requiring collectors – natural warm humid air can be the heat source. There is also no need for energy storage – the heat stored in the lower atmosphere, the sea and the earth surface can be sufficient to keep the vortex going 24 hours a day.

The AVE would increase the output of thermal power plants by 20% without increasing carbon emission by reducing the temperature of the cold source from plus 30 °C to minus 60 °C.

An AVE power station could have a diameter of 100 m and generate 200 MW of electrical power. The vortex could have a diameter of 30 m at the base and could extend to a height of 12 km. The draft produced by the vortex draws the air through peripheral turbines thereby producing electricity. There could be twenty 10 m diameter 10 MW turbines.

Mother Nature produces atmospheric vortices without any help from us; we can help nature do it better and thereby produce clean energy.

For further information visit: http://vortexengine.ca

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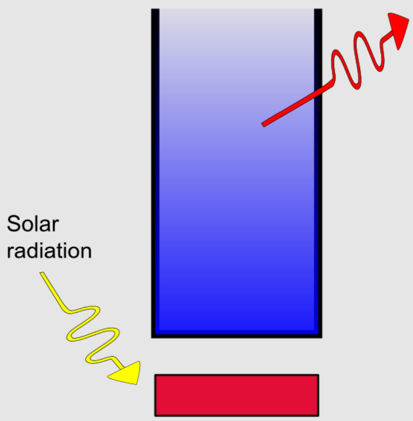
Atmospheric work production process

Basic requirements



Infrared radiation
to space

Upper pressure about 20 kPa
Upper temperature around -60 C

Air column 10 to 15 km high

Lower pressure about 100 kPa
Lower temperature around 30 C

Heat souce:
warm surface around 40 C
or warm water around 30 C

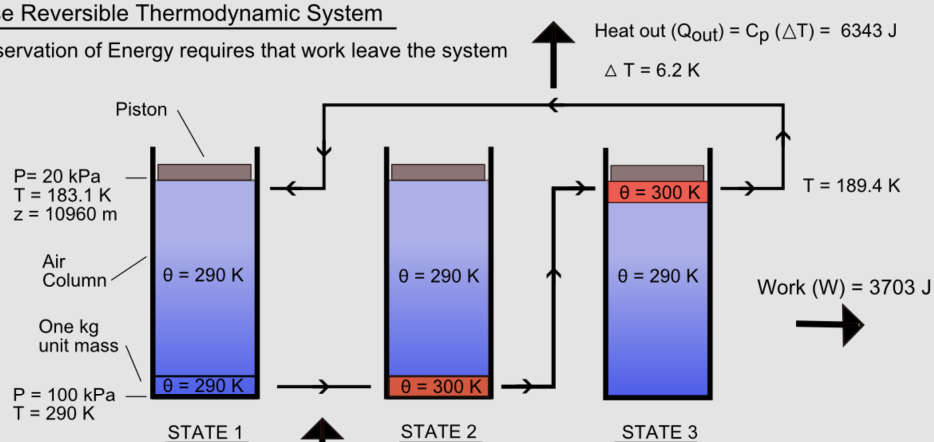
Heat to work conversion efficiency equals
Carnot efficiency based on average temperatures
at which heat is received and given up.

Close Reversible Thermodynamic System

Conservation of Energy requires that work leave the system

Heat out (Q_{out}) = C_p (ΔT) = 6343 J

Δ T = 6.2 K



Heat in (Q_{in}) = C_p (ΔT) = 1005 x 10 = 10050 J

C_p = 1005 J/kg ΔT = 10 K

1. First Law - Closed System -- Work = Heat received minus heat given up

$$W = Q_{in} - Q_{out} = 10050 - 6343 = 3703 \text{ J}$$

2. Second Law -- Work = Heat in multiplied by the Carnot efficiency

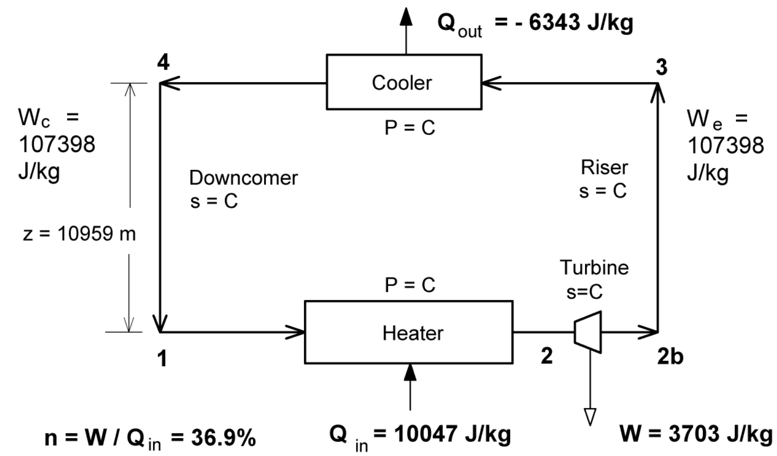
$$W = Q_{in} (1 - T_{out} / T_{in}) = 10050 (1 - 183.2 / 290) = 3703 \text{ J}$$

3. First Law - Open System -- Total energy equation

$$W = \Delta h - \Delta gz = 1005 (300 - 189.4) - 9.8 (10960) = 3703 \text{ J}$$

4. Atmosphereic Science - CAPE

$$W = \sum g \Delta (\rho / \rho_a) \Delta z = \sum (\Delta T_v / T_v) \Delta z = 3703 \text{ J}$$



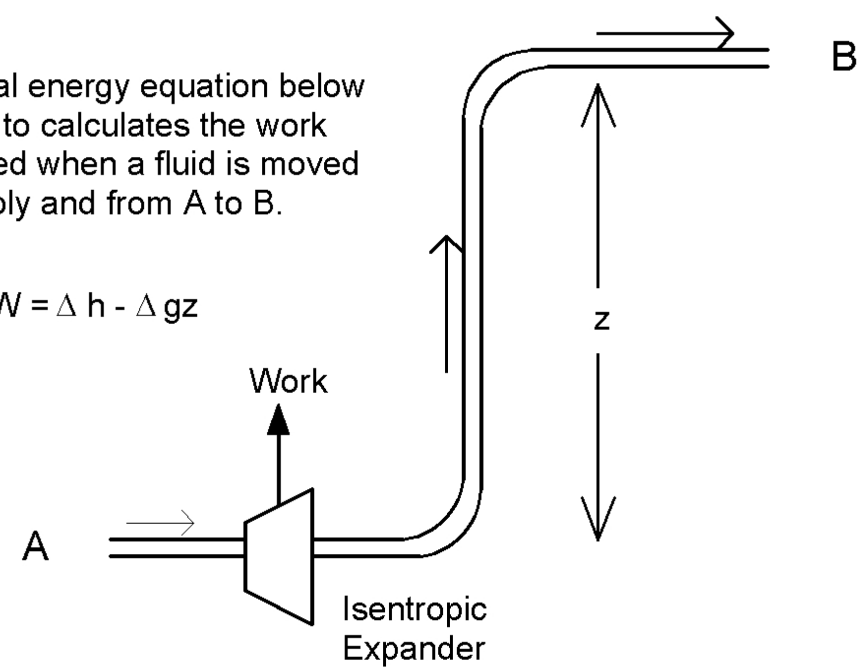
State	P (kPa)	T (K)	s (J/ K kg)	h (J/kg)	gz (J/kg)	h+gz (J/kg)
1	100	290	60.14	16929	0	16929
2	100	300	94.20	26975	0	26975
2b	95.77	296.31	94.20	23272	0	23372
3	20	189.42	94.20	-84126	107398	23372
4	20	183.10	60.14	-90467	107398	16929

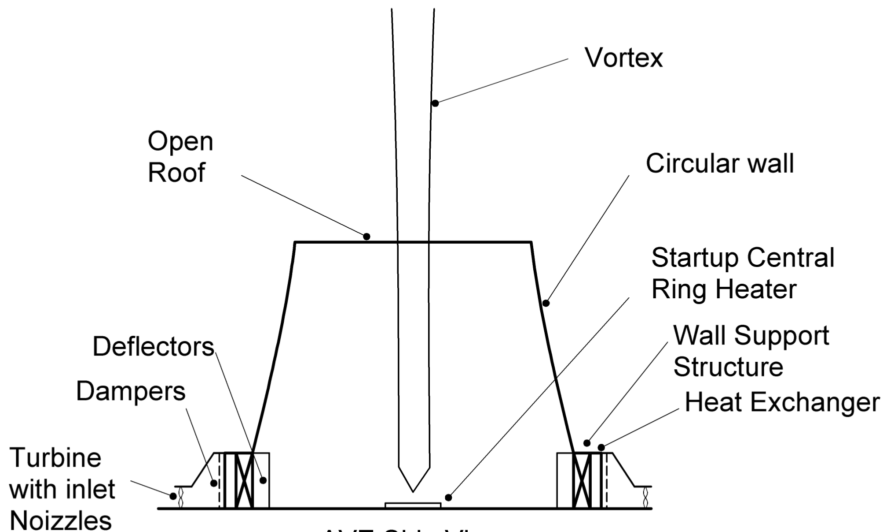
Gravity Power Cycle

- The heating and cooling take place at constant pressure.
- Efficiency is a function of pressure ratio only.
- Identical to the Brayton gas turbine cycle except that the expansion and compression take place in vertical conduits instead of in rotating machines.

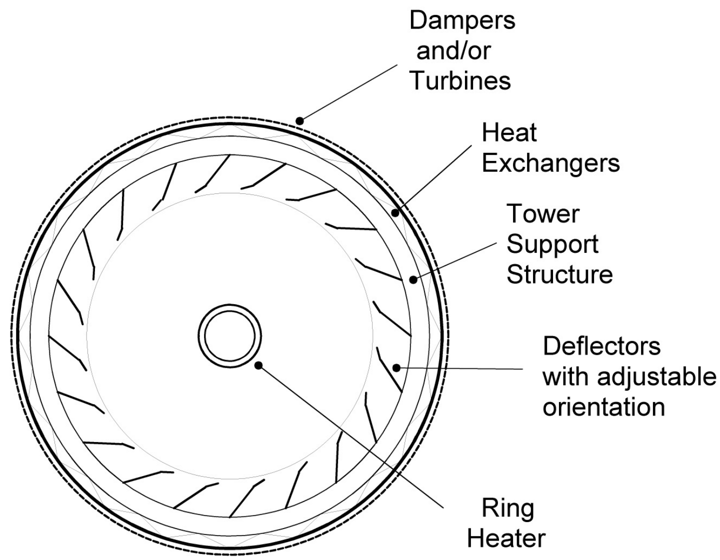
The total energy equation below is used to calculates the work produced when a fluid is moved reversibly and from A to B.

$$W = \Delta h - \Delta gz$$



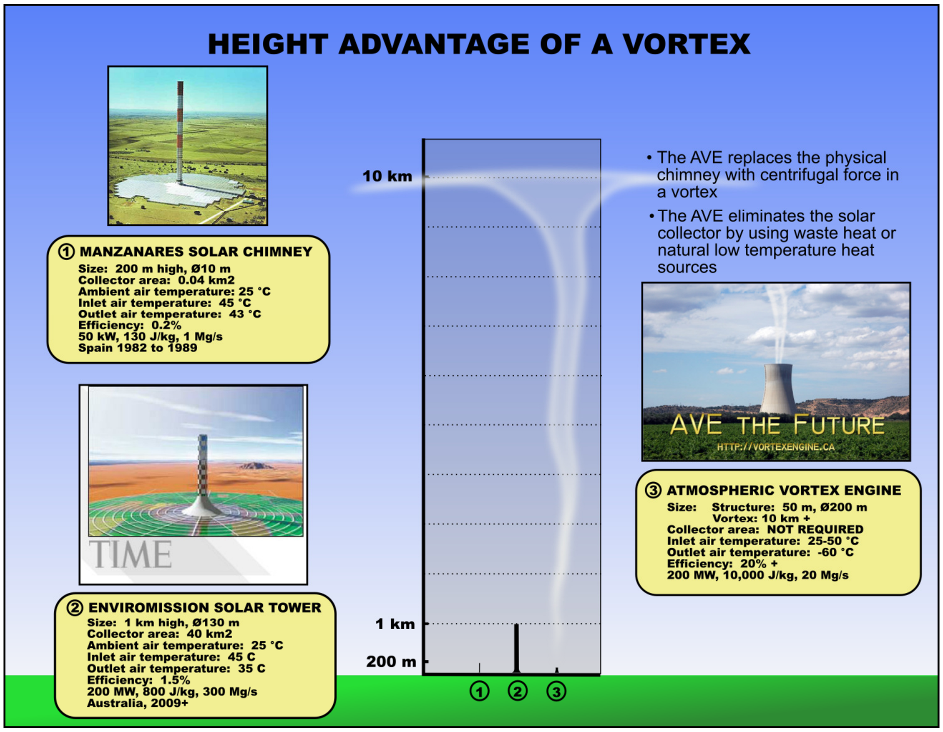


AVE Side View



AVE Plan View

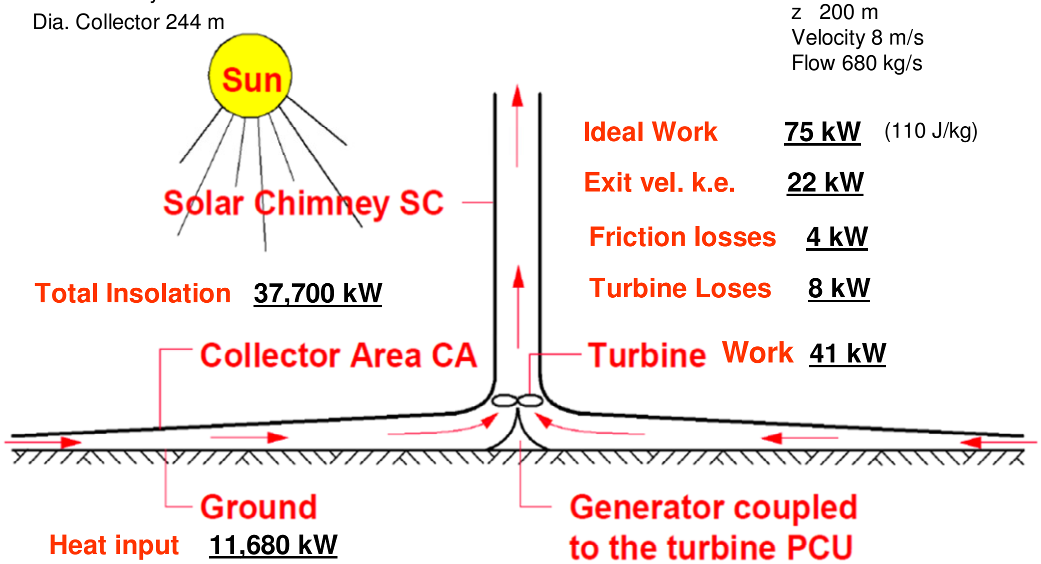
AVE plan and side views



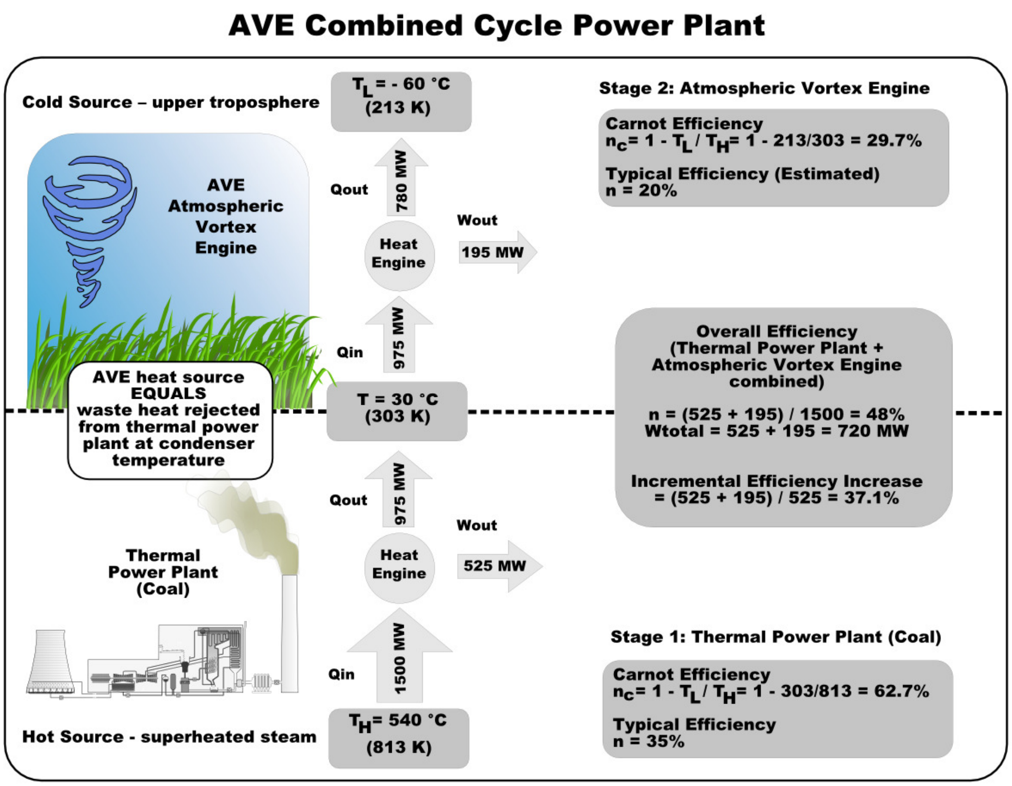
Conditions:
Collector Efficiency 31 %
Turbine Efficiency 80 %
Insolation 1000 W/m^2
Dia. Chimney 10 m
Dia. Collector 244 m

Resulting efficiency:
Ideal 0.64 % (Carnot)
Actual 0.35 %
Overall 0.11 %

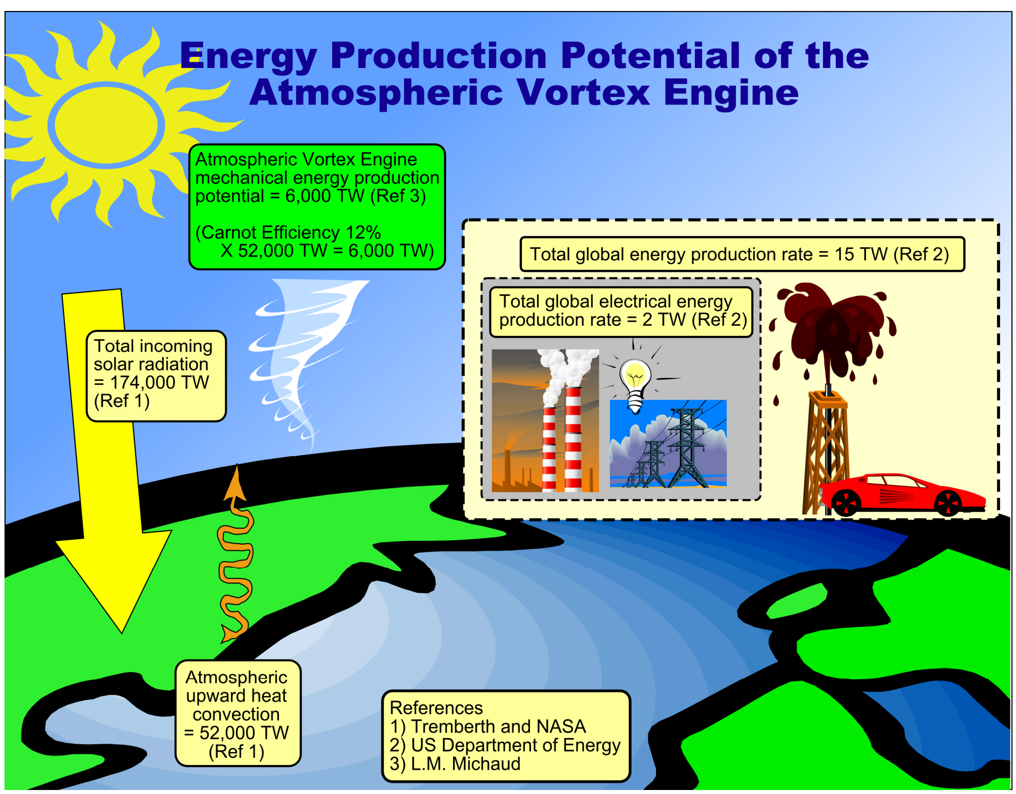
Conditions:
P_b 100 kPa
T_b ambient 30 °C
T_t ambient 28 °C
T_b chimney 47 °C
z 200 m
Velocity 8 m/s
Flow 680 kg/s



Manzanares Solar Chimney – Energy budget
(Based on actual operating conditions)



AVE Combined Cycle Power Plant
Cold Source – upper troposphere
T_L = - 60 °C (213 K)
Stage 2: Atmospheric Vortex Engine
Carnot Efficiency
$n_C = 1 - T_L / T_H = 1 - 213/303 = 29.7\%$
Typical Efficiency (Estimated)
n = 20%
AVE Atmospheric Vortex Engine
Qout
780 MW
Heat Engine
Wout
195 MW
Qin
975 MW
Overall Efficiency (Thermal Power Plant + Atmospheric Vortex Engine combined)
n = (525 + 195) / 1500 = 48%
Wtotal = 525 + 195 = 720 MW
Incremental Efficiency Increase = (525 + 195) / 525 = 37.1%
AVE heat source EQUALS waste heat rejected from thermal power plant at condenser temperature
T = 30 °C (303 K)
Qout
975 MW
Thermal Power Plant (Coal)
Heat Engine
Wout
525 MW
Qin
1500 MW
Stage 1: Thermal Power Plant (Coal)
Carnot Efficiency
$n_C = 1 - T_L / T_H = 1 - 303/813 = 62.7\%$
Typical Efficiency
n = 35%
Hot Source - superheated steam
T_H = 540 °C (813 K)



Energy Production Potential of the Atmospheric Vortex Engine
Atmospheric Vortex Engine mechanical energy production potential = 6,000 TW (Ref 3)
(Carnot Efficiency 12% X 52,000 TW = 6,000 TW)
Total global energy production rate = 15 TW (Ref 2)
Total global electrical energy production rate = 2 TW (Ref 2)
Total incoming solar radiation = 174,000 TW (Ref 1)
Atmospheric upward heat convection = 52,000 TW (Ref 1)
References
1) Tremberth and NASA
2) US Department of Energy
3) L.M. Michaud