Atmospheric Vortex Engine

Development
and
Economic

Demonstration Pilot Plant

Goals:

- Demonstrate the ability to produce and control dust-devil or tornado like vortices 5m in diameter and over 100 m high.
- Gather data required to design full scale plant.

Features:

- Outdoor pilot plant 10 m diameter 18 m high
- Warm outdoor location with access to a large steam source
- Controlled steam and air flows
- Instrumentation and data acquisition
- No cooling tower, air warmed with steam
- Flexible design within framed structure allows testing of a variety of configurations and operating modes.
- Cost: $5 million US

Commercial Plant Cost Estimates

1. **Full Scale** Power Plant vortex cooling tower **without turbines**
   100 m diameter, 1200 MWt capacity
   Cooling tower at atmospheric pressure, no turbines
   Substitute for conventional cooling tower, no fan power,
   Lower cooled water temperature
   Non-vortex forced draft fall back mode
   Cost: $20 million, competitive with conventional cooling tower

2. **Full Scale** Power Plant vortex cooling tower **with turbo-generators**
   100 m diameter, 1200 MWt capacity, 200 MWe capacity
   Sub-atmospheric cooling tower
   Increase plant power output by 20%
   Lower cooled water temperature
   Cost: Mature technology $60 million. $300/kW
   First prototype would be more expensive
   The turbo-generators do not all have be installed to test the concept

3. **Stand alone tropical-maritime AVE**
   200m diameter, 500 MWe,
   Cost: Mature technology 200$ million, $400/kW

Cost Estimate Basis – 800 MWe Power Plant

Cost of mature AVE cooling tower power plant technology similar to that of a conventional cooling tower.

- Slightly more than a mechanical cooling tower
- Much less than a natural draft cooling tower

Estimated cost of a vortex cooling tower capable of meeting the cooling requirements of a 800 MWe power plant is: $20 million.
Turbo-generator cost: $200/kW
Estimated cost of turbines and generators to produce Additional 200 MWe is $40 million

Total capital cost: $60 million
Incremental cost $40 million since conventional cooling tower not required.
Capital cost $300/kWe, one fourth of coal alternative
No variable operating costs and fixed operating costs are among lowest of all alternatives

Conventional Cooling System Cost - 800 MWe Plant

Item	Coal $M	Nuclear $M
Overall Plant	960	1520
Condenser and Auxiliaries	6.6	9.8
Pumps and conduits	5.6	8.8
Makeup system	4.2	5.6
Cooling Tower and basin		
Mechanical draft	6	9.1
Natural draft	14.7	24.9
Overall Cooling system		
Mechanical draft	22.4	33.3
Natural draft	31.1	49.1

Note: Based on Scientific American May 1971,
And equipment cost escalation factor of 3.5.

Cost Estimate Comparison Factors

Cost incrementing factors:

- Sub-Atmospheric enclosure
- Tangential entry ducts
- Flow restrictors
- Starting steam
- Additional instruments and controls
- Turbo-generators
- Electrical power transmission equipment
- Circular cooled water channel and pumping basin
- Safety and shutdown system

Cost decrementing factors:

- No fans
- Not as high as natural draft
- Machinery at grade
- Turbo-generators less costly than other electric power generator - simple axial flow turbine.
- No building required for turbo-generators.

Power Plant Capital Cost Comparison

Plant Type	$ million/MWe
Diesel	0.375
Gas Turbine	0.550
Wind	1.1
Coal	1.2
Nuclear	1.9

Based on DOE Annual Energy Report Table 38 (US$)
Note: Wind service factor 20-30%

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Capital cost of an AVE vortex cooling tower capable of generating 200 MWe is $60 million
which comes to 0.30 $ million/MWe.

Power Plant Total Cost

Plant Type	Capital %	O&M %	Fuel %	Trans. %
Diesel	15	20	63	2
Gas	30	3	72	5
Wind	74	14	0	12
Coal	57	9	27	7
Nuclear	73	12	11	4

Note:Based on DOE report

AVE	80	15	0	5

AVE Energy Production Cost

Conventional electrical energy production cost:
$50 per Mw-hr, $0.44 million per MW-year

AVE cooling tower for 800 MWe coal power plant
Value of 200 MW-yr additional electricity $88 million

Annual cost:
Capital: $6 million (10% of capital cost of $60 million)
O&M: $4 million
Total: $10 million
Energy production cost: 11% of competition
$5.5 per Mw-hr, $0.048 million per MW-y

Return on Investment
Initial investment: $60 million
Net product value: $84 million
Return on investment (ROI): 84/60 = 143%

AVE Power Plant Benefits

Power

- 20 to 30% of power plant waste heat converted to electricity in AVE turbo generators.
- Additional 5% power production from conventional steam turbine as a result of lower cooling water temperature.
- Additional Power from heat content of ambient air at high power demand times

Environmental Benefit

- Reduce fuel usage
- Reduce CO2 emissions and global warming
- Increase local precipitation
- Decrease local temperature – break heat inversions
- Global cooling
- De-pollution

Advantages of developing at a thermal power plant

- The temperature of the cooling water rejected by thermal power plant (40-50°C) is higher than the sea water temperature responsible for hurricanes (26-31°C).

- Thermal power plants already need cooling towers.
AVE eliminates the need for conventional cooling tower.
AVE technology is similar to thermal power plant technology.

- Power plants are in the power production business.
Power plant have appropriate infrastructure: electricity, steam, makeup water etc…

- Reduces fuel usage, green house gasses, and pollution.

- Thermal power plants are the low hanging fruit and the most logical implementation point.

- Other waste heat producers such as refineries and petrochemical plants could also be suitable sites.