Preventing solar energy degradation
could be the energy source of the future.

by: Louis Michaud, May 2017

Preventing the degradation of a small part of the solar energy received by the earth would meet human energy needs. The earth receives 174,000 TW of energy from the sun. There is a potential for producing 8,500 TW of mechanical energy from the solar energy received by the earth. Current solar energy production including: hydraulic, wind, photovoltaic and bio-energy is only 0.2 TW. How come the fraction of the solar energy that ends up as useful work is so small? How come the total solar energy produced is only 0.002 % of what could be produced?

The earth's current energy production is 18 TW(t) of primary thermal energy and 2 TW(e) of electrical energy. Solar energy degrades to valueless low temperature heat unless captured. The atmospheric vortex engine (AVE) could become the clean energy source of the future by preventing degradation of solar energy. The energy production potential of the AVE is much higher than that of either fossil fuel or nuclear energy. There would be no carbon emission or nuclear waste.

Earth solar energy budget	
Incoming solar radiation	174,000 TW
Reflected back to space by the atmosphere or by the earth surface	52,000 TW
Absorbed in the upper troposphere	60,000 TW
Absorbed by the earth surface	62,000 TW

Atmosphere upward heat convection budget	
Energy carried upward by convection	62,000 TW
Latent heat from the earth surface	41,000 TW
Sensible heat from the earth surface	9,000 TW
Radiation absorbed in the lower troposphere	12,000 TW

There is a potential to do work when heat is carried upward by convection in the atmosphere because the heat is received heat at higher temperature than it is given up. The potential to produce work from temperature differences is called by various names including: available energy, ideal work and exergy - literally extractable energy. Exergy is the maximum amount of work that can be produce when heat flows from hot to cold. The 52,000 TW reflected back to space is lost and therefore can produce no work.
The 60,000 TW absorbed in the upper troposphere produces no work because it is radiated back to space at essentially the same temperature as it is received. The 62,000 of solar energy carried upward by convection could produce useful work. Heat carried upward by convection can produce work because it is received at the temperature of the earth's surface and given up at the average temperature of the troposphere. The exergy of the troposphere is approximately 14 % because the heat is received at and average temperature of +20 °C and given up at an average temperature of -20 °C. The exergy of the atmosphere is therefore 14 % of 62,000 TW equal to 8,500 TW.

Atmosphere's estimated exergy budget

Total available energy (exergy)	8,500 TW
Energy used to lift water	2,000 TW
Exergy degraded in mixing processes	1,000 TW
Exergy degraded in overcoming viscous friction in prevailing ailing winds	100 TW
Exergy degraded by viscous friction in turbulent eddies	100 TW
Exergy degraded as a result of heat flow by conduction or radiation	100 TW
Exergy used to drive wind turbines	0.1 TW
Exergy lost because there is no load to push against	5,200 TW

By far the largest part of the energy degradation is due to the fact that work has nothing to push against. The energy required to sustain the winds is only a small part of the exergy because air has a low viscosity. Estimates of the mechanical energy required to sustain winds vary widely. Helmholtz calculated that it would take 43,000 years for the effect of viscosity to reduce velocity of the upper atmosphere by half. Irrespective of the exact value of the quantity of mechanical energy required to overcome viscous friction and other losses the largest part of the exergy is degraded simply because there is nothing for it to do or push against. When a gas is expanded in a cylinder/piston system, exergy degrades to heat unless the piston has something to push against. Without wind turbines or hydraulic turbines the work they produce would degrade to useless heat.

Mechanical and electrical energy are high grade energy. Heat is low grade energy. High grade energy can readily be completely degraded to low grade energy. Low grade energy can only be partially converted to high grade energy and only with costly machines. The heat to work conversion efficiency of heat engines is typically between 15 and 50%. An idling engine has 0% efficiency. The production of high grade energy requires that the heat be transported via the expansion and compression of a fluid. Heat carried by radiation or by conduction produces no work.

The Manzanares solar chimney demonstrated that upward heat flow in the atmosphere can produce power. A turbine located in the base of the 200 m high by 10 m diameter chimney produced 50 kW of electricity. Friction and exit losses were approximately 25 kW. Ambient air was heated by 20 °C in a 250 m diameter greenhouse located around the base of the chimney. The solar chimney stops exergy from degrading to heat. The exergy is captured by forcing the expansion to take place in a chimney and restricting the flow with a turbine located in the base of the chimney.

The chimney prevents the warm rising air from being diluted by cooler ambient air and transfers the work of expansion to the turbine, to the point where flow is restricted. If the turbine were replaced with a restriction, the mechanical energy would mainly degrade immediately downstream of the restriction. Little of the dissipation takes place in the slowly descending air outside the chimney.

In the free atmosphere degradation takes place preferentially near where the work of expansion is produced. Degradation occurs mainly in expanding rising air and not in slowly subsiding air. This realization is important because at any given time intense updrafts and precipitation only occur in approximately 5 % of the atmosphere. Looking at processes such as the solar chimney can help understand where degradation takes place. The degradation occurs mainly in areas of upward convection.

The ideal efficiency of a solar chimney is equal to the difference in ambient temperature at the base and top of the chimney divided by base ambient temperature. For the Manzanares solar chimney the vertical difference in ambient temperature was 2 °C and the ideal efficiency was 0.6 %. Solar chimney efficiency is proportional to chimney height. A 10 km high solar chimney, if it were possible to build one, could have an efficiency of 15 %. Natural vortices such as tornadoes produce intense mechanical energy because a convective vortex acts like virtual chimneys. Centrifugal force in the vortex prevents horizontal convergence and transfer the work of expansion downward. Learning to produce and control tornado like vortices could permit the production of clean carbon free energy in quantities far exceeding current human needs. The proposed atmospheric vortex engine, see: vortexengine.ca could produce clean energy and meet the world's electrical energy needs.

The mechanical energy produced and dissipated in a large hurricane can be 50 TW. The mechanical energy produced by a single hurricane can be more than the electrical produced in a year. A 100 m in diameter atmospheric vortex engine (AVE) with a vortex 30 m in diameter could produce 200 MW of electrical power. Ten thousand AVE's could meet current electrical energy needs of 2.2 TW. The presently installed 350,000 wind turbines produce an average of 0.1 TW. A much smaller number of AVE's could meet all electrical energy needs.

Developing the AVE will require a concerted development effort. Humans could surely learn to control a natural occurring process thereby meeting their energy needs. Mother Nature does it without any help from us why can't we?

References

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