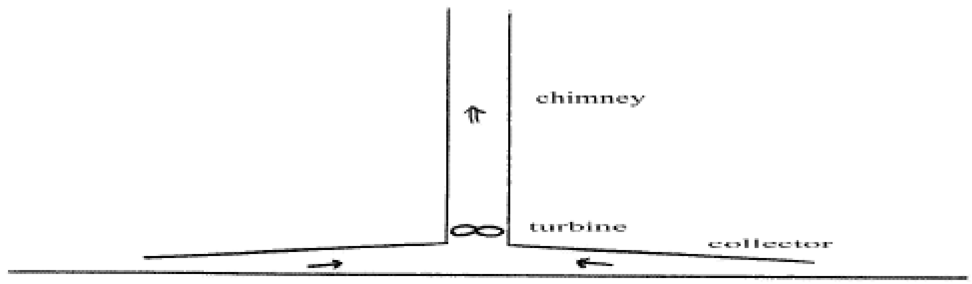
***THE SOLAR CHIMNEY** - would a regenerator improve efficiency?*

The solar chimney offers a method for the large scale generation of electricity from solar energy[1].



Ambient air is drawn into the glass collector. This is warmed by solar energy and rises up the chimney. The current of rising warm air drives a turbine. The prototype at Manzanares, Spain worked successfully over several years. There are proposals for the construction of commercial plants of up to 200 MW in India, South Africa, Australia and other countries. The capital cost is high but running costs are very low, the fuel is free and the power station has a long lifetime. The technology could become the cheapest method for the large scale generation of solar electricity.

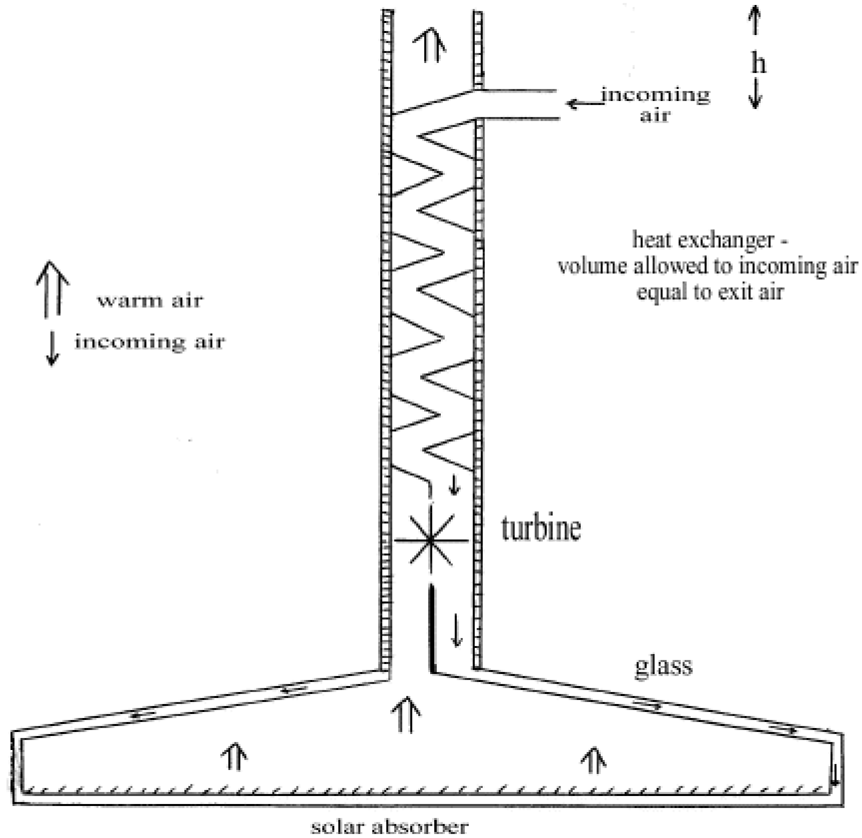
The overall conversion efficiency from solar energy to electricity is 2-3%. Where does the other 97% go?

1. There is a temperature drop with altitude of about 10° C for a 1000 metre chimney[2]. Large quantities of warm air have to be lifted from the ground to chimney top. This is gravitational energy lost.

2. The air that leaves the chimney is above ambient temperature at that altitude. This is thermal energy lost[3].

3. Ambient air that is drawn into the collector and is warmed expands with little increase in pressure. The majority of solar input is lost in the simple expansion of air before it reaches the turbine. None of this is surrendered to the turbine.

Would a regenerator improve efficiency? The author proposes a modified solar chimney where the paramount consideration is the rigorous elimination of all energy losses. The solar collector is sealed and double glazed with low emissivity glass. The entire floor area has a solar absorber. The chimney is well-insulated and incorporates a heat exchanger along most of its length.



Warm air rises from the solar collector and drives the turbine. Its residual energy is then transferred to incoming air in the heat exchanger – such energy recovery can be over 95% efficient. Incoming air enters well up the chimney at a level ‘h’ from the top, which is needed to drive the system. The incoming air is warmed as it travels down the chimney. It passes through the turbine and then between the two layers of glass to ground level, entering the solar collector from underneath the absorber.

There are no pumps. The chimney is open to the air and at atmospheric pressure. The driver is gravity – air in the collector is warmed by solar energy and rises because it is lighter. This will draw in colder, ambient air which is heavier.

The author claims that the energy losses listed earlier will be dramatically reduced in this proposal:

1. The loss of potential energy for the exit air is virtually compensated by the gain in potential energy for the incoming air, except that due to ‘h’.

2. The loss in thermal energy for exit air should be dramatically reduced by the regenerator.

3. If the regenerator was 100% efficient, then the volume of air entering the chimney per second will equal the volume of air leaving the chimney per second. There will be no nett loss due to the expansion of air.

There will be some energy losses through the double glazing, through the walls of the chimney and to gravitation due to the height ‘h’. Any losses in the turbine or due to friction in the heat exchanger will be recycled as heat into the incoming air.

The main energy loss will be in the regenerator and will manifest itself in the exit air having a higher temperature that ambient air at that altitude, a higher velocity and a greater volume than incoming air. The challenge would be to construct a regenerator of ever higher efficiency.

The modifications suggested would perhaps double the capital cost of the solar chimney. It is the author’s assertion, however, that its efficiency will be increased several fold.

References:

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2. Von Backström, T.W. & Gannon, A.J., 2000, "Compressible Flow Through Solar Power Plant Chimneys". ASME Journal of Solar Energy Engineering, Vol. 122, No. 3, pp. 138-145.
3. Padki, M.M. & Sherif, S.A., "On a Simple Analytical Model for Solar Chimneys". International Journal of Energy Research, Vol. 23, No. 4, March 25 1999, pp. 345-349.

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