Research Proposal

Evaluation of the Global Potential of Energy Towers

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1. Description of "Energy Towers"

Name - "Energy Towers" is the name of a technology which was developed at the Technion--Israel Institute of Technology, to produce electricity in arid lands, taking its predicament - a lot of hot and dry air - and turning it into an asset.

Compared to for instance wind power, hydroelectric and bio-mass the "Energy Tower", as far as we can judge, is the most economical of all the technologies which are being developed to produce environmentally clean electricity using renewable sources. Moreover, it does not require a solar radiation collector and it works continuously day and night. It is also capable of producing very large quantities, in fact an order of magnitude more than all the electricity produced today all over the world.

The principle - A vertical hollow cylindrical tower will be constructed, with typical dimensions starting from one hundred meters upwards in diameter and starting at 400 m and upwards in height (see figure 1 and [1], [2]and [3]). Water (usually sea water or brackish water) will be sprayed into the top opening. The water will partially evaporate thus cooling the air. The cool air is heavier and will sink down producing an inverse chimney effect. When properly designed, the air will flow at high rates, powering turbines connected to electricity generators and escape through openings close to the base of the tower. The larger the dimensions of the tower the lower are the costs per unit electricity.

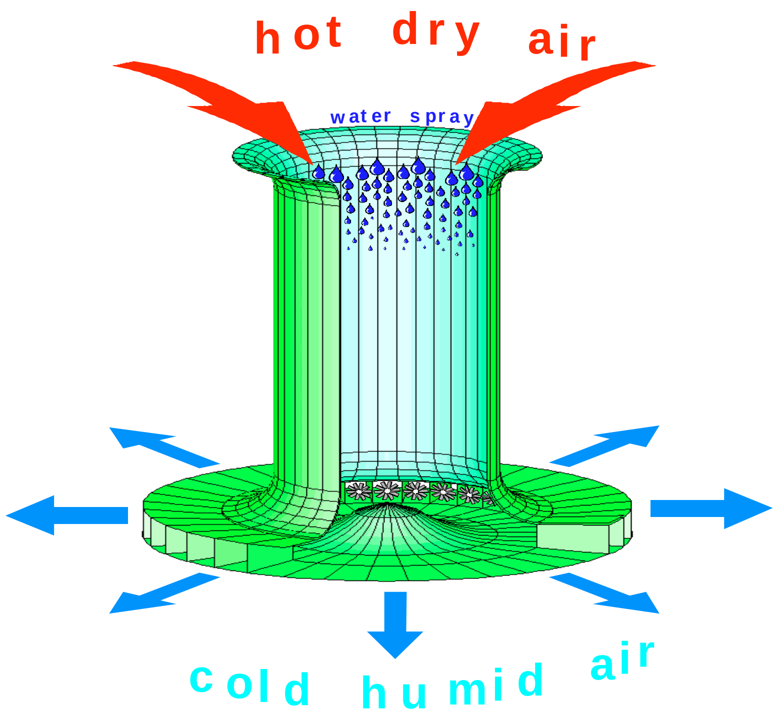

Figure 1 - Schematic description of the Energy Tower's operation

The source of energy and the "Energy Towers" potential - The source of energy used is the latent heat within hot and dry air. A global cyclic air flow named after its discoverer George Hadley drives it to the desert belts between the 15th and the 35th latitude (see e. g. [4]). Here the air descents and creates areas of arid lands and deserts. All over the world there are about 40 countries which have suitable climatic conditions for the installation of Energy Towers. The theoretical potential is big enough to provide at least ten times the entire world consumption of electricity at western European levels [4]. In Israel the potential would exceed the entire electricity demand expected for the year 2020 and beyond. In India the Energy Towers' potential could provide electricity for half a billion people at western European levels of consumption [5]. With modern long transmission lines electricity could even be provided to the majority of the global population.

Proof of the physical principle and the technologies - Feasibility has been repeatedly proven, using different methods reviewed by top outside experts [5]. The physical principle has been correctly formulated and the net electricity output correctly computed [4]. It has also been proven that Energy Towers can be built entirely based on proven technologies [4]. In fact, the unusually large dimensions of the tower does not pose any serious technical problem.

Renewable energy without the need for a solar collector - The most outstanding feature of the Energy Tower concept is that like wind energy, hydropower and biomass it needs no collectors in order to capture the solar radiation. This has several very important advantages:

- substantial cost savings
- electricity production by Energy Towers compared to the production by other renewable energies has a very advantageous temporal performance
- the area needed is no more than twice the area for a conventional power station, but only one tenth of what is needed by all other solar technologies.

Cost of electricity production and transportation - The costs, given optimal dimensions e. g. at a site like Elat in Israel, are between 2.5 and 3.9 cents per kWh for 5% and 10% interest rates respectively. This includes the operation and maintenance costs of roughly 0.6 cents/kWh, interest during construction and a 30 years projected lifetime [6].

It is perfectly possible to transport the produced electricity over distances of 3000-5000 kilometres, even including large stretches of sea. Using the right technique power lines would add transmission costs in the range of 1-2 ¢/kWh for distances of about 3000 km length (see also [6]). So the total costs are still reasonable even if far distant regions are to be supplied with “Energy Tower” electricity.

“Energy Towers” and production of freshwater - In many of the regions suitable for “Energy Towers” scarcity of freshwater is a serious problem. By devoting 20% of the electrical energy produced by one “Energy Tower” with a height of 1000 m and 400 m diameter to desalination, about 200 million cubic meters of fresh water could be produced from sea water at less than 40 cents per cubic meter. Utilizing the full potential of the deserts in north Africa could produce close to 20 times the volume of the Nile river. The desert area could then be turned into blossoming gardens.

“Energy Towers” and disposal of salty drainage water - Regional “Energy Tower” projects may have in common water supply and salt disposal. For example, in India there is a problem of drainage water from irrigated fields at the Indira Gandhi Canal. The drainage water is salty and endangers the fertility of the soil. One possible solution is to use this drainage water within Energy Towers produce electricity and reduce the volume of the salty water. The rest of the water can be disposed economically.

2. The objectives of the research and the methods

It is necessary to develop a method that will help to evaluate the output from Energy Towers in several steps:

a.) Using climatic and topographic data and a simplified model will compute the worldwide output of Energy Towers [7]. This model will take into consideration the following meteorological parameters: air temperature, air humidity, wind velocity, air pressure at a given elevation and topographic data: distance from the water source and elevation above the water source. Simplification of the computational model will be necessary in order to make the required computer time reasonable. However, there is a good chance to produce at least a rough survey of sites and to assign some priorities according to economic parameters. As input data the reanalyses of the European Centre for Medium-Range Weather Forecasts (ECMWF) will be used. This data is available for many years in a grid resolution of roughly 1.125° in longitudinal and latitudinal direction. The use of data from the latest ECMWF operational model can significantly reduce the grid size to about one third. Up to now it is only available for a period of some month but will continue to be produced for years to come. This data can be used to get a more detailed view on the worldwide "Energy Towers" potential. Both the data derived from the reanalysis and the latest operational model will be used to select the most promising regions for the erection of the Towers.

b.) A more detailed set of climatic and topographic data and a more accurate mathematical model [8] will be used to calculate the output of the towers at the selected sites. A method to calculate the hourly output from the meteorological data which is available at six hourly time steps will be developed. The required detailed data will include: air temperature, air humidity, wind velocity and air pressure at different elevations for each hour for 10 years. The mathematical model will be a one dimensional model that calculates the air and the droplet properties and finds the optimal operational parameters: water discharge and air velocity in the tower in order to obtain the maximum net power for given climatic data and for a specific tower design. This set of data could already be used as a basis for future designs.

c.) The next step is to develop an economic model – The economic model should be based on the detailed output model and will take into consideration population growth, if available time series of specific power demands within different countries, government policies, the interest rates and the opportunity electricity prices at each site. Output of this model will be a world map that will give us the most promising places where to build Energy Towers taking into consideration all the climatic and economic parameters. Furthermore, the regional water prices and needs will be taken into account to shed some light on the possibility of desalination and its economic impacts.

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