Solar potential of the Sahara Desert with an introduction to solar updraft power plants

Stefanie Fiedermann, Jadranka Halilovic and Torsten Bogacz

***Abstract*— Considering the rising energy demand, it is necessary to support new sources and possibilities for energy extraction. Renewable energies play a determining role. Amongst others, it is inescapable to regard geographic regions with extreme climatic circumstances. The desert Sahara has a huge potential of solar energy. Its dimension and climatic circumstances give cause to inspect those factors, which would permit solar power generation. An excellent way to use the premises is e.g. solar updraft power plants.**

***Index Terms*— Sahara, updraft, Renewable energy, solar potential, wind**

I. INTRODUCTION

As a consequence of the rising worlds demand for electric energy it is necessary to use alternative possibilities to the conventional generation of electricity.
The focal point is on the renewable energies. The sun plays a major role if its potential is used properly. It produces huge amounts of energy. In one hour it radiates enough energy to earth to cover the yearly energy demand of the whole world. If just 0.1 % of the solar energy would be used, the problems of energy supply could be solved (Figure 1).

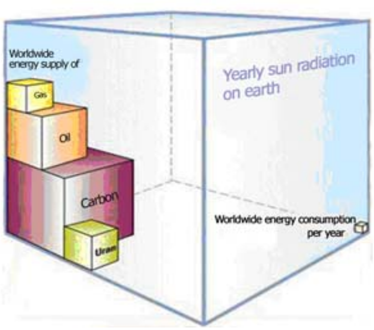

Fig. 1: yearly solar radiation on earth

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The desert Sahara extends over nine million square kilometer and thus gets the most solar radiation in the world. [4] Due to the geographical position and the resulting low clouding the sunshine duration is very high. This leads to a long-time average of 4000 hours, or eleven hours of sunshine a day in the deserts heart. This number is shortened to 3285 hours per year (9 hours/day) on the outside margins.
The sunshine hours of selected sunny meteorological stations in Germany are well below 2000 hours. [3]
This huge potential of available solar power combined with the very low population density predestines the Sahara as a central location for the generation of electricity. The condition for this is the realization of the transfer of electric energy over long distances with a minimization of losses.
One option for using the solar power is the solar updraft power plant. The typical build-up will be described below.
In this power plant the sun heats up the air mass which is situated below the solar collector. Due to a central chimney occur differences of pressure. The following equalization of pressure generates up winds. One or more turbines produce electric energy as a result of the airflow. [1]
This method of generating electricity was described by Isidoro Cabanyes for the first time in 1903. The pilot scheme in the 1980’s should prove the technical feasibility as well as the efficiency for a period of years.

II. GLOBAL AND LOCAL FACTORS

Capabilities for the use of solar power are especially sunny regions. The generated electric energy, which gets along with almost no consumption, could be used primary for the own requirements of this region and later for the external trade by exporting this electricity. There is no necessity for fossil burning (coal, oil, gas) moreover the investment grows and a lot of jobs can be created.
Especially developing countries would profit from work and energy. Furthermore the generation of updraft energy is environment-friendly and inexhaustible.

III. MODE OF OPERATION

The mode of operation of updraft power plants is based on the three physical doctrines: greenhouse effect, chimney draft and transformation of kinetic energy.

The build-up of such energy-producing facilities consists basically of three essential components. These are the solar collectors, the chimney and the turbines with generator and gear (Figure 2).

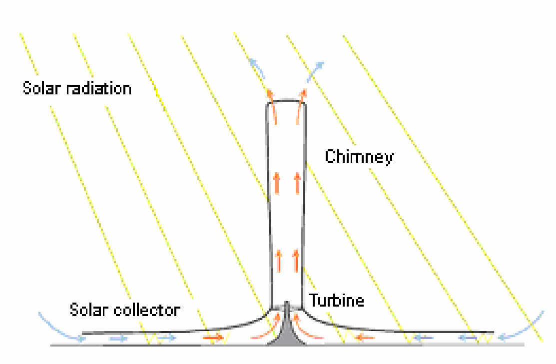

Fig. 2: typical construction of a solar updraft power plant

The solar radiation impacts on the solar collectors and on the water reservoir which heats up the air mass and the ground below. The consequence of this is a pressure difference between the chimney and the heat store.

Through the lesser density of the warm air mass under the glass roof it rises up in the chimney. The Stack Effect intensifies the pull of more air mass.

Due to these effects a continuous upwind is ensured for driving one or more turbines. The gear transmits the mechanic energy to the generator, which finally transforms it to electric energy.

One big advantage of solar updraft power plants is the possibility of a 24/7 operation. This is possible because of the constant heat emission of the heat stores. These are realized by water tanks under the glass roof as well as heated ground. Therefore the heat, saved during the day, can be released in the night. This opportunity makes the operation possible during darkness and without fossil burning. [2]

IV. COMPONENTS OF SOLAR UPDRAFT POWER PLANT

a) Solar collectors

This basic component of the solar updraft power plant consists of glass- and foil-cover and uses the greenhouse effect. For instance, a 200-megawatt disposition would need eight kilometers diameter of solar collector area and a 1000 metres tower. The warm air mass, which is the result of the heating under the glass-roof, flows radial through the collector towards the base of the chimney, where it rises up. [1]

b) Chimney

The main task of the chimney is the conversion of the heat energy into kinetic energy. Furthermore, the chimney is an important constituent because the performance of solar updraft power plant depends largely on two factors: on the one hand the surface of collectors and on the other hand the height of the chimney.

There are different solutions for the chimney construction (Figure 3), e.g. out of Ferro concrete or as a steel construction, which should be taken under consideration of the location. This is a crucial point, whether it is about the investment-calculation or construction. The primary factors, which should take attention, are the wind- and climate-terms, but mainly the strength and commonness of earthquakes. [1]

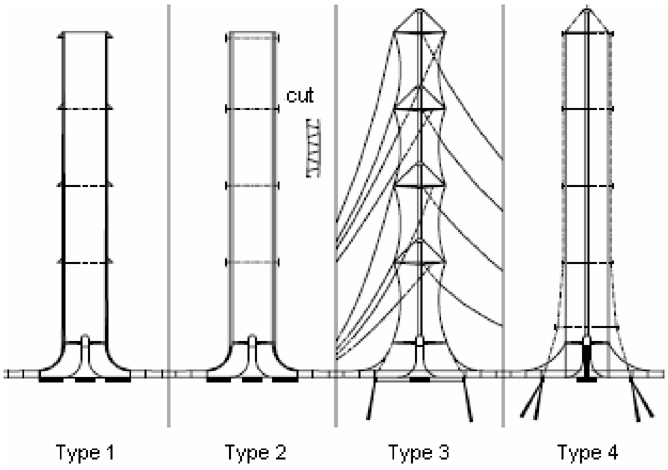

Fig. 3: different kinds of chimney construction

c) Turbine and generator

By dint of turbines it is possible to detract the mechanical energy of the airflow.

Several turbines fill the diameter of the chimney and are driven by the constant airflow in the chimney (updraft). Through the kinetic energy of the turbines a generator is provided which then converts the accrued energy into electricity. [1]

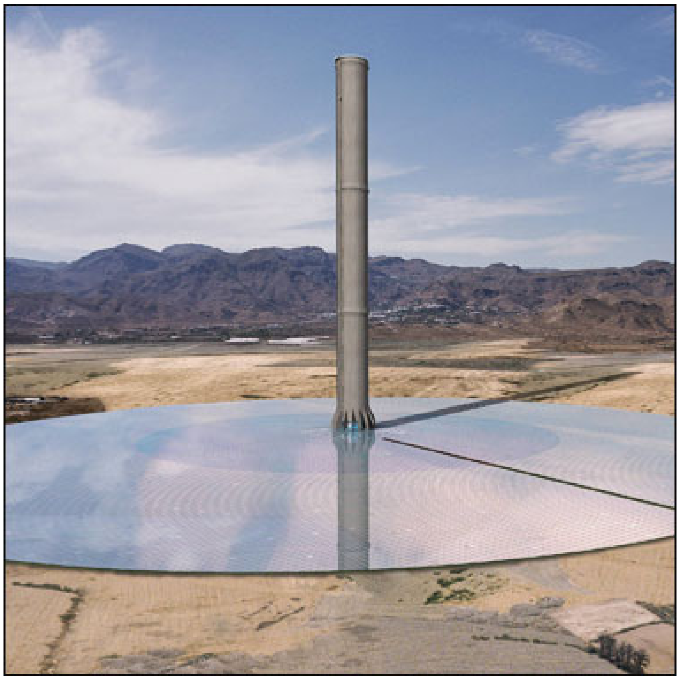

Fig. 4: solar updraft power plant

V. CONCLUSION

The solar updraft power plant distinguishes through a simple concept in connection with a simple construction. The basic components consisting of collectors, turbines and chimney do not have to be newly developed, solely an adaptation and possibly advancement is necessary.

Important assumptions for the operation of such power plant are a capacious surface for the collectors and long solar radiation. This can be warranted in areas like the Sahara desert e.g. another advantage of the Sahara location is the closeness to Europe. Considering the fact of the high energy demand in Europe, the EU states could be potential electricity importer. Therefore, it is certainly fundamental that low-loss energy transfer is assured.
By achieving the mentioned requirements, the solar updraft power plant could develop into an environmentally friendly power generation alternative and become an important economic factor in an economically underdeveloped region.

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FIGURE REFERENCES

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