Solar Islands – A Novel Approach to Cost Efficient Solar Power Plants

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Existing Solar Power Plants are too small, need complex constructions and drive systems to follow the sun's altitude and have a limited use factor of the area. Therefore the generated energy is too expensive. The target of the new concept "Solar Islands" is to improve all these cost factors and to end up with a cost per kWh which is competitive with today's energy costs. Furthermore the design as a floating "island" allows not only the application on land, but also on lakes, lagoons or on high seas. The vision is to build very large islands, floating on the pacific, that could contribute 1/4th of the estimated global energy demand in 2030.

The generation of sustainable energy will become one of the main challenges of our civilization for the coming decades. Worldwide energy demand is expected to grow from about 10 GTep (Giga Ton Equivalent Petrol) in the beginning of the century to 15-20 GTep by 2050.

Among the many renewable energy sources, the potential of solar energy is at least one hundred times larger than any other renewable energy source. Today, there are four main classes of solar energy systems in operation or in development:

- Photovoltaic panels (PV)
- Low temperature solar panels (collectors)
- Thermo-solar high temperature panels and systems (100-350°C) also known as "Concentrated Solar Power" (CSP) and higher temperature (800-1000°C), e.g. solar tower

As costs for PV panels are still quite high, efficiency of the energy conversion is quite low, and storage of produced energy has not been solved, this technology is not appropriate for bulk energy supply. Low temperature panels are only useful for warm water supply for domestic and industrial use. Therefore only CSP is a promising candidate for large scale application.

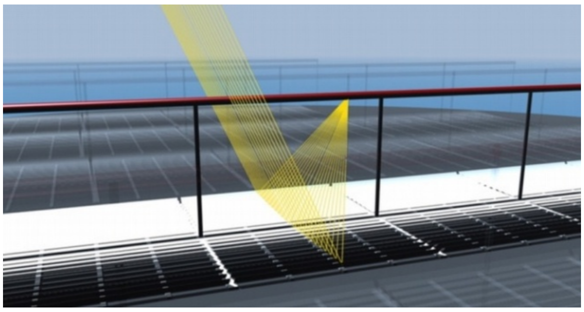

Figure 1: Extra-Flat Concentrator (EFC)

Most of the currently build and planned CSP power plants [1] make use of parabolic trough-shaped mirror reflectors, that concentrate sunlight to receiver tubes placed in the trough's focal line. The tube contains a heat exchange fluid or direct steam generation (DSG) is used. The steam is converted to electrical energy in a conventional steam turbine generator. The heat can be stored by using latent storage materials like liquid salt in order to extend delivery of electric energy in the evening hours.

As a lower cost alternative, Solar Islands will use extra flat concentrators, built out of flat mirror glass blades which form a Fresnel reflector, see Figure 1. The concentrators will not follow the elevation of the sun, but its azimuth. To this end, the concentrators are mounted flat on the platform. Thus all elements of the platform will be passive, only the platform itself will rotate in order to follow the azimuth.

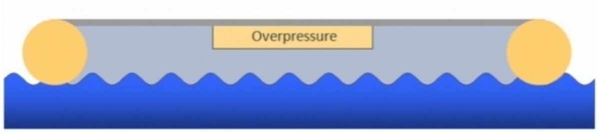

Figure 2: Floating Platform

The platform will consist of an outer torus (e.g. steel ring). The inner part is covered with a low-cost surface sheet (e.g. plastic foil). An overpressure is applied below this membrane, thus exerting a vertical force equal to the weight of the solar thermal modules placed on the membrane, as depicted in Figure 2. Only about 5 mbar overpressure is needed to carry a load of 50 kg/m^2. This novel design enables a simple turning of the platform by using electric hydrodynamic motors.

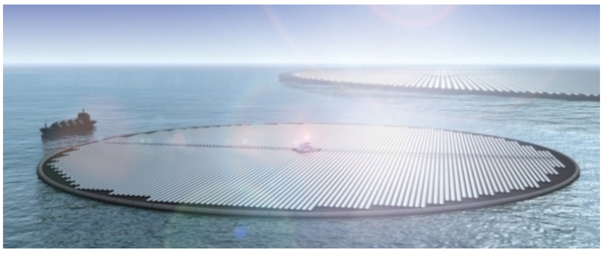

Figure 3: Large Islands on open sea (computer graphic)

The same principle can be applied for land based platforms, where the outer ring is simply swimming in a circular water trench. In that case, drive wheels will be used for the island's propulsion.

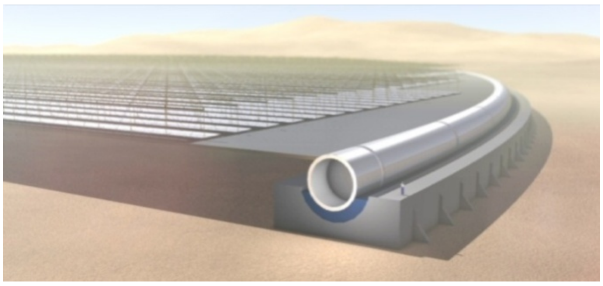

Figure 4: Cross-section of land based Solar Island (computer graphic)

As a first step, CSEM is building such a land based prototype in the emirate Ras Al-Khaimah (RAK) with a diameter of 86 m, see Figure 5. This island will be equipped with 68 solar thermal modules, each of size 8 m x 8 m. The modules and the entire thermal loop is designed and manufactured by the CSEM startup Nolaris.

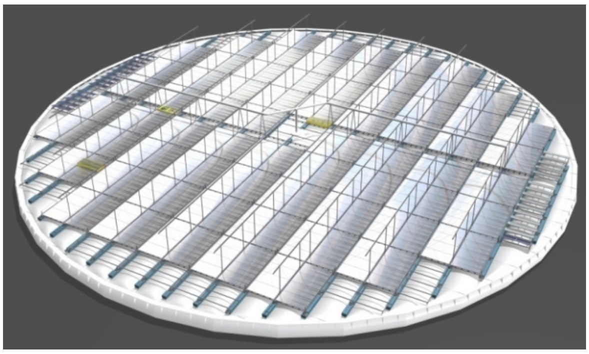

Figure 5: Prototype of diameter 86m (CAD Model)

The outer ring is designed as a torus of 2 m height, made out of 6 mm thick steel. Figure 6 shows the first produced segments.

Figure 6: Steel torus elements

A simple polyolefin foil of 2 mm thickness, enforced with some polyester fibers, will be clamped to the torus and span the entire inner part of the island. Spacing elements will be arranged in linear rows in order to distribute the load of the modules to the foils. Additionally, steel cables will be spanned over the island in a 4 m x 4 m grid to stabilize the modules and transmit horizontal wind forces to the torus. Intensive FEM and wind simulations have been made to assure the utmost stable orientation of the modules, see Figure 7.

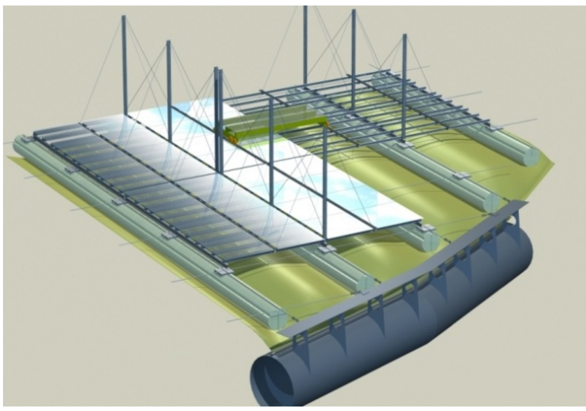

Figure 7: Part of the CAD model (absorber tubes not shown)

At the centre of the island the feeding water will be supplied by a pivotable joint. From there, the water will be distributed to the modules. All modules of a row form one branch of this network. The branches are in fact the absorber tubes, which are mounted 4 m above the mirror blades. In a coaxial manner, the feeding water floats through an inner pipe to the end of the branch. Figure 8 shows the basic principles of the absorber tube.

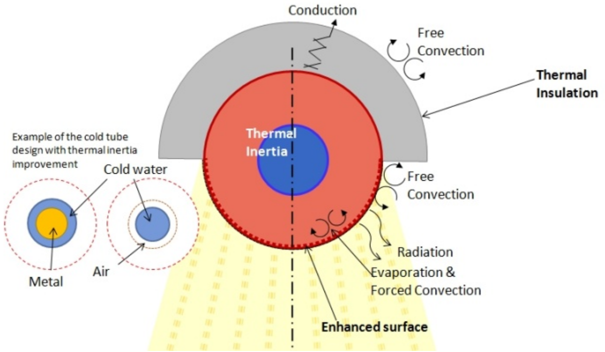

Figure 8: Design of absorber tube

The water will arrive preheated at the end of the branch and will flow at this point to the outer pipe (Figure 9). On its way back to the central tube, the water will heat up further and will be transformed into steam. The steam will leave the island through a pivotable joint and will drive a steam turbine which is placed next to the island.

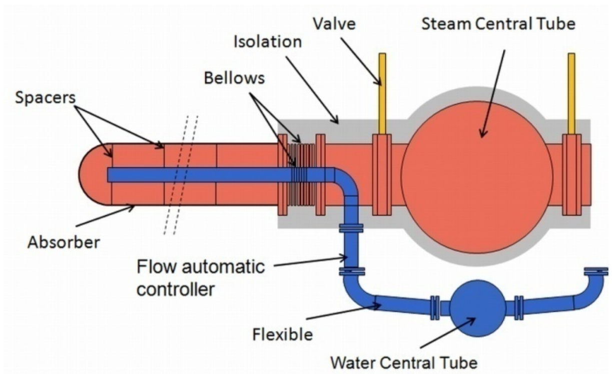

Figure 9: Water and steam network

The generated peak power of the prototype will amount to approx. 1 MW, with an average power of 250 kW. The annual energy production is expected to reach 2.2 GWh.

• Nolaris SA, a CSEM Start-up

•• Independent mechanical designer, consultant to CSEM

[1] F. Trieb, H. Müller-Steinhagen, “Sustainable Electricity and Water for Europe, Middle East and North Africa”, DESERTEC, Whitebook of TREC and Club of Rome (2007).