

Concentrated Solar Power Case¹²

Managing Projects
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Eamon Kirkpatrick is a project manager at AP Energy Corporation's³ Renewable Energy Division (APRD). He is tasked with developing an initial analysis of a proposed concentrated power facility to be built by APRD in Algeria. Concentrated solar power (CSP) derives energy from the sun by collecting sunlight with mirrors and using that sunlight to create electric energy. The most common type of CSP system utilizes a parabolic trough mirror to focus sunlight onto a high-tech receiver tube that contains a circulating thermal oil (Figure 1).



Figure 1: CSP parabolic trough mirrors (source: Wikipedia)

The receiver tube allows solar energy to penetrate the tube to heat the thermal oil within, but prevents that heat energy from radiating away (Figure 2). This causes the thermal oil to heat up to 400 degrees Celsius.

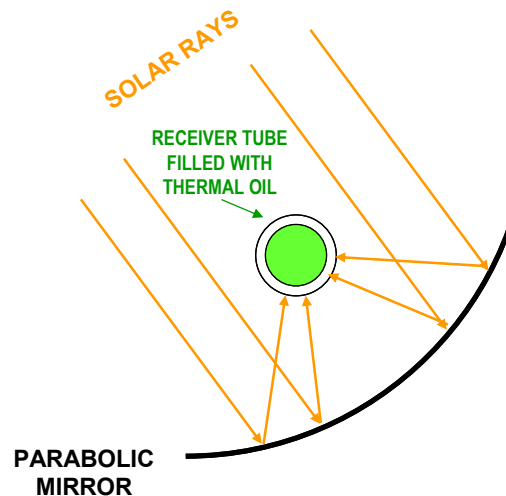


Figure 2: Solar radiation heats circulating thermal oil in a high-tech receiver tube

¹ Unless otherwise cited, information on this page comes from the TREC websites, www.trecers.net or www.trek-uk.org.

² Many thanks to Mary Ann Anderson and Nitin Joglekar for their suggestions on this case.

³ The AP Energy Corporation is a fictitious corporation that is roughly similar in the size and scope of its business to BP or ExxonMobil. Its headquarters are in Dublin, Ireland.

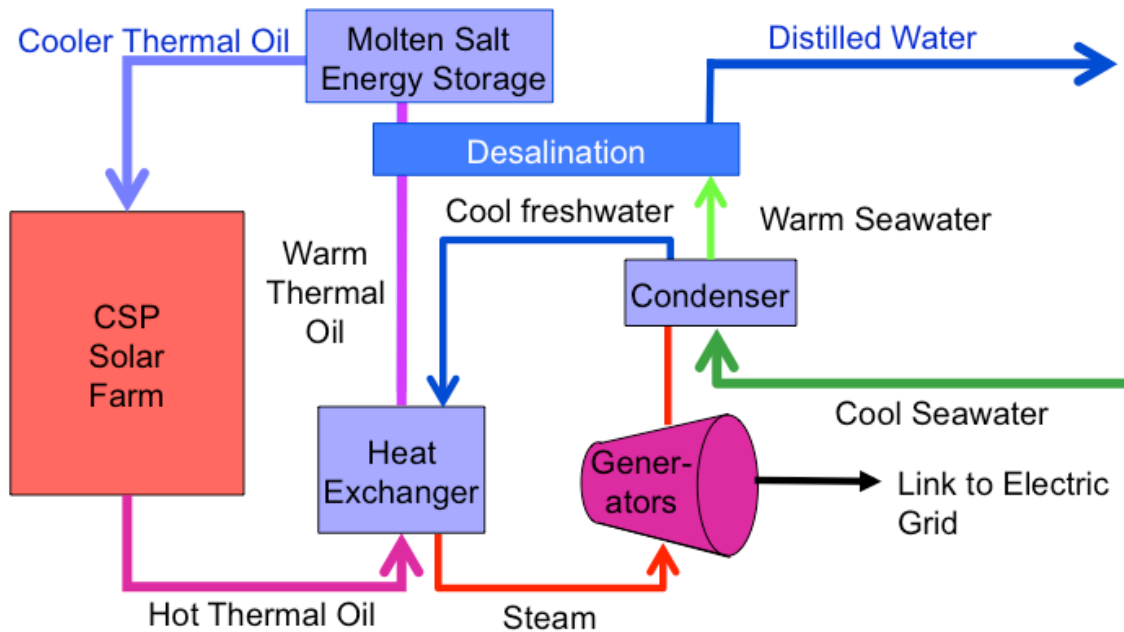


Figure 3: CSP Electricity plant schematic

The thermal oil then circulates from the mirrors to a heat exchanger. There the oil heats water up into steam to drive generators that produce electricity (Figure 3). It is important to realize that the efficiency of the energy conversion into electricity depends upon the maximum temperature of the heated oil (in practice, this is the maximum temperature that the components of the system such as the receiver tube can experience without deterioration). Both the receiver tubes and mirrors are made by a small number of specialist suppliers because of their high-tech, low-volume characteristics. There is only one supplier of mirrors and two suppliers of receiver tubes in Europe. (Technology Review, April 2007).

APRD proposes to use the proposed CSP plant's waste heat to exploit two technological opportunities, which have not been yet realized in practice. One is to use the thermal oil to heat molten salts during the day. Its heat energy can then be tapped to create steam to drive the generators at night. This ameliorates solar energy's biggest weakness, that it cannot produce energy at night (or during inclement weather). Another opportunity is that much of the heat produced by the proposed CSP project be used to desalinate seawater as proposed by Dr. Gerhard Knies, the Coordinator of the Trans-Mediterranean Renewable Energy Cooperation (TREC), and the DESERTEC and AQUA-CSP studies (www.trecers.net). This opportunity is key because the best places to build CSP plants are those areas around the globe with highest average insolation (that is solar energy per square meter), which are typically desert regions (Figure 4).

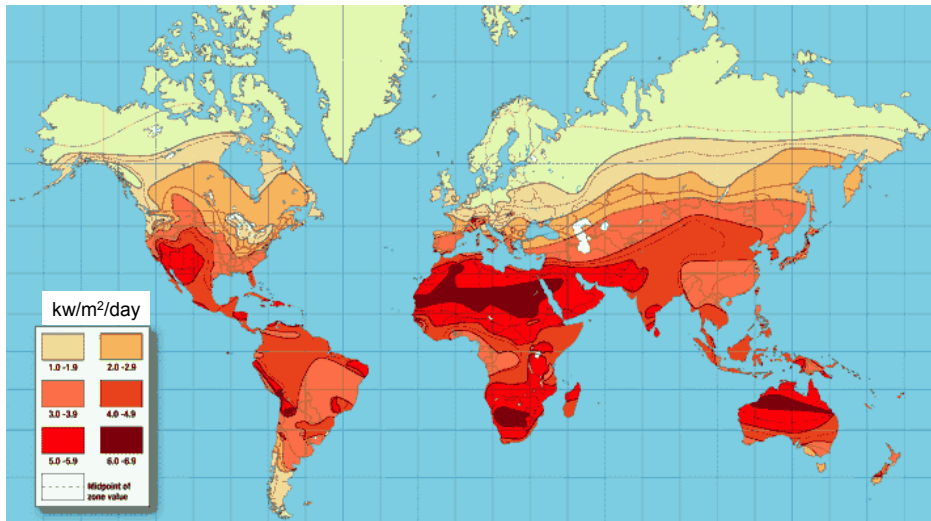


Figure 4: Average annual global insolation (source: www.trec-uk.org)

Algeria is ruled by an authoritarian regime (according to the Economist's Intelligence Unit Democracy Index in 2010) currently headed by President Abdelaziz Bouteflika. Since 2010, there have been significant protests (including numerous self-immolations), due in part to a persistently high unemployment rate. However, the government has sought strenuously to bolster its fiscal health, which has led it to pursue pro-Western business policies including a tariff-free association with the EU concluded in 2005 (Wikipedia). Anadarko Petroleum has led a major push by Western Oil Companies into Algeria to exploit its abundant natural resources, although this has slowed somewhat with a tax levied on foreign energy firms by the Algerian government in 2007. Nonetheless, AP Energy still does not have an energy project on the ground there, which is seen by upper management as a missed opportunity.

Algeria has recently expressed interest in hosting a CSP project to exploit its "desert resources" to further increase its energy revenues. Moreover, like much of North Africa, Algeria still suffers from a shortage of freshwater. Current desalination techniques produce water at approximately €1.50 per gallon according to the World Bank, but desalination from a CSP plant would be almost costless according to Dr. Knies.

A major issue in desalinating the water is the need to build and maintain a pipeline system from the CSP project site to transport water back and forth from the project to the coast. Additionally, the coastal region and the desert in Algeria are separated by the Atlas Mountain range and a number of semi-mountainous highland regions with elevations up to 1000 meters (Wikipedia). This same barrier will hinder connection to the European electrical grid, which is expected to be the prime consumer of energy from the project (Figures 5 and 6).

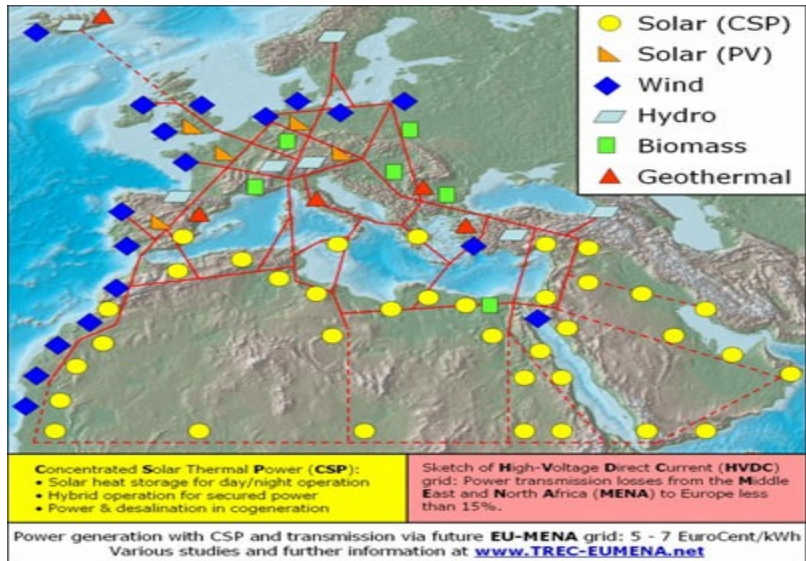


Figure 5: The European electrical grid (source: www.trec-eumena.net)



Figure 6: A map of Algeria (source: EmbassyWorld)

The proposed project will cost €1.3 billion over ten years to construct. When finished, it will produce 500 megawatts of electrical energy and 250,000 cubic meters/day of desalinated freshwater. The electricity should be generated at approximately 3-4 eurocents per kilowatt-hour (kWh). Current (as of September 2011) costs of electricity are approximately 1.5 eurocents per kWh from nuclear or coal plants and approximately 6 eurocents from oil or natural gas plants. Note that the cost estimates for the project's electricity generation "bake in" various renewable energy subsidies from member nations

of the European Union. These estimates also assume a strong “learning curve” effect in which unit cost of receiver tubes and mirrors will decrease by 10-30 percent with each doubling of cumulative production. Electricity from windpower farms, which experienced similar learning curves, have dropped from over 20 eurocents per kWh in the 1980s down to about 5.5 eurocents today.

Eamon’s Dilemmas

Should Eamon and APRD go forward with all or part of this project idea? Should they even spend the money necessary to investigate the project further? How and in what manner should they determine these questions?