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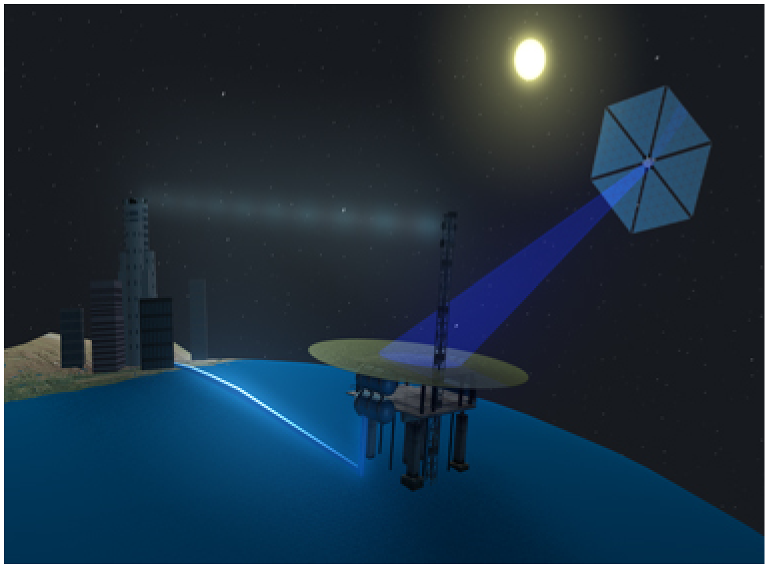

Space Solar Power for Seawater Desalination

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ABSTRACT

Seawater desalination has existed for decades as a proven technology for supplying water in coastal areas; however, desalination processes are energy intensive and this has reduced their widespread use. It is noted that California offshore oil and gas platforms already use seawater desalination to produce fresh water for platform personnel and equipment.

This visualization draws on the proposal that, as California coastal oil and gas platforms come to the end of their productive lives, they be re-commissioned for use as large-scale fresh water production facilities. Solar arrays, mounted on off-shore platforms, are able to provide some of the power needed for seawater desalination during the daytime. However, for efficient fresh water production, a facility must be operated 24 hours a day.

The use of solar power transmitted from orbiting solar power satellites (SPS) to substantially augment the solar array power generated from natural sunlight is a feasible concept. As the visualization shown below illustrates, space satellites in geosynchronous orbit (GEO) will enable 24 hours a day operations for fresh water production through seawater desalination. Production of industrial quantities of fresh water on re-commissioned oil and gas platforms, using energy transmitted from solar power satellites, is a breakthrough concept for addressing the pressing climate, water, and economic issues of the 21st Century using space assets.

TECHNICAL BRIEF

There are 27 offshore oil and gas platforms operating along the California coast. Ten are nearing the end of their productive lives and the U.S. Department of Interior, Minerals Management Service estimates that their decommissioning will be completed by 2025. Complete removal is the only option allowed under current regulations. A high percentage of these platforms are deepwater structures in water depths of 300-1200 feet; their sizes make removal both technically challenging and costly to the industry. Initial estimates for complete removal of all remaining platforms ranged from $1.2 to $2 billion. However, since current technologies are inadequate to remove the deepest platforms, the actual costs will likely be substantially higher with estimates reaching $1 billion per platform.

Some of the offshore oil and gas platforms have small seawater desalination facilities already in operation producing fresh water for platform personnel and equipment. Their existence demonstrates the technical feasibility of seawater desalination on offshore facilities. Kent Tobiska, the Mentor of the Ohio University design team doing a creative visualization of this idea, has proposed that as the California coastal oil and gas platforms come to the end of their productive lives they be re-commissioned for fresh water production. While not all platforms may be suitable due to age, size, and scheduled decommission-date, the platforms are generally capable of supporting industrial scale seawater desalination. In addition to successful small-scale desalination demonstration, they are ideally located for contributing to a California coastal fresh water supply.

Assuming that technical and environmental concerns are properly answered, the re-use of these platforms for fresh water production would benefit:

1. the coastal populations by providing an inexhaustible water supply;
2. the agricultural industry by enabling the diversion of some existing urban water sources to agricultural use;
3. the oil and gas industry by enabling it to realize a tremendous cost savings by not removing the platforms and generating lease revenue from water production; and
4. the environment by preventing local sea floor damage that would occur during platform removal and by reducing the global carbon footprint if the energy source described below is utilized.

Seawater desalination is a mature technology. Fresh water is reclaimed from seawater with an efficiency of 15-50%, depending upon the production process of either distillation or reverse osmosis (RO). Distillation plants do not shut down their operations for cleaning or replacement of equipment as often as RO plants although tube bundles do need occasional replacement and cleaning. The requirements for water pretreatment in distillation plants are less because coagulants are not needed to settle out particles before water passes through the membranes as in RO plants.

Additionally, distillation plants do not generate waste from backwash of pretreatment filters. On the other hand, feedwater into RO facilities does not require heating, which means that the thermal impacts of discharges are lower. RO plants have fewer problems with corrosion, they usually have lower energy requirements, and they tend to have higher recovery rates for seawater, e.g., around 45%. The RO process can remove unwanted contaminants, such as trihalomethane-precursors, pesticides, and bacteria and they take up less surface area than distillation plants for the same amount of water production.

The advantage of a solar power satellite in geosynchronous orbit (GEO) is that it is able to produce power 24 hours a day. Power can be transmitted at night to the surface of the Earth. Only minor outages of up to 1½-hours per day over a 2-week period occur during the spring and fall equinoxes.

Historically, solar satellites were envisioned for providing large-scale electricity to towns or small cities. This is based on the fact that a single kilometer-wide band of space at GEO experiences nearly enough solar flux in one year to equal the amount of energy contained within all known recoverable conventional oil reserves on Earth today. The size of an orbital solar array is still technically prohibitive to provide power for cities. However, the concept described here would use a satellite conceptually similar to existing commercial communication satellites but with a much larger solar array.

In comparison, the International Space Station (ISS) has a total power of 120 kW using 16 solar panels of approximately 5600 m2. A 2 MW solar satellite would require approximately 16 times the number of solar panels as the ISS, i.e., a configuration that is technically challenging but not unfeasible. Without considering inefficiencies in the system or advances in solar cell technology, a single 2 MW-class satellite can provide power for a Santa Barbara-class seawater distillation plant on a converted offshore platform during the night and can supplement the power for operations during the day.

An added advantage of SPS is that power sharing in 100-ms bursts can serve up to 10 geographically isolated locations every second. SPS power received at the Earth's surface is about ½ Sun in the center of the beam, day and night.

BUSINESS PLAN

The use of solar arrays for powering seawater desalination is not new nor is the idea of using heat flow tubes in the distillation process. Solar arrays are coupled with seawater desalination in the eastern Mediterranean and Persian Gulf. The prime disadvantages of using solar arrays are that solar energy is limited to approximately half a day (no solar power at night), seasonal Sun angles reduce solar array efficiency, and clouds reduce power from solar arrays.

Energy requirements for desalination plants are high. It is estimated that 20 million kWh yr- is required for full-time backup (reduced production) operation of the City of Santa Barbara, CA facility in order to produce 3,000 acre-feet yr- of water. This is 11,000 m3 per day that can serve about ½ the population of Santa Barbara (total population 90,305 in 2004) using 70 gallons per capita per day. The daily energy cost is near 2.3 MW. In contrast, the energy needed to pump over twice that amount (7,500 acre-feet yr-) from the Colorado River Aqueduct or the State

Water Project to the Metropolitan Water District of Southern California is about the same (26 million kWh yr-).

Thus, desalination energy requirements are about double other water energy costs and greater than the energy use of small-sized industrial facilities (refineries, small steel mills, large computer centers) typically using 75,000 to 100,000 kWh yr- (Tobiska, 2010).

The cost can vary, depending upon technology and capitalization expenses. In fact, high costs of capitalization and electricity are two reasons often cited why conventional seawater desalination can be prohibitively expensive. However, compared to new fresh water sources, the California Coastal Commission (CCC) estimates that the cost of seawater desalination is rapidly becoming equal to or less than other sources.

The cost of a SPS at GEO is more than a communications satellite, which costs around $100-200M. However, it should be much less than a direct linear scaling by size. The complexity is less although the structure is larger, requiring additional attitude control and surface charging mitigation. While a more realistic cost needs to be determined, we estimate it to be around $500+M for one satellite using existing technologies.

ISS-Class Solar Power Satellite	Gross Metric with No Inefficiencies
Fresh water production	700 m^3/day or 170,000 gal/day
Population served	3000 people
Power required	120 kW

Table 1. Summary of gross metrics for an ISS-class solar power satellite

Benefits derived from Space Water can be global. These include:

1. a clean, no-carbon footprint energy legacy for centuries to come;
2. a credible method for global fresh water production; and
3. a transformative solution to the global climate crisis.

Prof. Don flournoy and the Space Solar Salt Water Desalination Team at the International Space Development Conference in Chicago Il in May 2011

REFERENCES

1. Tobiska, K. (2011). The Vision for Producing Fresh Water Using Space Solar Power. Space Environment Technologies. http://www.spacewx.com/SpaceWater.html
2. Tobiska, K. (2010) Vision for Producting Fresh Water Using Sun Power. Online Journal of Space Communication, Issue No16: Solar Power Satellites, Fall 2010. http://spacejournal.ohio.edu/issue16/tobiska.html
3. Tobiska, K., B. Flayler and D. Flournoy. (2010) New Challenges for the 21st Century: Creating Fresh Water Usng Space Solar Power. International Space development Conference – Chicago, May 29, 2010. http://spacejournal.ohio.edu/issue17/pdf/2010_ISDC_SpaceWater.pdf