1. Space Water Background and Needs

1.1. Objectives and expected significance

The problem. The unfolding global climate crisis is occurring partially as a result of the increasing accumulation of carbon dioxide and methane greenhouse gases in the lower atmosphere. One of its results is to affect the global water infrastructure, which includes hydropower, flood defense, drainage, and irrigation systems for major population areas. The adverse climate effect on freshwater systems aggravates population growth and weakens economies. In the western U.S. reduced water supplies, combined with increased demand, are provoking more interstate and urban–rural competition for water resources in the face of increased water shortages. If the trend is not reversed, the unavailability of fresh water could make the single largest negative impact on human society by the end of this century.

The solution. Seawater desalination has existed for decades and is a proven technology for supplying fresh water. Continued coastal population growth makes it economically feasible to consider seawater desalination as a major metropolitan and agricultural water source. However, a prime obstacle to developing seawater desalination facilities has been their intensive energy consumption.

The method. Coincident with climate change and fresh water shortage events, and at the same time as the emergence of seawater desalination, some California coastal (offshore) oil and gas platforms are reaching the end of their productive lives. Some platforms already use small-scale seawater desalination to produce fresh water for platform personnel and equipment. Policies are presently under review to determine if these platforms can be re-commissioned for alternative uses since the cost of removing a single offshore platform can approach $1B.

An active community is proposing that one or a few California offshore platforms can be re-commissioned as large-scale fresh water production facilities. Platform-mounted photovoltaic (PV) solar arrays can provide some of the power needed for seawater desalination. However, efficient fresh water production requires that a facility be operated 24 hours a day. If solar power is transmitted from orbiting satellites via Solar Power Satellites (SPS), this can augment the power generated from natural sunlight. A single SPS in geo-synchronous orbit (GEO) is able to transmit power day and night, thus enabling 24 hours a day operations. A SPS is conceptually similar to an existing commercial communication satellite but with a much larger solar array.

While none of these concepts are individually unique, their combination is. Production of industrial quantities of fresh water on re-commissioned oil and gas platforms, using energy transmitted from solar power satellites, is a breakthrough architecture that uses space assets to open avenues for solving pressing climate, water, and economic issues of the 21st Century. We call this architecture *Space Water*.

1.2. Current architecture needs

Need 1 – Short-term studies. Short-term studies are needed on the policy issues, technical feasibility, and economics of producing industrial quantities of fresh water on re-commissioned offshore oil and gas platforms, using solar arrays for diurnal power, and augmented with space-based solar power for around-the-clock operation.

As a starting point, the maturity level of this architecture is subjectively rated:

- climate change affecting the water infrastructure – relatively mature scientific understanding with prediction details still evolving;
- continued population growth in coastal areas – mature, clearly defined trend;
- use of seawater desalination as a source for metropolitan water supplies – mature technology where implementation issues are tied to energy costs;
- California coastal oil and gas platforms coming to the end of their productive lives – mature, well-defined technical and policy direction tempered by a serious concern for the tremendous costs involved in decommissioning platforms and the probable sea floor disruption that accompanies removal;
- platform re-commissioning for alternative uses – relatively mature idea but there is a continuing debate on platform re-use; the concept for a large-scale fresh water production facility has not yet been considered;
- solar arrays on offshore platforms to generate electrical power for desalination – mature technology but the implementation needs further study;
- efficient fresh water production requires 24 hours a day operation – mature concept but implementation is not well defined;
- solar power from orbiting solar power satellites can substantially augment the solar array power generated naturally from sunlight – mature concept but immature implementation and a SPS proof-of-concept has yet to be demonstrated; and
- production of industrial quantities of fresh water on re-commissioned oil and gas platforms, using energy from solar power satellites, is a breakthrough concept for addressing the pressing climate, water, and economic issues of the 21st Century – this is a novel combination of mature technologies in a new way to provide new solutions.

Since the least mature element of this concept is space-based solar power, we have relied heavily on previous space-based solar power (SBSP) work (Mankins, 1997; Henley *et al.,* 2002; Landis, 2004; Potter *et al.,* 2009) to understand whether or not this path for augmented power generation is reasonable. The National Security Space Office (NSSO) SBSP study (2007) laid significant groundwork by outlining next-step tasks, including:

- the need to identify clear targets for economic viability in markets of interest;
- the need to identify technical development goals and a risk roadmap;
- the need to select the best design trades; and
- the need to fully design and deploy a meaningful SPS demonstrator.

One SBSP study finding was that the commercial sector needs the Government to accomplish three major activities to help SBSP development. These include i) removing a major portion of the early technical risks via an incremental research and development program culminating with a space-borne proof-of-concept demonstration for a SPS; ii) facilitating the policy, regulatory, legal, and organizational instruments that will be necessary to create the partnerships and relationships (commercial-commercial, government-commercial, and government-government) needed for a SPS to succeed; and iii) the need for the government to become a direct early adopter and to provide incentives for other early adopters.

The above outline provides a framework for bringing the SBSP study area together with the other study areas of seawater desalination, solar array use on platforms, and policy, economic, societal impacts and it can be used as a guide for developing proposed study agendas.

Need 2 – Technical, Economic, and Societal Impact Workshops. As part of the first steps in developing feasibility studies, it is recommended that expert workshops be held on technical, economic, and societal impact issues to obtain relevant advice and material. These workshops would solicit contributions from leading experts in order to address the fundamental tasks and the 3 major activities of required government assistance described in the section above.

Need 3 – Technical Feasibility Reports. Technical feasibility reports should be produced. These reports would necessarily cover the identification of technical development goals, the selection of the best design trades, sizing of power needs for water production rates, the feasibility of converting offshore platforms to other than oil and gas uses, the possibility of solar array construction on offshore platforms, the method of water delivery from offshore to onshore distribution facilities, the removal and use of brine, the ability of SBSP for enabling continuous fresh water production, the design and deployment path for a meaningful space-borne SPS proof of concept demonstrator, and a roadmap using incremental research and a development program for removing technical risks.

Need 4 – Economic Feasibility Reports. Economic feasibility reports should be produced. These reports would necessarily cover the need to identify clear targets for economic viability in the fresh water production market, water production versus energy trade-offs, a first user or anchor customer identification, an evaluation of niche market feasibility, an evaluation of water production costs in this concept versus conventional water sources, an evaluation of cost benefits to the oil and gas industry for converting offshore platforms rather than removing them, estimating the economic benefit of leasing, water, mineral, and cap-and-trade credit sales that could provide secondary revenue streams, an evaluation of the costs for a SPS demonstrator and who would pay for it, and a roadmap that includes the government as a direct early adopter and an agent providing incentives for other early adopters in order to help remove economic risks.

Need 5 – Societal Impact Reports. Societal impact feasibility reports should be produced. These reports would necessarily cover the policy, regulatory, legal, and organizational instruments that would be necessary to create the partnerships and relationships, including commercial commercial, government commercial, and government government, needed for this concept to succeed. There are many Federal, California, county, and municipal coastal regulations and policies related to water management, offshore platforms, and environmental concerns. There are also public concerns for use of new energy technologies (laser or microwave radiation beamed from space) near their homes and work. These impacts suggest that the California coastal example can be a national pathfinder for a societal impact assessment. A roadmap for addressing and removing societal risks must be addressed.

2. References and Relevant Publications

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