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Nationwide Student Movement on Space Solar Power

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Creating and Managing a Nationwide Student Movement

Abstract

Solar energy beamed from orbiting power satellites could be the ultimate form of renewable energy. Space Solar Power (SSP) advocates explore many architectures, but the field lacks consensus. A research organization has been formed to unify and optimize SSP architecture objectively. The challenge is engaging all 170 SSP researchers nationwide. This paper discusses the creation of a new student organization to become the coordinating body for a nationwide student movement. Activities are coordinated via webinar in a manner intended to be self-organizing. The project culminates with students lobbying Congress in support of SSP.

I. Introduction

Greenhouse gas emissions from combustion of fossil fuels is detrimental to our climate[1]. Such combustion also generates nitrogen and sulfur oxides, ozone, plus particulate matter, all air pollutants with adverse human health effects[2,3]. Mining of coal and unconventional petroleum deposits (e.g. bituminous sands) contaminates surface and ground waters[4]. Burning coal for electric power releases heavy metals which deposit across the land[5]. Uranium-based nuclear reactors generate long-lived radioactive wastes for which no long term storage is presently available[6]. World-wide demand for energy is increasing rapidly at a time when easily-obtained resources are being exhausted[7]. Energy production for the present human civilization is steadily and quietly harming us all, and poisoning future generations.

To achieve a sustainable civilization requires energy production from renewable sources. The scale of energy production in 2013 is enormous, and despite recent progress, renewables provide a small fraction[8]. The most popular renewables, wind power and terrestrial solar power, are intermittent. No matter how large-scale, neither can provide baseload power – the type which is "always on". This disconnect can be addressed either with grid storage that stores vast quantities of energy for later use, or with a world-wide grid[9] which allows global leveling of power from intermittent renewables. Grid storage faces huge challenges in scale and cost. A world-wide grid would suffer significant transmission losses, and would require investment and cooperation on a scale never before demonstrated.

Space Solar Power (SSP, also called space-based solar power, or SBSP) is another solution. The concept is to place in orbit solar farms which beam power to the earth[10]. Power satellites in geosynchronous earth orbit (GEO) are exposed to sunlight night and day, for 364 days of the year (once in spring and once in fall each solar farm is briefly shadowed for several hours). SSP has the potential to dramatically increase production of renewable energy with greatly reduced pollution generated per unit of power delivered. SSP has the potential to achieve economic parity[11] with conventional sources of power when externalities are included[12].

SSP faces challenges of economics and technology, arguably less severe than grid storage or a world-wide grid. However, there is no general agreement about how to overcome these challenges. Many top researchers in SSP champion widely-differing architectures on the sequence and configuration of building, delivering, and operating powersats[13]. This lack of cohesion, coupled with the high costs and technical risks, preclude the ability to gain the attention of US law and policy makers. Since the origin of this concept in 1968, and despite considerable study by NASA[14], DoD[15], and the DOE[16], no significant deployments of SSP have been made by the US. At present, no federal agency has provided more than a trifle of funding for SSP.

The Organization for Space Energy Research (OSER) intends to unify SSP architecture through a meta-process of objective optimization using subsystem modules of existing architectural concepts. In this way US researchers can speak with one voice to advance the cause of what could be the ultimate answer to renewable energy.

Reaching and engaging SSP architects, who tend to be widely-dispersed and poorly funded, is a considerable challenge. There are between 170 and 220 active or semi-active researchers on SSP in the US. Bringing them all together in an optimization project requires a significant effort, especially at the start. This paper describes the way in which a US-initiated student space organization is being enlisted to bring together the SSP community to attempt the architectural optimization. This activity involves students of various interests, widely-dispersed geographically, working to ease the burden on individual SSP architects so that their existing work can be brought together in this first-ever attempt at developing an objectively optimal approach for SSP to provide a large and growing fraction of the world's energy needs.

II. Student Organization

Students for the Exploration and Development of Space (SEDS) is an independent, student-based organization which promotes the exploration and development of space. SEDS was founded at the Massachusetts Institute of Technology and George Washington University in 1980 and has grown to include 36 chapters across the US[17].

OSER contacted members of the SEDS leadership team in summer 2012, receiving favorable consideration. At the same time, a new SEDS chapter was formed on our campus. The 37 charter members were told of the plan to engage SSP researchers, with the appeal that this chapter could become the nexus for this nationwide student movement. The OSER director serves as faculty advisor for the campus chapter, but has imposed no requirements for participation in the movement.

III. Appealing to SSP Pundits

OSER has developed an extensive database of those who have published, advocated for, or expressed interest in the development of space, and in particular in generating power from space for use on earth. During spring 2013 these pundits will receive two appeals. The first is for participation in the SSP architecture optimization effort – the subject of this paper. The second is participation at the International Space Development Conference (ISDC) sponsored by the National Space Society (NSS) at one of the four technical tracks focused on SSP/SBSP. By coordinating these two approaches it is expected that greater awareness will be generated than either alone. If there is a perception that the topic of SSP is gaining momentum, there may be more motivation for participation. One stated objective of the architecture optimization process is the potential to generate federal funds for developing key technologies needed for SSP, thereby providing financial motivation for participation.

To solicit student participation, OSER is holding webinars, posting on-line videos, and hosting a website with more information and resources. Motivation needed to boost participation comes in the form of prizes, leadership roles, and in certain cases sponsored internships. Intrinsic motivation is generated by appealing to the desire to be part of something greater with positive implications for the future, and by the potential to help in the creation of jobs which the students can later fill.

Student participants are matched with SSP pundits according to geographic proximity, and if that is not practical, then by subject matter interest. The students are provided a packet of information to provide to the pundit, and a how-to document for making contact and delivering the request in a respectful, professional manner. The goal is to engage the pundit with OSER. Once connected, the students are encouraged to remain in contact, and will be copied on e-mail communications with the pundit. In this way, the connection between student and architect has the potential to grow into a mentorship, internship, collaboration, job offer, or simply a friendship.

IV. Students and OSER

Figure 1 shows an organization chart for the involvement of SEDS in the OSER effort to unify and optimize SP architecture. There are two main requirements for the student-pundit interaction. First, the pundit is being asked to provide a model-based representation of his or her complete architecture. The student helps explain this, and provides guidance on how to capture what may be notional into a series of equations. In many cases this may become a hurdle to participation, so the student is asked to notify OSER. OSER may, at its discretion, use a portion of its resources (students or funding) to help the architect capture their concept in a standardized module (which will be provided). Second, the pundit is asked to participate in creation of a fitness function, used to drive the architecture optimization program. The fitness function is of primary importance since the architecture scoring highest will be deemed the “best”. The fitness function will be determined by the SSP community, but as a simple example, could be a weighted sum of normalized variables such as cost, duration, and risk. Pundits may contribute one, both, or neither.

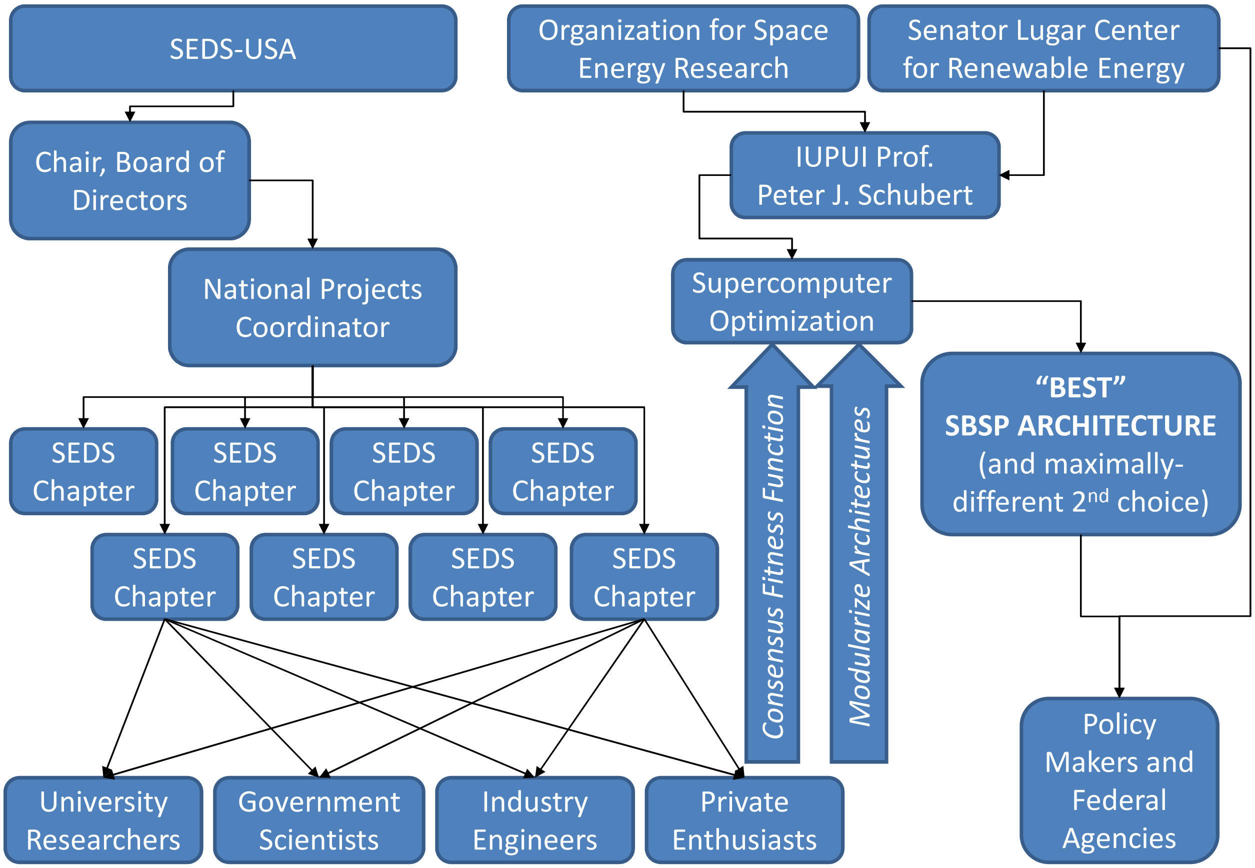

Figure 1. Role of SEDS in SSP Architecture Optimization

Students are individuals, of course, and may have different interests and skills. In the webinar and video students are asked to self-identify among the following four roles:

- First Contacters: Energetic, outgoing people needed to spark interest among pundits.
- Subspace Networkers: Fastidious, reliable folks working behind the scenes to keep the entire enterprise operating smoothly, efficiently.
- Workshop Warriors: Confident, mature, able to communicate firmly but respectfully with faculty.
- Super-Programmers: Computer-savvy, math-loving code writers for SBSP architecture modularization and supercomputer preparation.

Figure 2 shows the general configuration of the architectural framework used in developing an optimal architecture. Each architecture is divided into modules, and each module modifies a pre-defined list of state variables. Within each module there will generally be adjustable parameters, lying within a range representing either a valid solution space or a lack of certainty for a given variable. The optimization routine to be used in a combination of genetic programming and particle swarm optimization[18]. In this way, the selection of modules is determined by the routine, and the parameters are adjusted so as to maximize the value of the fitness function. The optimization routine repeats iteratively in a manner which increases the fitness function. When negligible further increases in fitness are obtained from one generation to the next, the routine is halted. In addition to the "best" result, another nearly-best but maximally different solution[19] will be selected as an alternate.

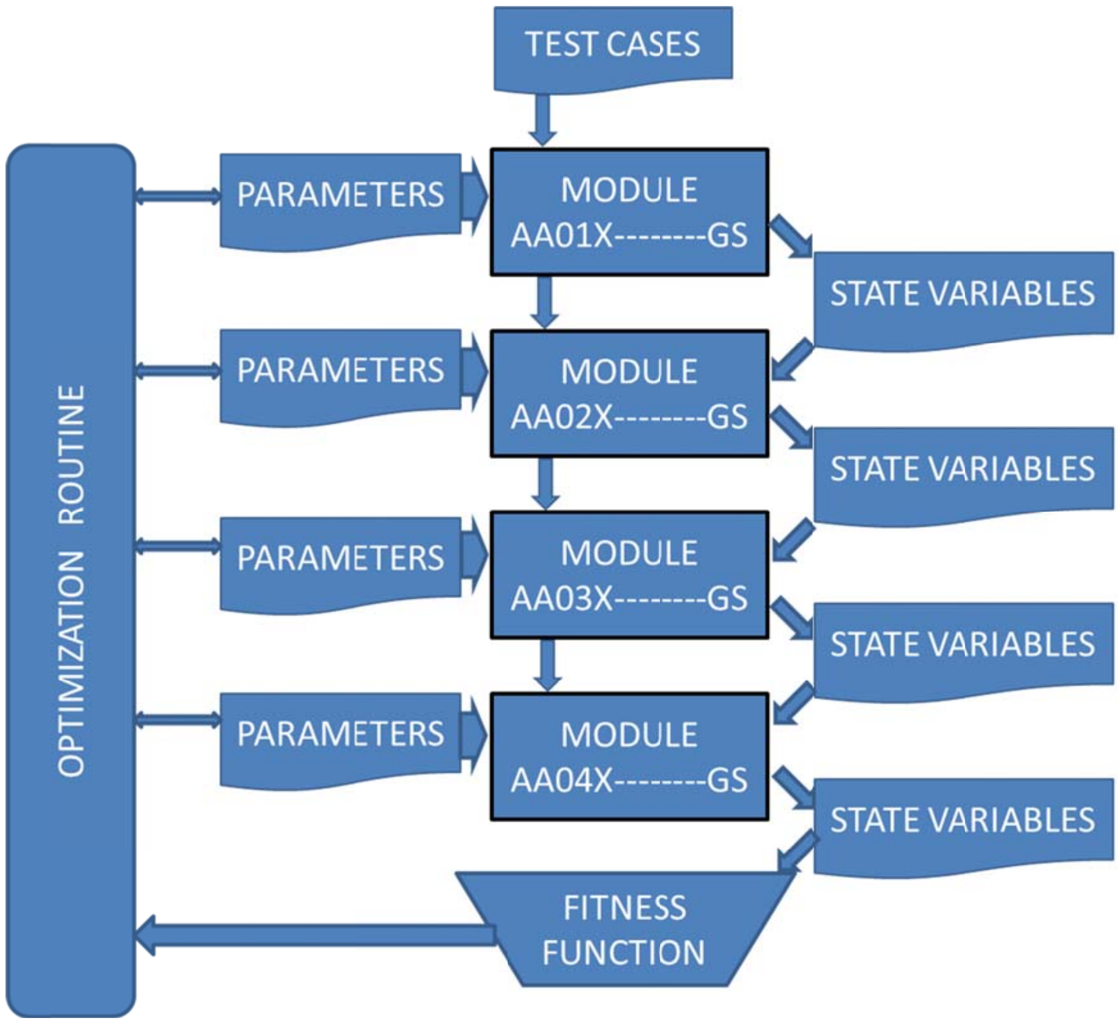

Figure 2. General configuration for optimization of architectures

Figure 3 shows a timeline for the activities of this nationwide movement, starting with enlisting the help of SEDS students, and culminating in the petition to Congress for funding for SSP. This is approximately 2 semesters in duration.

A webinar has been held with SEDS leaders from around the US. Planned next is a webinar for all SEDS members, to be held several times over a three day period to provide the most opportunity for participation. As of press time, a website registration is being formed (oser-ssp.org) for students to log their contact with SSP pundits.

TASK	Description	DAYS
1	Schedule nationwide webinar	0
2	Develop plan, organization, structure, tasks	8
3	Broadcast plans to SEDS-USA	10
4	Conduct nationwide webinar	17
5	Assign individuals to Roles	23
6	Assign SBSP pundits by SEDS chapter	25
7	Schedule Fitness Function workshop	29
8	Create national database & comms system	37
9	Engage SBSP pundits	30
10	Prepare optimization HW/SW design	25
11	Modularize SBSP architectures	61
12	Conduct Fitness Function workshop	66
13	Obtain supercomputer facilities	71
14	Regular feedback to pundits	87
15	Identify policy makers in pundit territories	62
16	Vet and catalog architecture modules	86
17	Announce optimization run	87
18	Conduct transparent optimization	119
19	Collect and report on results	137
20	Broadcast/present results to pundits	147
21	Signatures on national petition to Congress	176
22	Provide testimony to Congress	186
23	Carry message to federal agencies	204
24	Present results at national conference	255
25	Disperse to work on SBSP technologies	257

Figure 3. Timeline for Student-led SSP Architecture Optimization

Figure 4 shows a budget for the OSER effort to achieve an optimal SSP architecture, plus a maximally-different next-best choice. These costs assume labor provided at no fee from the SEDS members, which is a considerable value. This fact will be impressed upon the Members of Congress as evidence of the widespread support for this activity.

Organization for Space Energy Research				
Task	Provider	Cost	Number	Extended Cost
Generic module	CU Aerospace	20,000	1	20,000
Supercomputer time	IU	4,000	2	8,000
Grad students	IUPUI	35,000	2	70,000
Student interns	IUPUI	4,000	5	20,000
Travel to DC	TBD	1,000	3	3,000
Consulting support	CU Aerospace	5,000	1	5,000
Publication support	IUPUI	2,500	1	2,500
Presentations	IUPUI	1,250	4	5,000
Emergency travel	TBD	1,000	1	1,000
Website and support	TBD	2,000	1	2,000
Expenses	TBD	2,000	1	2,000
Contingency	IUPUI	5,000	1	5,000
		TOTAL		**143,500**

Figure 4. Budget for OSER to achieve SSP Architecture Optimization

V. Getting the Word Out

Once the optimal and next-best architectures are determined, the next step is identifying key enabling technologies that are not yet developed sufficiently for deployment. The focus for the OSER organization will now shift to directing research funds to groups capable of advancing these key enabling technologies. This generally requires federal funding, determined by Congress, and has been estimated to require approximately $230M per year for 12 years[20]. Research contracts would be let through a competitive process.

With this specific request in hand, the student teams will now be redirected to conduct citizen's or "grass roots" lobbying to Members of Congress. Unpaid lobbying of this nature is part of our freedom of speech, guaranteed by the 1st Amendment to the Constitution. Students will meet with Congressmen from their district, ideally with the pundit involved, to promote the benefits of SSP, and to encourage the sponsorship, passage, and appropriation for funding to OSER to direct such research. A related effort is the "Space Blitz" conducted annually by the Space Exploration Alliance. The author lobbied for two days with aerospace engineering students, who reviewed this plan, and enthusiastically support it.

The American public has a short attention span, so it will be important to establish step-wise demonstrations of SSP enabling technology on a fairly regular basis. While the ISS still flies, it will be an ideal test bed for beamed power receiving. While the Arecibo antenna is still being funded, it also provides an excellent test bed for power beaming. In addition to in-space demonstrations, it is vital that newly-developed technologies have dual-use applications for terrestrial markets. As a possible example, improved microwave generation efficiency could lead to lower energy consumption kitchen microwave ovens.

As the eve of private investment draws nigh, OSER will push for a public-private partnership whereby the government helps reduce financial risk to developers. An example of this is the COMSAT Corp., which was chartered by Congress in 1962 to manage the fledgling satellite telecommunications industry. International partnerships would be sought, provided the political climate is amenable. Other countries expressing interest in SSP include Japan, China, India, and members of the European Union. Because this technology can be used by anyone on earth, international cooperation seems appropriate.

Looking further ahead, once orbital farms are being built and delivering power to Earth, the focus of OSER will shift again. Now, the organization will morph into a regulatory agency dealing with safety, risks, conflict resolution, and setting of standards. The human presence in space may give rise to permanent settlements in orbit or on the moon. OSER can provide a logical starting point for the oversight and management of these nascent capabilities.

VI. Summary

The attempt to unify SSP architecture could be considered nearly impossible for the following reasons: (1) little or no funding exists at present, so potential researchers may logically pursue other avenues; (2) academic researchers are rewarded for uniqueness, which tends to make collaboration and unification difficult; (3) corporations may wish to keep their own ideas proprietary, so we may not get the best starting point available; (4) grass roots recognition of the seriousness of energy-related issues in the US has been downplayed to an extent not seen in other so-called “free” societies, impairing motivation; (5) political leadership on a solution which may not materialize for decades is sorely lacking; and (6) established energy interests may have reasons to impede progress on competing technologies. It is therefore reasonable to expect that the nationwide movement described herein will fail.

A key purpose of this paper is to document the means by which an optimal architecture could be created, simply because it will eventually become an imperative. Even failure will leave a residue of the attempt which may be reactivated at a date when the challenges listed above have ameliorated somewhat. By engaging students in the fundamental activity the foundation is being laid for future generations to step up to the energy challenge faced by our society and make progressive steps to improve upon the present status quo.

It may be that the generations of Americans presently alive are the last hope for civilization. With heavy metals impairing neurological development of children[21], and a newly-observed lack of increasing lifespans year over year[22] from the accumulation of harmful substances in our environment, and with the increasing costs of energy from traditional sources, it is not inconceivable that a finite window exists for realizing SSP. The reader is encouraged to spread word of this initiative, and to encourage students to join the effort.

VII. Acknowledgements

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