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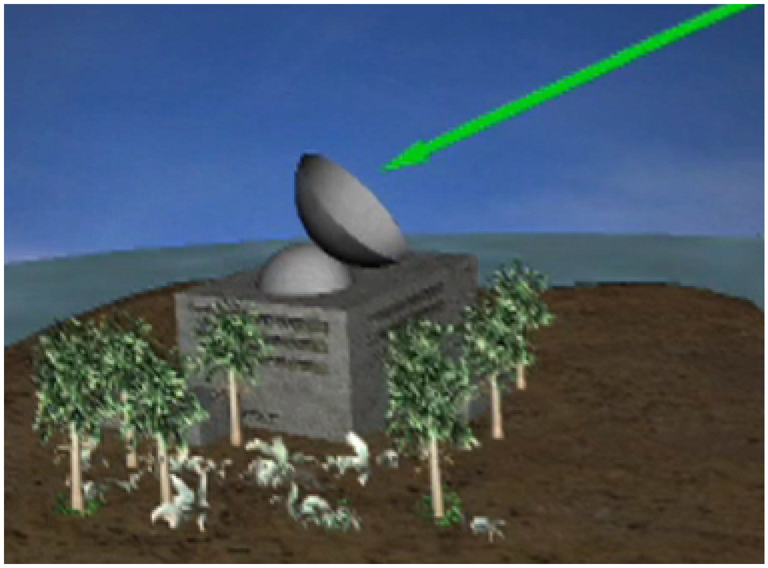

Millimeter Wave Space Power Grid

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ABSTRACT

The Space Power Grid (SPG) architecture illustrated in this visualization represents an evolutionary approach to realizing the global dream of Space Solar Power (SSP). The Georgia Tech approach to SPG concentrates on helping terrestrial power plants become viable, aligning with public policy priorities. It enables a real-time power exchange through space to help locate new plants at ideal but remote sites, smooth supply fluctuations, reach high-valued markets, and achieve baseload status. Over time, this approach will enable other architectures and applications of space solar power.

Space Solar Power for Global Energy Exchange from Space Communication Journal on Vimeo.

TECHNICAL BRIEF

Key Features

1. Evolutionary approach to Space-Based Solar Power (SSP)

2. 220 GHz Millimeter Wave Beaming
3. Constellation of L/MEO satellites
4. 3-Phase Architecture
5. Initially no Space-based power generation
6. Synergize terrestrial renewable energy with SSP by establishing infrastructure
7. Beam energy to high demand locations
8. Attempt to eliminate cost to first power barrier
9. US-India Demonstration as a first step

A real-time power exchange through a Space Power Grid (SPG) will help terrestrial power plants become viable at ideal but remote sites, smooth supply fluctuations, and reach high-valued markets.

The launch cost risk in GEO-based SSP architectures is exchanged for the R&D risk of efficient millimeter wave technology in the next decade.

220 GHz Millimeter Wave Beaming

- Bring antenna and receiver size down by order of magnitude from 5 GHz microwave beamed power
- Trade launch cost riskof GEO-based SSP against technology riskof millimeter wave
- Technology issues: absorption in rain and fog; possible solutions: “burn-through” techniques

Constellation of L/MEO Satellites

- GEO architectures require massive antenna and receiver sizes due to beam divergence
- Constellation of 2000 km altitude satellites offers balance between time over ground location while minimizing beam divergence
- Using combination of near-equatorial and sun-synchronous orbits, can efficiently deliver power all over the globe

Phase I

- No Space-based power generation, establish grid in Space
- L/MEO satellite constellation of around 20 satellites at altitude of 2000 km
- Growing to 100 satellites over 17 years
- Transfer energy to meet market demand
- Eliminate need for terrestrial plants to have auxiliary generators by smoothing fluctuations in power

Phase II

- 17 years after project start

- Replace non-power generating satellites with space solar power collector satellites
- Infrastructure already established
- Time for technology improvements

Phase III

- Final stage: starting after year 17
- Large ultra-light solar collectors
- High altitude orbit (20000-30000 km above Earth)
- Reflect unconverted solar energy to L/MEO constellation for relay to ground

US-India Demonstration

- US-India space-based power exchange demonstration is a first step towards SPG and SSP.
- 4 Near-Equatorial Satellites at 5500 km altitude can provide continuous beaming to the United States and India using few ground locations

BUSINESS PLAN

There is no short-term viable prospect for space solar power as a significant source of Earth energy except for some very special and high-valued markets. We argue for a strategy where SSP helps, rather than competes, with terrestrial renewable energy initiatives, as a way to establish the technology and the infrastructure for exchanging power between markets. In other words, space is a venue for power exchange rather than just generation.

The Space Power Grid (SPG) approach will buy time to develop the best technological options for the gigawatt-level SSP satellites that will replace our first-generation relay satellites. At Georgia Tech, we have shown in recent work that such a strategy can lead to an economically viable infrastructure with a continuing revenue stream. These revenues will help develop the massive satellites needed to expand SSP to the 4 terawatt level of today's fossil-based primary power supply.

With retail cost kept to moderate levels, our proposal supports a constellation that grows in 17 years to 100 power relay satellites at 2000 km sun-synchronous and equatorial orbits and 250 terrestrial plants, exchanging beamed power at 220 GHz. In another 23 years, power collection satellites replacing the initial constellation will convert sunlight focused from ultralight collectors in high orbits and add it to the beamed power infrastructure, growing SSP to nearly 4 terrawatts with wholesale and retail delivery.

The SPG system can break even at a healthy return on investment, modest development funding, and realistic launch costs. The immense launch cost risk in GEO-based SSP architectures is exchanged for the moderate risk in developing efficient millimeter wave technology and dynamic beam pointing in the next decade.

A US-India space-based power exchange demonstration would constitute a rational first step towards a global SPG. We discuss two options to achieve near-24-hour power exchange:

1. 4 to 6 satellites at 5500km near-equatorial orbits, with ground stations in the USA, India, Australia and Egypt; and
2. 6 satellites in 5500 km orbits, with ground stations only in the US and India.

The Millimeter Wave Space Power Grid team joins the Ohio University students at the International Space Development Conference in Huntsville, Alabama in May 2011

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