SSC20-P3-13SmallSat Space Solar Power: A Pathway to a Sustainable Future

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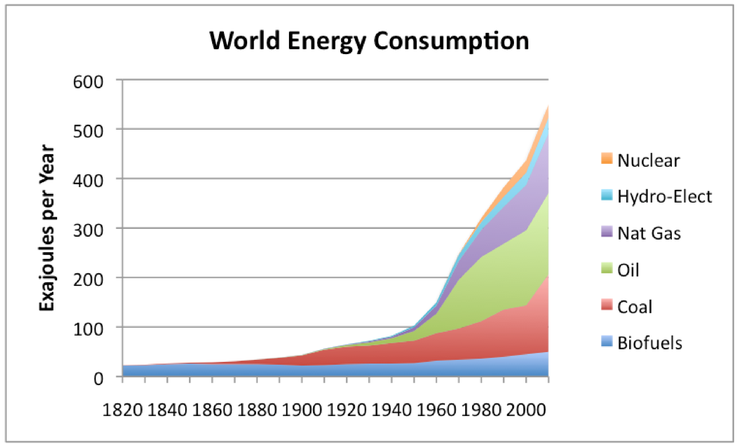
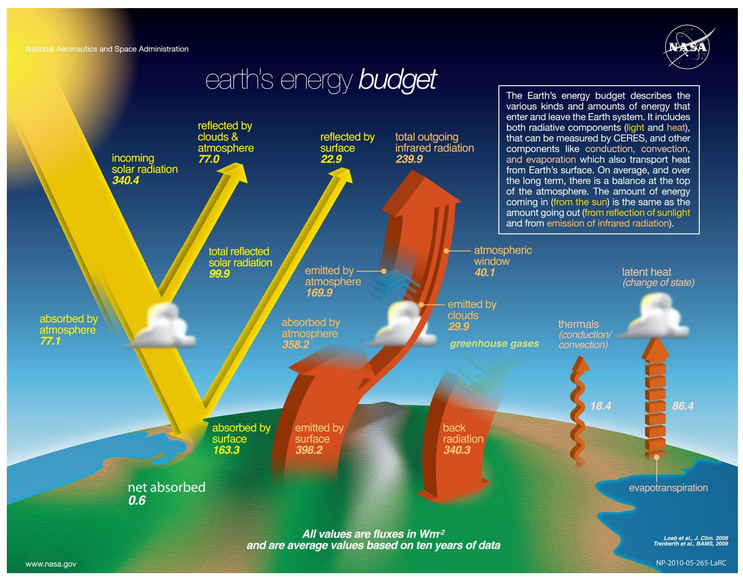
I. The Problem

On the 29th of July, 2019, humanity had already used more resources than the Earth regenerated in the entirety of the year. This is while 13% of people do not have access to electricity, and 40% do not have access to clean energy for cooking. Simply put, the Earth cannot sustain humanity's energy needs.



Source: https://www.resilience.org/stories/2012-03-16/world-energy-consumption-1820-charts/:



Source: NASA

II. The Solution

Therefore, we either need to drastically reduce our energy consumption and quality of life … or we need to find ways to harness energy available elsewhere. Above the atmosphere we get 1370 Watts per square meter from the sun. Due to the rotation of the Earth and the fact that half of the Earth is always in the dark, we only get an influx of 350 Watts/square meter. Even worse, about 25% of this energy is absorbed by water vapor, dust, and ozone in the atmosphere and almost 30% is directly reflected back into space. Therefore, only about 10% of the solar energy from space reaches the Earth's surface, just 166 Watts / m^2. Therefore, Space Solar Power satellites harness the energy where it is most powerful, directly in space. This is an established premise that has been unable to get off the ground due to urgency, economic constraints and feasibility. This work leverages the agility and accessibility of New Space to provide power from space through a constellation of Solar Power SmallSats. Each of the SmallSats carry large deployable structures hosting efficient solar arrays to generate electricity directly from the sun. Subsequently, the energy is transmitted across the constellation, as needed, to be delivered to either other satellites or the Earth via harmless micro wave transmission to a static or moving target.

III. The Technology Demonstration

To demonstrate the capabilites of generating energy from space, a team of researchers at Deployables Cubed GmbH (SmallSat actuators and deployables) and California Polytechnic State University (CubeSats) are working together to launch a 3U cube satellite to space that will deploy a 100W solar array from within a 1U storage size in 2021. This mission will be used to verify new concepts for deployment and energy generation while also educating the next generation of space engineers.

Source: Deployable Sail StrathSat-R

Challenge	Solution
High Cost	Significant decrease in launch costs expected, especially in LEO (500$/kg by 2030) economic megaconstellation due to COTS satellites.
Competitiveness	Unlikely to replace terrestrial renewable energy (0.15$/kWh). But attractive for remote applications like search and rescue/disaster relief, e-mobility, outdoor activities (<500$/kWh).
Technology Readiness	Solar Arrays, SmallSats, Wireless Energy Transmission are proven technologies. Space Solar Power in-space tech demonstrator mission planned for Fall 2021.
Efficiency	Solar cells efficiency of up to 32%, microwave transmission efficiency of 54%. SSP efficiency only limited by legal transmission limits. High SSP efficiency of 100W/m^2 compared to terrestrial photovoltaic of 25W//m^2.
Danger to People and Animals	1985 experiments (at 250W/m^2 @ 2.45GHz) with 2x IEEE and 5x ICNIRP standard for human exposure showed no danger for birds.
Power Transmission Regulations	100W/m^2 are currently allowed within existing safety standards.
Atmospheric Interference	Frequencies of 2.45 GHz and 5.8GHz have minimum atmospheric attenuation.
Misuse as Weapon	Not possible, as power density is within existing safety standards (<100W/m^2).
Microwave Frequency Spectrum	Frequency allocation is needed and power beaming not yet in a Telecommunication Union.
Availability	Constant coverage, independent of weather and seasons due to LEO constellation.
Resource	Hourly solar energy hitting Earth (1.2x10^{14} kWh) > energy humanity needs annually (1.1x10^{14} kWh).