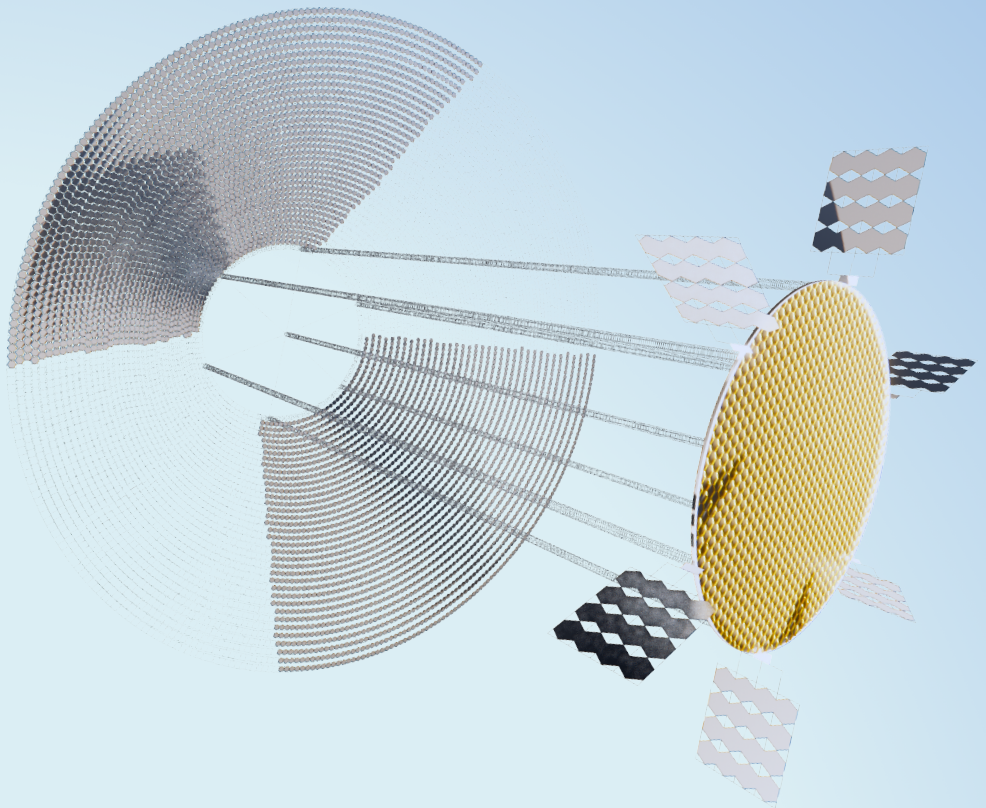


It is time for International Coordination on Space Solar Power

February 2022

John C. Mankins
Board Member at Large, National Space Society
Chair, IAF Power Committee
Chair, IAA Space Solar Power Permanent Committee
Director, Solar Space Technologies LTD, Pty.
President, Artemis Innovation Management Solutions LLC

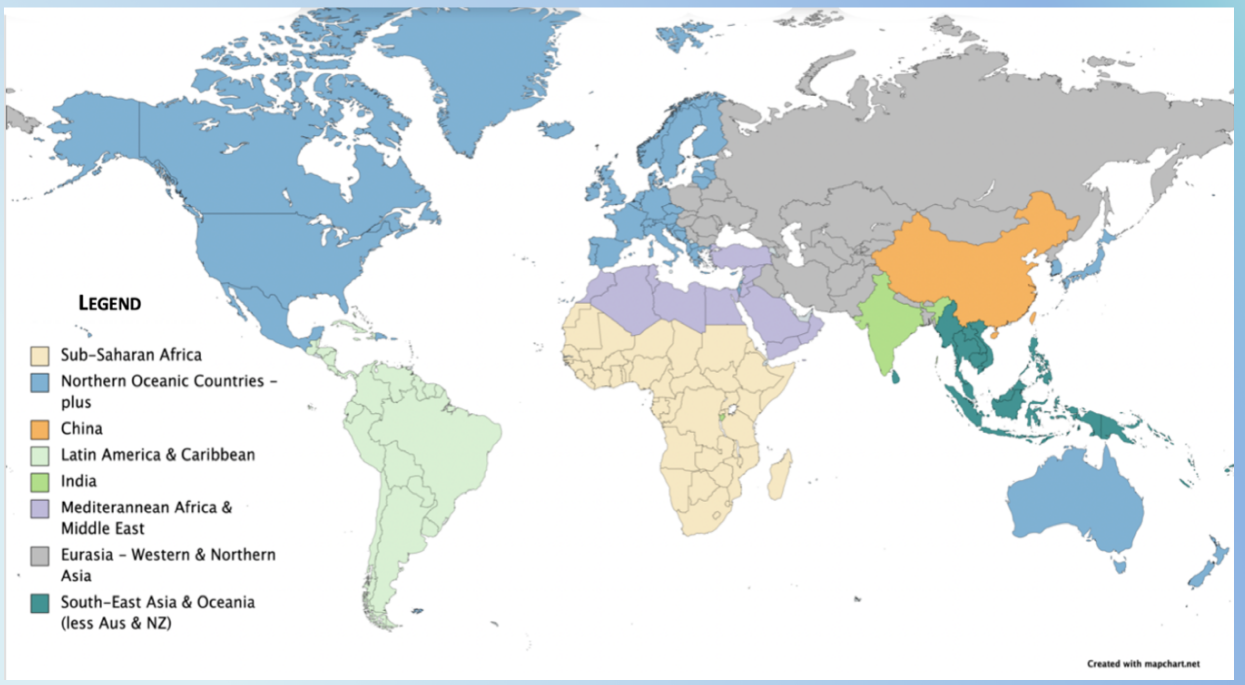
The Urgent Need for New Energy Solutions

EURASIA (Western & Northern Asia)
Population Today: 0.93 Billion
Energy Today : 19,100-kWh/person
Population in 2100: 1.1 Billion

CHINA
Population Today: 1.47 Billion
Energy Today : 26,500-kWh/person
Population in 2100: ~1.09 Billion

We must transition more than ~3 Billion in "current economies" to net-zero carbon energy by 2050

NORTHERN OCEANIC
Population Today: 1.03 Billion
Energy Today : 58,000-kWh/person
Population in 2100: 1.1 Billion



INDIA
Population Today: 1.45 Billion
Energy Today : **7,800-kWh** /person
Population in 2100: 1.45 Billion

LATIN AMERICA & CARRIBEAN
Population Today: 0.65 Billion
Energy Today : **11,000-kWh**/person
Population in 2100: 0.68 Billion

SOUTH-ASIA & OCEANIA
Population Today: 0.71 Billion
Energy Today : **14,600-kWh**/person
Population in 2100: 0.79 Billion

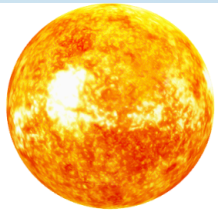
AND
Provide Sustainable Energy to some ~6 Billion in "emerging economies" by 2100

Note: Based on UN & EIA Data & Projections

SUB-SAHARAN AFRICA
Population Today: 1.09 Billion
Energy Today : **5,900-kWh/**person
Population in 2100: 3.7 Billion

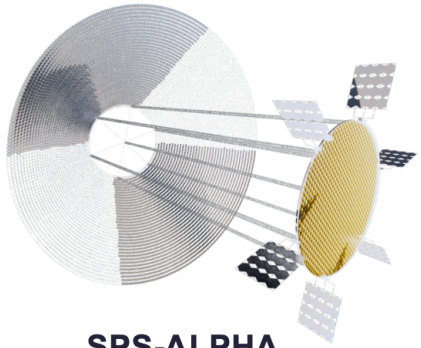
MEDITTERANEAN AFRICA & MIDDLE EAST
Population Today: 0.53 Billion
Energy Today : 27,500-kWh/person
Population in 2100: 0.93 Billion

How Would Space Solar Power Work?



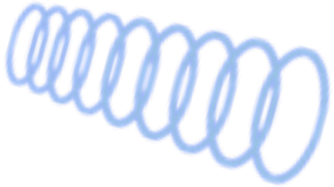
THE SUN

- Can power 2,880 trillion light bulbs
- 1.4 million kilometer diameter
- The Sun has enough hydrogen fuel for billions of years



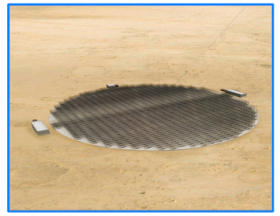
SPS-ALPHA SPACE-BASED HARVESTING

- ~6 km reflector array
- ~1.8 km solar PV panels + wireless power transmitter array
- ~7 km backbone structure
- Modular, robotic construction
- Cheap to launch; less than $1,000/kg
- 99.95% Available Power



MICROWAVE ENERGY TRANSFER

- Precisely controlled transmission of energy
- Less than 20% of summer sunlight
- Can be “shared” across receivers and coordinated with ground-based solar



GROUND STATION

- 2 GW delivered
- ~6km diameter (elevated 5-10 m)
- Outside metro areas
- Mesh RF ‘Rectifying Antenna’ system
- Batteries to modulate supply to existing grid

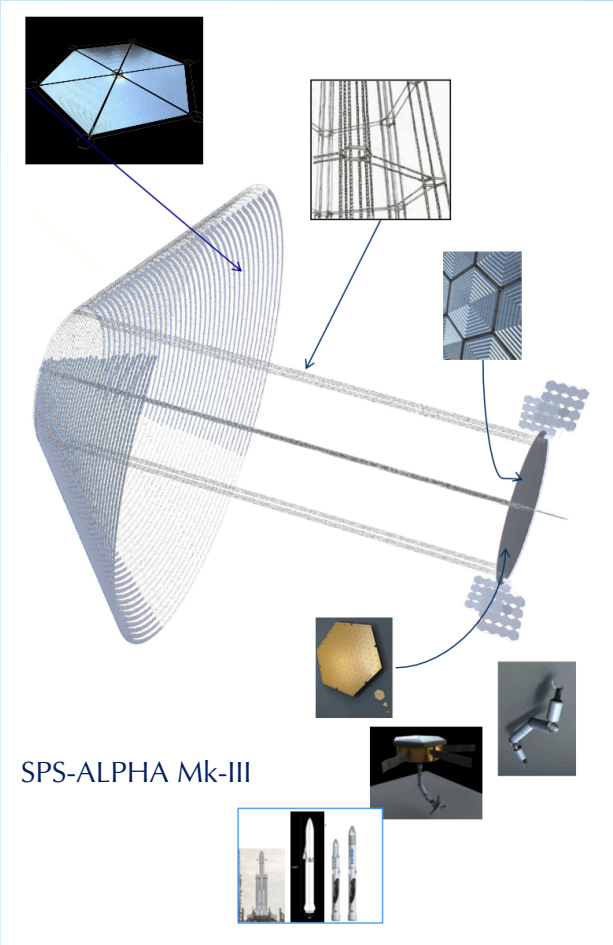
EXISTING INFRASTRUCTURE

- DC or AC fed into the local grid
- Resembles Hydroelectric Power – but…
- “Always” available
- “Shareable” across markets

HOMES AND BUSINESSES

- Base Load low cost electricity
- No carbon emissions
- Supports use at all hours of the day

SPS-ALPHA
(SPS by means of Arbitrarily Large Phased Array)



- **SPS-ALPHA represents a novel class of space system design that uses a physical / optical configuration to distribute energy by photons coupled with local thermal management...**
- SPS-ALPHA comprises the following characteristics :
  - Very low hardware cost, via "Cubesat-scale" (1-10 U) modules that can be mass-produced
  - Simple, modular interconnections among diverse module types and mass-produced modular robotics
  - Local solar power, management and distribution
  - On-board Wi-fi integrating all modules
  - RF payload modules (diverse, retro-directive phase control)
  - Deployable moderate-scale thin-film reflectors
  - Stand-alone propulsion and attitude control modules

Proof that critical Hurdles CAN be overcome:
LEO Mega-Constellation Production

Description

Initial Constellation: 4,400 Satellites

- RF Satellites
- Solar-powered (@ ~5 kW)
- Dry Mass: @ 260 kg
- @ $500,000 each)

Manufacturing Capacity

@ 120 Satellites / Month

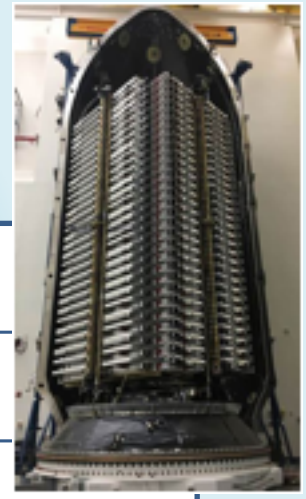
@ ~30 MT / Month

Estimated Development "CER"

~$300,000 / kg

Estimated Mfg Curve: ~0.66

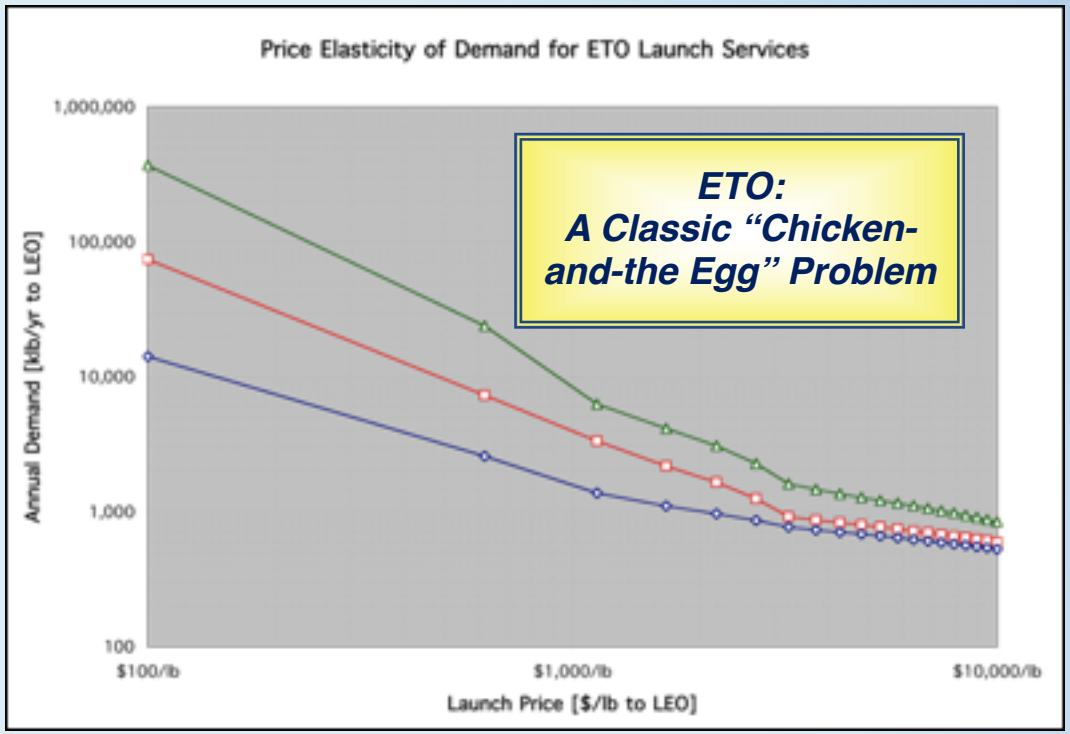
H/W Cost Reduction: >99%



Proof that critical Hurdles CAN be Overcome:
Low Cost Space Launch

PAST
Government Launch
Costs ~ Unchanged in 60 years
@ roughly $20,000 / kg

Now & Forward
New Systems driving
Costs Much Lower



Launch Cost Changes

2000 @ ~ $20,000/kg

2022 @ < $2,000 / kg

2025± @ < $200 / kg???

Dramatic Launch Cost Reductions:

> 90% in 2021

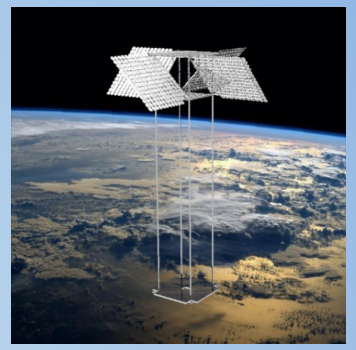
Launch Cost Reduction > 99% by 2025??

A Roadmap for Commercial/Civil Space Solar Power

mid-2020s → mid- to late- 2020s → late-2020s

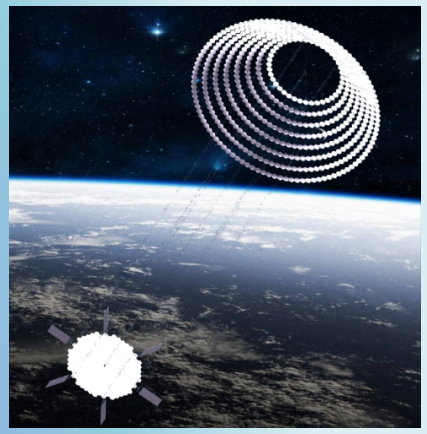
By the mid-2020s, establish the technical foundation that will enable Space Solar Power to meet sustainable terrestrial & space commercial and government needs

By the mid-2020s, develop capabilities that enable production of SSP systems suitable for sustainable delivery of net zero carbon energy to markets on Earth at commercially-competitive prices



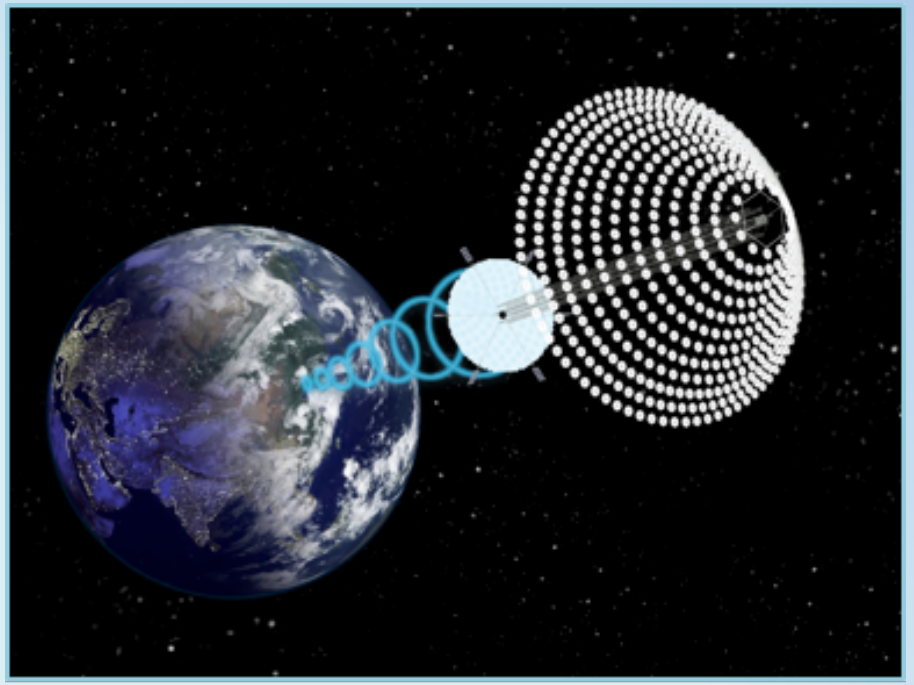
By the mid- to late- 2020s, resolve spectrum management and other regulatory issues, working through appropriate US and international organizations

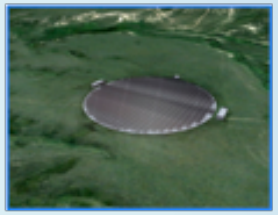
By the mid- to late- 2020s, demonstrate an SSP system delivering power from low Earth orbit to the Earth's surface – delivering not less than 1 kW



By the to late- 2020s, demonstrate space solar power systems delivering power to the surface of the Moon

By the late-2020s, develop, deploy and operation an SSP pilot plant delivering net-zero carbon power to one or more markets on Earth at 100 MW or greater, and scalable to 1 GW or more to support commercial operations in a wide range of terrestrial markets





The International Academy of Astronautics has formed a Permanent Committee on Space Solar Power

This committee will discuss and coordinate key topics of international concern regarding Space Solar

- International cooperation
- Spectrum Allocation
- Space Launch Considerations
- Sustainability and Space Debris
- Others…

An initial International Workshop will be organized September 2022

- *Members / observers of UNOOSA / COPUOUS are invited to participate in this important first meeting*
- *For additional Information, contact:*

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