

UN Sustainable Development Goals and the Cislunar Market Place

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NSS VISION & Mission

- People living and working in space, human settlement beyond the Earth, and the economic use of space and space resources for the dramatic betterment of humanity.

UN Global Framework of Sustainable Development Goals

- The National Space Society proposes that the Framework of 17 Sustainable Development Goals be expanded to include the economic development of space, utilization of space based resources, and the goal of permanent human settlement of space as the 18th Sustainable Settlement Goal as a critical SDG enabling of those SDGs adapted earlier.

- The growth of the human population of Earth, the ever increasing demands for energy, improved living standards, and efforts to achieve a economically and socially more just world have outstripped the carrying capacity of the Earth's environment.
- We believe that that the framework and sustainable development goals that have been set by the United Nations cannot be realized without the development of space based energy and material resources which can compliment the resources available on Earth.

We Face Undeniable
Challenges on the Ground

Air Pollution from fossil fuel use in Mexico City, Beijing, Dehli, Los Angeles



Species Imperiled by Climate Change



Zaartari Refugee Camp Jordan, Dadaab Refugee
Camp in Kenya, and Jalozi
Refugee Camp Peshawar reflect unmet human
requirements



- These populations can experience benefits in meeting the SDG goals of Sustainable Cities & Communities and innovative industrial infrastructure: They must become Islands of Hope and Growth.
- No Hunger
- Clean water and Sanitation,
- Health and Sanitation
- Decent Work and Economic Growth
- Responsible Production and Consumption
- Clean Sustainable Energy with no pollution

- At Present: We are living beyond the natural carrying capacity of the Earth
- The Challenge: We must use the resources available in space to address the requirements of humanity and preserve our environment
- The Near Future: Space Solar Power can provide clean solar energy to fully address clean energy demands on Earth as well as protect and restore the environment. It can enable us to create a sustainable civilization both on Earth and beyond.

Are Space Resources Obtainable?

- Yes, the twin economic forces of exhaustion of Earth's resources and technological change will eventually cause space resources to be utilized.
- These twin forces are virtually unstoppable barring catastrophe
- Consider the example of the oil industry.

Humanity's Shared Hope of the Future both on Earth & In Space

- Sustainable Cities and Communities

Space Settlement Design with LEED's standards for Green Architecture

- Innovative industrial infrastructure:

Additive manufacturing and advanced design with In Situ materials can be used in construction

- No Hunger

Local Controlled Environment Agriculture Systems hydroponic and aquaponic systems can produce food locally and cost effectively

- Clean water and Sanitation,

Bio-regenerative food production and water purification and waste processing

- Health and Well Being

Adequate nutrition, and clean environment and a lifestyle including a more physical fitness

- Decent Work and Economic Growth

Construction of Arcologies which optimize local resources and sustainable practices

- Responsible Production and Consumption

Optimize energy use and a foot print of local production, consumption and recycling.

- Clean Sustainable Energy with no pollution

Utilize solar energy and minimize imported fossil fuels

PLAN FOR PRESENTATION

- The vast majority of the resources of the solar system lie in space rather than on the Earth
- A successful space solar power (SSP) program opens the gate to obtaining these resources
- In the long run, the nation (or group of nations) that controls these resources will control most of human economic activity and hence will be in a position to dominate the Earth, both economically and militarily
- Therefore, international cooperation in the development of SSP is of enormous importance.

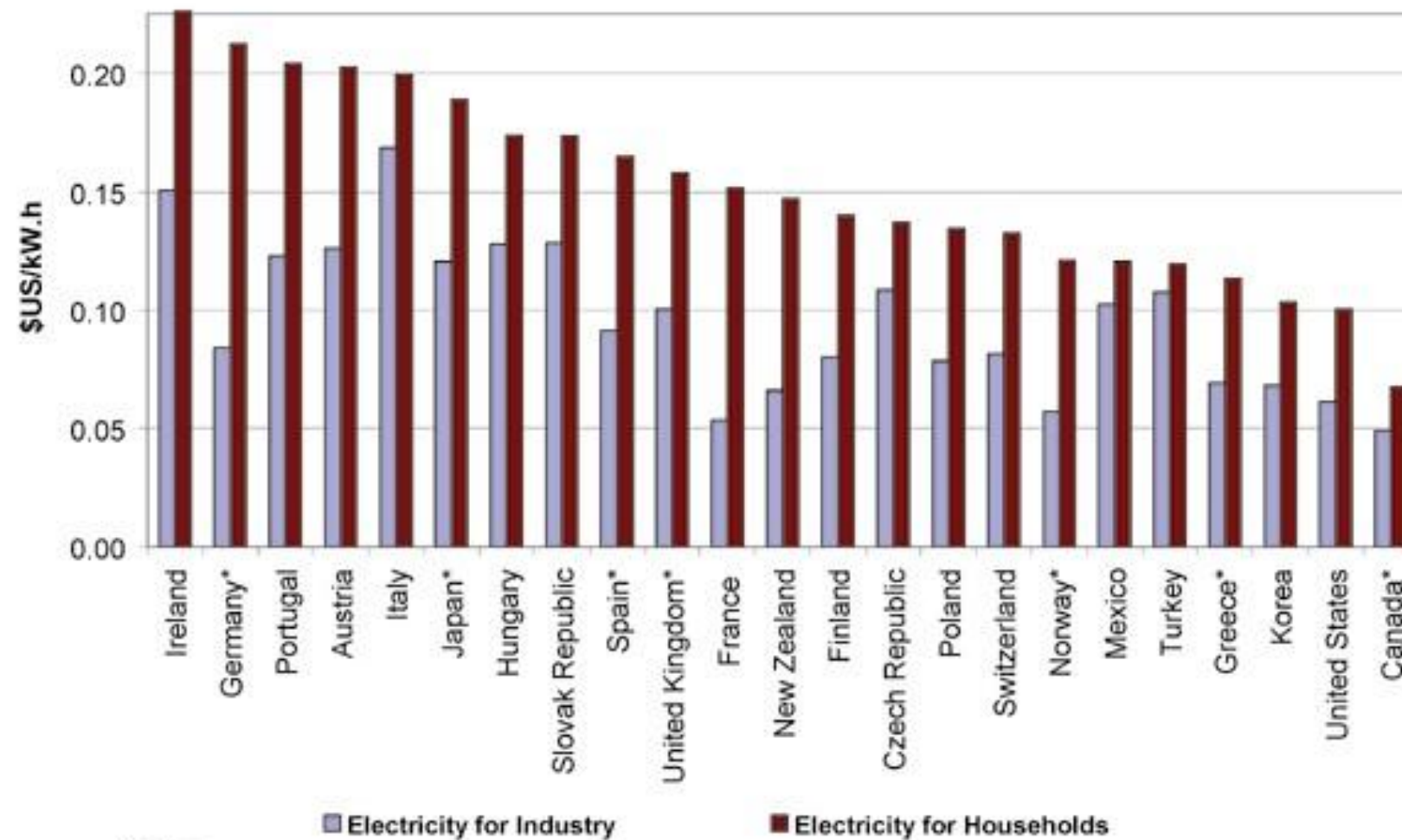
AN ENVIRONMENTALLY FRIENDLY EARTH

- Further into the future, the large scale use of space materials, space energy and manufacturing in space may allow most human activities that create substantial amounts of pollution to be done in space rather than on the Earth.
- Thus allowing Earth to return to the nearly pollution free condition that was enjoyed before the industrial revolution

Defining Cislunar Market Metrics

- Space Solar Power on ISS \$600 kwh
- My Wisconsin Public Service Bill \$ 0.099 kwh
- Alpha CubeSat Design cost target \$ 0.09 kWh

Electricity Prices: Industry v. Households



Notes:
* Earliest available data

Source: EIA

High Cost Niche Markets are Bridge Opportunities for Early Space Solar Power Application

- Space to Space Power Beaming to Augment Space Based Manufacturing Spacecraft Power Supplies
- Space to lunar surface beaming to extend useful life of equipment in lunar temperature cycles and permanently shadowed regions
- Space to Earth power beaming in remote high cost niche applications for military and disaster relief applications

\$1M Per Minute of Humans on The Moon in Apollo Program i



A 2 Week Long Trip To ISS Launch Cost & Back

- 7 Astronauts in Dragon Capsule for 14 Days =
Astronaut 2352 Hours = 141,120 Minutes
- \$10 M Estimate Cost of Falcon 9 R Flight (excluding
cost per flight of Reusable Dragon Capsule)
- \$ 70.85 per minute Astronaut time
\$ 4,251 per hour Astronaut time \$
102,040 per day Astronaut time
- \$ 1,428,571 per Astronaut Trip

Inverse Cost per lbs of propellant versus high yield of isp

- Lox and LH2 = 450 isp (Space Shuttle Main engine)
- Lox and Methane = 386 isp (Merlin engine)
- Xenon = 3,000 isp Hall effect thruster
- Magnesium 12,000 isp = Newman ion propulsion

Is there a market opportunity for Salvage of aluminum or magnesium as cost effective fuels for in-space propulsion?

- The challenge of mediating space debris may be significantly boosted by a case for salvage of aluminum tanks as a source for a high sip propellant for ion propulsion
- The reduction of risk from additional collisions of empty tanks has significant insurance costs
- The damage and reduction of service life of satellites and loss of service revenues add uncertainty to business models and require redundant satellites

In space construction of GEO platforms from salvaged GEO aluminum tanks as feedstocks for space trusses maybe be low hanging fruit for early in space resource demonstrations

- Existing market demand for communication services, tele-education, and telemedicine, geo-positioning, navigation, and Earth Observation make optimization of GEO orbital slots with larger platforms and transponder farms may drive demonstrations of tele robotic construction and in-space manufacturing of orbital materials and also accelerate space debris remediation.

New Space Capabilities and reduced costs of metrics for space operations and space infrastructure enable UN Sustainability goals to be addressed.

- Clearly the coming wave of LEO and MEO satellites are targeted for many of these SDG requirements.
- GEO platforms are another quantum leap in ambitions and capabilities
- Space Solar Power satellites can also be driven by the multi-trillion \$ energy market demand.

Space Energy Resources Have Not been included in market evaluation of “proven reserves” in a way parallel to the way that fossil fuel proven reserves are used in company market value evaluations.

- The great amount of under utilized investment capital has not been well integrated into a cislunar economic development model of diverse goods and services for space based clean energy, space based resources utilization in manufacturing and construction, space debris remediation opportunities and threats, and identified market niches for launch services, habitation and tourism.

An International Lunar Decade is an Appeal for Much Expanded International and Commercial development

- The Cislunar and Lunar Surface Frontiers should fully engage **all G-20 countries and many other smaller countries with advanced economies and technical resources** to provide the twin stimuli of
 - 1) expanded investment and utilization via Public Private Partnership contract commitments and
 - 2) the creation of an open and broad but regulated international market for space based services and goods.

- The UN Declaration of Human Rights must be extended into space. Individual rights including property rights are foundational for market incentives, financing of infrastructure with expectation of returns on investments, and the ability to use accessible proven reserves of In Situ Resources as collateral for investment and market potential.

Facilitating Utilization while Insuring Global Access to Cislunar Resources

- The Space Treaty provides that no nation can make claims of ownership of any celestial body.
- Space Resources must be accessed to meet the global requirements for a sustainable civilization
- The mechanism of UN Trusteeships and Development leases of the specifically defined areas of the Moon's surface can provide an alternate legal mechanism (to prohibited national ownership claims) for assay, investment, and infrastructure development, and mining, production, and services operations for national or commercial consortia. The leases given also might have the requirements 1) that all resources and services generated be sold into an unrestricted global market open to all nations and 2) that standard customs and export tariffs levied to coverage infrastructure cost must be transparently applied to infrastructure debt retirement as well as maintenance of effort and operations.

Connecting Space Resource Development to Sustainable Development Goals and Requirements

- The development of abundant energy and material resources in cislunar space and the lunar surface to the substantial requirements and necessity of a sustainable civilization on Earth must be broadly understood by all nations. Not all nations have either the technological or financial resources to access these space based resources but all nations can benefit by those who can bring these resources to the global marketplace. We are at a tipping point of much more affordable access to space resources.

- Thank You