



# Energy

Cislunar Market Place Workshop Report  
Orchestrating the Technology Development, Demonstration,  
and Deployment (TD<sup>3</sup>) Missions needed to foster  
electrical utilities for Cislunar space

Cislunar Workshop Presentation  
33<sup>rd</sup> Annual Space Symposium  
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## Session 1 – Energy Key Considerations

**Sectors** → There are no unilateral sector options

**Products/Services** → Cislunar Electrical Utility that leverages the economies of scale

**Customers** → Near term service degraded systems

→ Mid term enhanced new systems

→ Long term immortal systems infrastructure

**Supplier/Resources** → Trading the state-of-the-art vs. Satisfactory & Sufficient vs. optimal both a systems engineering and an economics challenge. Robotics and advanced automation are essential to meeting both challenges

**Transportation** → Foster the market – government(s) role as NACA/IACA and first customers

**Investment/R&D** → Matching investment tranches, staging, perceived & actual cost/schedule/technical risk, and returns

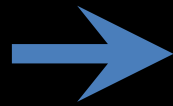
**Infrastructure** → Elements, linkages, and operational procedures must be defined

**Regulation** → Create a regulatory framework that is informed and driven by the confluence of interests necessary to grow the market

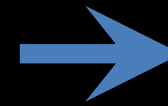


## Session 2 – Energy TD<sup>3</sup> Milestones

Technology  
Development



Technology  
Demonstration



Technology  
Deployment



### Space Solar Power

	2018	2020	2024	2029	2038	2047
	ISS TD <sup>3</sup>	LEO TD <sup>3</sup>	GEO TD <sup>3</sup>	GEO TD <sup>3</sup>	GEO TD <sup>3</sup>	SSP's >
	3-6 KW	~100 KW	~100 MW	~2 GW	10 GW	50 GW
	SSP Testbed	SSP LEO Demo	SSP GEO Demo	Full SSP		
● Space-to-Space	NASA/DOD	NASA/DOD/DOE	NASA/DOD/DOE	Electrical Utility		
● Space-to-Luna	Commercial	Commercial	Commercial	Commercial		
● Space-to-Earth						
● Space-to-NEO	Co-orbiting Test	ComSats Recovery	ComSats Primary	→ \$\$\$	→ \$\$\$\$	
● Space In situ	Platform Model	Platform TD <sup>3</sup>	Platform Ops	→ \$\$\$	→ \$\$\$\$	
● Luna-to-Luna	Spectrum Model	Spectrum Apply	Spectrum Allocation			
● Earth-to-Earth	Orbit Slot Model	Orbit Slot Apply	Orbit Slot Allocation			
	LP&L Seed/Angel	LP&L Series A/B/C	LP&L IPO	→ \$\$\$	→ \$\$\$\$	
	Co-orbiting Tests	Co-orbiting Labs	Co-orbiting Facilities	→ \$\$\$	→ \$\$\$\$	
		Lunar Test(s)	Lunar Operations	→ \$\$\$	→ \$\$\$\$	
		NEO Test(s)	Asteroidal Assay	→ \$\$\$	→ \$\$\$\$	



## Session 3 – Energy Challenge Questions

- Sectors** → Orchestration is essential in a cooperative+collaborative+competitive market.
- Products/Services** → Cislunar Electrical Utility demand will scale with demonstrated supply.
- Customers** → As soon as energy is available it will be used - Are customers really ready?
- Supplier/Resources** → Establish standards, make economic sense and scale - reality check!?
- Robotics, advanced automation, and human involvement needed.
  - System trades require iterative and recursive Technology Development, Demonstration, and Deployment (TD<sup>3</sup>)
- Transportation** → Match to mission requirements, be sustainable, and affordable to use.
- Investment/R&D** → Each increment of investment needs to lead to actual customer use.
- Infrastructure** → Elements, linkages, and operational procedures need definition & buy-in.
- Regulation** → Consistent long term government commitment to foster the market and help mitigate perceived and actual cost, schedule, and technical risk.



# What's Next?

**Lunar Power & Light Company**  
an XISP-Inc Consortium



*Don't wait for the future, help us build it!*  
[www.xisp-inc.com](http://www.xisp-inc.com)

## BACKUP CHARTS - Energy

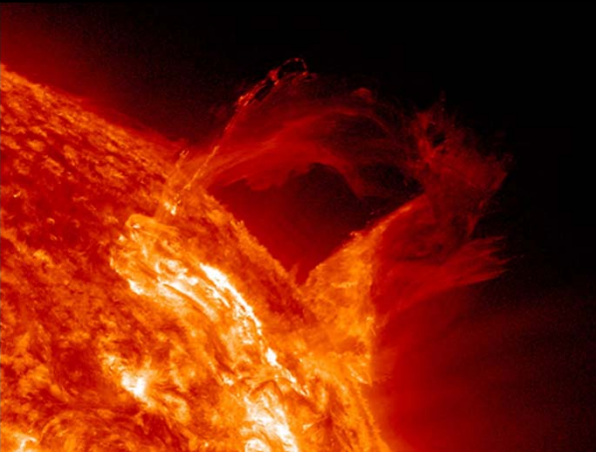
- Sectors
- Products/Services
- Customers
- Supplier/Resources
- Transportation
- Investment/R&D
- Infrastructure
- Regulation



## BACKUP - SECTORS

- International Governmental Consortia
- Government Consortia
- Government-Commercial Consortia
- Government-Not for profit Consortia
- Commercial Consortia

**→ THERE ARE NO UNILATERAL SECTOR OPTIONS**



## BACKUP – PRODUCTS/SERVICES

### Cislunar Electrical Utility

- Earth-to-Earth Wireless Energy
- Space-to-Earth Wireless Energy
- Space-to-Space Wireless Energy
- Space-to -Luna Wireless Energy
- Space-to-Asteroid Wireless Energy
- Space Power Generation (insitu)

### Product Catalog

- Emergency Power
- Backup Power
- Auxiliary Power
- Primary Power
- Indirect/Direct Momentum Transfer
- Allied Utilities (Comm, Nav, Data, etc.)

 → ***Leverage Economy of Scale***





## BACKUP – CUSTOMERS “Earth”

### Earth

- Other Electrical Utilities (existing & new)
  - less than 10 cents/kwh delivered to the grid
  - environmentally benign
  - scalable to meet world demand
  - accessible near where it is needed
  - limited security issues
- Military Logistics → cost per kwh is fungible provided that the required power is available where it is needed, when it is needed, with no exceptions
- Emergency Response Logistics → readily deployable, reasonable to operate, relatively low cost,
- Remote Infrastructure Alternative → where SSP is a cost effective alternative to other available options
- Transportation Vehicles → where SSP is a cost effective mission appropriate options
- Kinetic storage, water desalination, synthetic fuel production → very low cost surplus power

*The baseload power market is driven by the delivered cost per kwh to the grid.*

*All other categories of power demand trade off cost to some extent to accommodate one or more other objectives.*



## BACKUP – CUSTOMERS “Space”

### Space

- Transportation Vehicles
- Propulsion Augment (resistojets, etc.)
- Debris Mitigation

### *Bit Gathering/Processing/Transfer*

- Constellation Systems
- Fractionated Systems
- Multi-Use/Customer Platforms
- Integrated Platforms
- Stand alone Spacecraft

### *Human and/or Robotic Facilities*

- R&D Facilities
- Manufacturing Facilities
- Intermodal Facilities
- Processing Facilities (fuel, ores, etc.)
- Mining Facilities (water, ores, etc)
- Hospitality Facilities (tourist)
- Habitation Facilities

*Near term - Degraded Legacy Systems*

*Mid Term - Enhanced Systems*

*Long Term - Immortal Systems*



## BACKUP – CUSTOMERS “Lunar”

### Lunar

- Electrical Relay Infrastructure (new)
- Exploration Vehicle Support
- Emergency Response Logistics
- Remote Infrastructure Alternative
- Transportation Vehicles

### *Bit Gathering/Processing/Transfer*

- Allied Utilities (Comm, Nav, Data, etc)

### *Human and/or Robotic Facilities*

- R&D Facilities
- Manufacturing Facilities
- Intermodal Facilities
- Processing Facilities (fuel, ores, etc.)
- Mining Facilities (water, ores, etc)
- Hospitality Facilities (tourist)
- Habitation Facilities

*All services are mission enhancing  
if not mission enabling*



## BACKUP – Suppliers/Resources

### Logistics

- Earth Launch Systems
- Transfer Systems
- Luna Launch Systems

### Low Mass Power Generation

- Photovoltaic
- Solar concentrator
- Solar Dynamic

### Radiant Energy Beaming

- Microwave
- Frequency Agnostic
- Laser

### Other Technologies

- Robotic Assembly Assets
- Control & Damping of Large Structures
- Piece Part Manufacturing in Space
- High temperature tolerant electronics
- Radiation tolerant electronics
- Modular structures
- Network Control Architectures

*Trade State-of-the-art vs.  
satisfactory and sufficient vs.  
optimal*



## BACKUP – Transportation

- Earth to LEO
- LEO to Earth
- LEO to LEO/MEO/HEO
- LEO to GEO
- LEO to Lunar Orbit
- LEO to NEO
- GEO to GEO
- GEO to LEO
- GEO to Lunar Orbit
- Lunar Orbit to Luna
- Lunar Orbit to Lunar Orbit
- Lunar Orbit to GEO
- Lunar Orbit to LEO
- Lunar Orbit to NEO
- NEO to NEO
- NEO to Lunar Orbit
- NEO to GEO
- NEO to LEO
- Luna to Lunar Orbit
- GEO to NEO

*Foster the market – Government(s) as the NACA/IACA and first customers*



## BACKUP – Investment/R&D

- Low cost launch
- Low cost transfers
- Low cost mass production
- High efficiency solar power generation
- Control and Damping of large structures
- Demonstration of Power Beaming
- High Temperature Solar Cells
- Luna/Lunar manufacturing

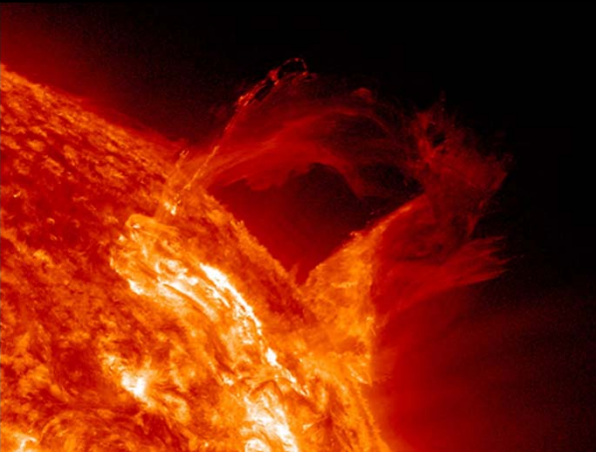
*Match between tranches of investment, staging of effort, perceived and actual cost/schedule/technical risk and returns is critical to success.*



## BACKUP – Infrastructure

- Transportation System
- Network of Space Solar Powered Satellites
- Ground Station "Rectennas" (receiving antennas)
- Maintenance Capability
- (As an exception) crewed teams for repairs
- Asteroid Manufacturing
- Lunar Manufacturing

*Elements, linkages, and operational procedures must be defined and built.*



## BACKUP – Regulation

- Spectrum regulation
- Inspection of System for Compliance with Outer Space Treaty
- Space traffic Control
- International Indemnification
- Debris Management and Mitigation
- Zoning on Earth Rectennas
- WHO compliance for Health and Safety

*We need to create a regulatory framework that is informed and driven by the confluence of interests necessary to grow the market.*

