SOLVING THE WORLD’S ENERGY PROBLEM FOR GOOD
A NEW ERA OF SPACE ENTERPRISE FOR HUMANITY

Jim Keravala, COO, Shackleton Energy Company
3D Additive Construction for Space using In-Situ Resources
Keck Institute for Space Studies
25th August, 2015
EARTH’S POWER CONSUMPTION WILL INCREASE SUBSTANTIALLY THIS CENTURY

2015

WORLD POWER CONSUMPTION

17 TERAWATTS

2100

WORLD POWER CONSUMPTION

100 TERAWATTS
EARTH'S POWER CONSUMPTION WILL INCREASE SUBSTANTIALLY THIS CENTURY

Energy Projections: "Global Energy Perspectives" ITASA / WEC
G7 COUNTRIES AGREE TO PHASE OUT FOSSIL FUELS BY 2100
EXCEPT NOW IMAGINE THESE SOLAR FARMS IN SPACE.
CAPTURING SOLAR ENERGY IN SPACE IS 10-40 TIMES MORE EFFICIENT.

GEOSTATIONARY ORBIT
36,000 km

1,440 WATTS PER M²

-DAY-NIGHT CYCLE
-ATMOSPHERIC LOSSES
-SUNLIGHT ANGLE

36-144 WATTS PER M²
WE’LL NEED 10-40X LESS INFRASTRUCTURE
#1: ELECTRICITY FOR 10 BILLION PEOPLE
#2: EXCESS POWER FOR WATER DESALINATION
#3: 100X INFORMATION BANDWIDTH
“GREAT. EXCEPT...
IT WILL NEVER HAPPEN.”
TRANSPORTING INFRASTRUCTURE UP FROM EARTH IS PROHIBITIVELY EXPENSIVE.

GEOSTATIONARY ORBIT 36,000 km

SOLAR FARMS IN GEO BUILT ON & LAUNCHED FROM EARTH

$30 TRILLION CAPEX

$30,000 per kg
“WELL, MAYBE ONE DAY, WHEN LAUNCH COSTS DROP BY 95%...”
OR...
WE THINK BIGGER, IN SYSTEMS AND DOWN, NOT UP.
We have the right resources on the moon.

1.6 billion tons of water ice for fuel
+ 99% of mass materials for solar power satellites
Using lunar resources to build solar power stations makes the idea economically viable.
Solar stations, doubling as communications platforms in geostationary orbit (36,000 km above Earth’s surface) are the cleanest, most efficient and most elegant way to supply 30 terawatts of power to 10 billion people by 2100. Excess power can be used to desalinate water. Gigabit internet trunk communications can be modulated on to the transmission beam. The addressable market for this combined infrastructure by 2050 will be almost $3 trillion for wholesale electricity alone.
ECONOMIC VALUE OF THE MOON:
$250 PER KG TRANSPORTATION COST TO GEO
WE WILL PROCEED IN THREE PROGRAMS.

2015-2023

PROGRAM 1
Fuel Station & Lunar Supply Chain
Estimated cost $18 billion

2024-2030

PROGRAM 2
Manufacturing on the Moon
Estimated cost $40 billion

2031-2100

PROGRAM 3
Off-World Solar Power & Internet
Estimated cost $270 billion
EACH PROGRAM WILL CREATE NEW MARKETS.

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$80 BILLION IN 2030
OFF-WORLD TRANSPORT VEHICLES
ORBITAL SERVICES
FUEL

$100 BILLION IN 2050
LUNAR EXTRACTION & MANUFACTURING

$3+ TRILLION IN 2060
WHOLESALE ELECTRICITY
WATER DESALINATION
TRUNK COMMUNICATIONS
WE’LL USE LUNAR RESOURCES
FOR THE COMMON BENEFIT OF ALL HUMANKIND.
WE WILL USE THE INCOME STREAM OF PROGRAM 1 TO FUND THE REST.

- **PROGRAM 1**
  - Fuel Station & Lunar Supply Chain
  - Estimated cost $18 billion

- **PROGRAM 2**
  - Manufacturing on the Moon
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  - Off-World Solar Power & Internet
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The SEC team have been working on the concept of Program 1 beginning in 1995 when the Clementine mission reported detection of water ice on the South Pole of the Moon. Water ice in the deep, cold trap craters represented an opportunity to generate large quantities of rocket propellant by splitting water into hydrogen and oxygen and use it to re-fuel spacecraft in the space between the Moon and low Earth orbit (LEO).

Since 2007, Program 1 has been carefully planned—technically and commercially—drawing on contributions from hundreds of experts with the combined aerospace and mining experience of ~4,000 man-years.
THE GOAL IS TO CREATE FUEL STATIONS WITH A LUNAR SUPPLY CHAIN.
PROGRAM 1 WILL CREATE TWO REVENUE-GENERATING ASSETS.

**Asset #1:**
Fuel station in LEO with a lunar supply chain of fuel

1,040 Metric Tonnes of Fuel

Total annual production capacity of SEC’s lunar supply chain, consisting of 71 spacecraft and lunar modules.

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**Asset #2:**
Production line for a new generation of reusable spacecraft

30 Spacecraft

Total annual production capacity of facilities used to produce SEC’s new generation of modular, reusable and refuelable spacecraft and modules.

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[Diagram showing various spacecraft and modules]
BUILDING FEASIBLE MODULAR SSP BY 2030
THREE GUIDING OPERATING SYSTEMS

OFF-WORLD COUNCIL
Needs of Humankind

OFF-WORLD FUND
Equality of Investors

OFF-WORLD DEVELOPERS
Efficiency of Operations
Primary governance role: Foresight

OW COUNCIL
Multi-lateral membership organization
Mandate: Secure “common benefit for all humankind”

OW FUND
Investment fund with sovereign and private investors
Mandate: Finance OW Operations

MASTER DEVELOPER
Mandate: Deliver Operations in the most efficient and effective way

Sub-contractor

Primary governance role: Control & Compliance Accountability

Governance role: Foresight, Strategy, Accountability
USING LUNAR RESOURCES
TO SCALE SPACE BASED SOLAR POWER THIS CENTURY

OFF-WORLD CONSORTIUM
LAUNCHING 2016