SSP: Hearts and Minds

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Three Generations of SSP Conception

1970s-1980s  Clever but not technically feasible

1990s-2000s  Increasingly feasible but not economically viable

Today  Economic non-viability beginning to be seen as diminishing, but...

...neither on the “main sequence” of humankind’s quest for renewable energy

...nor of our 21st-century space agenda

SO WHAT?!
Forks in the Fog

Today

No development

Stepwise non-USG tech demos (e.g., Japan)

USG tech demos

Private development

DOE

DoD

NASA STMD

No space power for Earth

“Manhattan Project”

Stepwise capability emplacement

Tomorrow
5-Point Framework for Changing the Conversation

1. Know the competition

2. Know the customer

3. Do our homework

4. Learn aikido

5. Start small
Know the competition

• Inertia
• Linear thinking
• Acceptable costs of delivering power
• Alternative visions about renewable energy
• Orthogonal visions about what space is good for

What is SSP really competing against?
## Getting on the space radar

<table>
<thead>
<tr>
<th>Option</th>
<th>Purpose</th>
<th>Myth</th>
<th>Needs (+ $10^{11}$ over 40 yr)</th>
<th>Yields</th>
<th>2050 Space Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explore Mars</td>
<td>Extend direct human experience as far as possible</td>
<td>Hero (Lewis and Clark)</td>
<td>Public commitment sustained over several decades</td>
<td>Cultural achievement: setting foot on Mars</td>
<td>Six international civil servants</td>
</tr>
<tr>
<td>Settle the Moon</td>
<td>Establish humanity as a two-planet species</td>
<td>Pioneer (Heinlein)</td>
<td>• Routine heavy traffic to lunar surface</td>
<td>“Living off the land” in space</td>
<td>$10^3$ citizens raising families off-world</td>
</tr>
<tr>
<td>Accelerate space passenger travel</td>
<td>Create new travel-related industries</td>
<td>Jet set (Branson)</td>
<td>• “Four 9s” reliability launch and entry</td>
<td>• Highly reliable, reusable space vehicles</td>
<td>$10^3$ crew + $10^5$ citizens in LEO every year</td>
</tr>
<tr>
<td>Enable space solar power for Earth</td>
<td>Prepare for post-petroleum age with minimal disruption</td>
<td>Green</td>
<td>• Public-private and inter-Agency partnerships</td>
<td>• Energy-abundant future</td>
<td>$10^2$ skilled workers in GEO</td>
</tr>
</tbody>
</table>

Know the customer

• Those who are used to easy electrical power

• Those who provide it today

• Those who could make a fortune providing it tomorrow

• Those who could change the world – and make a fortune – by using electrical power in new ways

Who should (or will...) care about SSP, and what motivates them?
Geopolitics: Urban Geography from GEO

- Tokyo
- Melbourne
- Sydney
- Auckland
- Honolulu
- Anchorage
- Seattle
- Portland
- San Francisco
- Los Angeles
- Phoenix
- Denver
- Houston
- Mexico City
- San Salvador
- Buenos Aires
- Brasilia
- Rio de Janeiro
- Sao Paulo
- Lisbon
- Casablanca
- Freetown
- Dakar
- Reykjavik
- Glasgow
- London
- Lagos
- Geneva
- Munich
- Vienna
- Rome
- Istanbul
- Cairo
- Mecca
- Jerusalem
- Moscow
- Tehran
- Riyadh
Do our homework

• Understand the practical alternatives to SSP
  – Advocate them, too

• Acknowledge the enormity of the SSP undertaking
  – Describe it in relatable terms

• Study side-effects of vast quantities of cargo launch
  – Differentially advocate the most sensible option(s)

• Benchmark public and environmental safety
  – Expose, analyze, validate, and become definitive about it

• Know the terrestrial side – land use, regional integration
  – Show people what they will actually see
A simple calculation

World electricity energy usage in 2010\(^1\) = 18.5 \((10^{12})\) kWhr

World power average consumption = \(\frac{18.5 \times (10^{12}) \text{ kWhr}}{24 \text{ hr/d } \times 365 \text{ d/yr}}\) = 2.1 \((10^{9})\) kW = 2.1 TW

Assume \(~50\times\) today’s power demand: 100 TW
- Neutral demand growth in the west due to conservation
- 3\(^{rd}\) world rises to 1\(^{st}\)-world standards
- Electricity to desalinate sea water for potable supply
- Electricity to crack water for hydrogen mobile fuel

Assume end-to-end SSP efficiency = 1%
- Losses from PV conversion, \(\mu\)wave xmitter, free-air xmission, atmospheric absorption, rectenna spill, inversion, etc.)

GEO collector area = \(\frac{100 \text{ TW}}{1400 \text{ W/m}^2 (0.01)}\) = 7.14 \((10^{12})\) m\(^2\) = 7140 km\(^2\)

For comparison: U.S. National Highway System\(^2\) = 259 \((10^3)\) km long, and cost \sim 425 \((10^9)\) B\$2006

Assume average paving width \sim 10 \text{ m} = 10^{-2} \text{ km} \rightarrow \text{Total paved area} = 2590 \text{ km}^2

\(^1\) U.S. Energy Information Administration
\(^2\) Wikipedia, 21 Sep 2013
Learn aikido

Capitalism
Hegemony
Natural resource price at the pump
Social welfare
Balance of trade
Environmental stewardship
Potable water

Harmony
Energy
Path
Morihei Ueshiba

Limits to growth
Global warming
Energy independence
Conquest of space
Potable water

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Start small

- $10^{11}$ infrastructure project
- Creation of a new federal agency
- Fully robotic assembly and maintenance
- ...or, an O’Neill colony of construction families
- ...mining the Moon for construction materials

Some of something is better than all of nothing
“When you come to a fork in the road…”

**Commercial Investment**

- Space passenger travel
- Orbital resort hotels
- Industrialize GEO
- Demonstrate SSP scale-up
- Demonstrate end-to-end SSP
- Explore the solar system
- Settle the Moon

**Government Investment**

- Develop space flight
- Demonstrate space habitation
- Expand HSF into GEO
- Industrialize GEO

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Our limited world is just a soccer ball held at arms’ length...as viewed from tomorrow’s source of energy