Outline

- Energy use underlies our economy
- We are reaching limits because of our energy usage
- How global space solar fits in
Energy use underlies our economy
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- Energy makes the world go around

Source: Jewishworldreview.com
Energy allows us to transform raw materials into finished products

- Extracting raw materials requires energy
- Transport requires energy
- Services require energy
Increased energy use is associated with increasing prosperity.

Source: Based on 2012 BP Statistical Review of World Energy and USDA Economic Research Data
Population grows as fuel use grows

- Fuels allow more food, better medicine and sanitation

We are reaching limits because of our energy usage
Cost Limit

Source: Fossil fuel cost from EIA Table Annual Energy Review Tables 3.2 and 3.9, wages from BEA Table 2.1.
Pollution limits: Air, water and CO2

Figure 1. U.S. primary energy consumption by fuel, 1990-2040 (quadrillion Btu/year) Source: EIA AEO 2013 Reference case 84% fossil fuel in 2011; 80% in 2040.

Salt Marsh, the most productive agricultural land known, nursery for shrimp, crab, fish, etc... Courtesy: University of Georgia
Fresh water limits

- Coal-fired electric, base-load gas, nuclear-electric plants
- Biofuels

Source: BikingIllinois.com
Oil is becoming more expensive to extract

- Extract the cheapest first
  - Move on to the more expensive
- Always seems to be more!
- Producers need higher oil prices to be profitable
High oil prices lead to RECESSION

- Economist James Hamilton has shown that oil price spikes connected with 10 out of 11 recent US recessions!

Source: Based on BP 2013 Statistical Review of World Energy data
High oil prices lead to depressed wages

Source: 2012 BP Statistical Review of World Energy, BEA Private Industry Wages, and CPI-Urban from BLS.
Economic growth seems to reflect a positive feedback loop

- **Energy use is key**
  - Can’t make goods without energy
  - Even making services requires energy
  - Encourages rising population

- **Cheap energy key to competitiveness and growth**
  - Increasingly cheap energy makes salaries go farther, country more competitive
Percentage of US population with jobs is decreasing.

Based on US Bureau of Labor Statistics data.
Governments already having trouble collecting enough taxes

Source: Based on US Bureau of Economic Analysis data.
Civilizations that collapsed seem to follow a similar pattern.
Current approach is not working

- New renewables total 2% in 2012

Source: Based on 2013 BP Review of World Energy.
Characteristics of Needed Replacement Fuels

- Inexpensive compared to today’s fuels
- Uses resources sparingly
- Not polluting (CO$_2$ and other)
- Doesn’t add hidden costs – intermittency
- Available in very large quantities
- Available with little government cost
- Available now
How global space solar fits in
Goal: Inexpensive

- Goal of Japanese group is 9 cents per kWh
- With development, cost should be lower yet
- With low-cost electricity, can make liquid fuels
- If truly low-cost, other countries would copy
Goal: Uses resources sparingly

- SSP generation uses no water
- Uses high purity silicon very sparingly
  - PV only 1% as thick as conventional PV can be used
    - Doesn’t need to withstand earth’s weather
  - Capacity factor is 99.3% vs 18% on ground in US
  - 50% of PV electrical output would get onto earth’s power grid
  - Combined effect: silicon goes 275 times as far
Goal: Not Polluting

- Pollution minimized by low resource use
- No CO$_2$ from ongoing operations
- Microwaves will meet existing regulations
Goal: Doesn’t add hidden costs

- Total cost is what is important
- Intermittency characteristic of wind, ground solar
  - Hidden costs:
    - Upgrades to grid design and regulation
    - Longer distance grid transmission
    - Electricity storage costs
    - Increases cost per kWh of fossil fuel electricity
- If we have low-cost electricity, we can make liquid fuels
  - Less abrupt transition than to plug-in electric alone
Goal: Available in very large quantities

- If low-cost, much greater chance of ramp-up
- Possibility of making liquid fuel, using electricity
  - Example 1: Ammonia available using water, air and electricity
    - Have made liquid ammonia for 50 years for farming
      - Also move it in pipelines (http://www.nh3fuelassociation.org)
  - Example 2: Isobutanol
    - Created using water, air, carbon source, and electricity
Goal: Available with Little Government Cost

- Japan’s SSP project cost ~ $1 billion per year
- Public/private congressionally chartered corporation could provide needed government support
  - Comsat Corp., chartered in 1962, opened space for communication satellites.
  - Communication satellites now a $250+ billion/year industry
- Need similar act for SSP
Available now

- Unfortunately, no.
  - But neither is any other alternative that might meet these goals
- Long lead time expected
  - Reason to start now
- Businesses will likely need to take lead
  - First step - enabling legislation similar to 1962 Comsat Act