Solar Energy In Space

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Outline

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Motivation

- Sun is a vast source of energy!
- In space, more sunlight available and for longer times
- No interference from weather, atmospheric gases, plants, or animals
- No land requirements

Difficulties

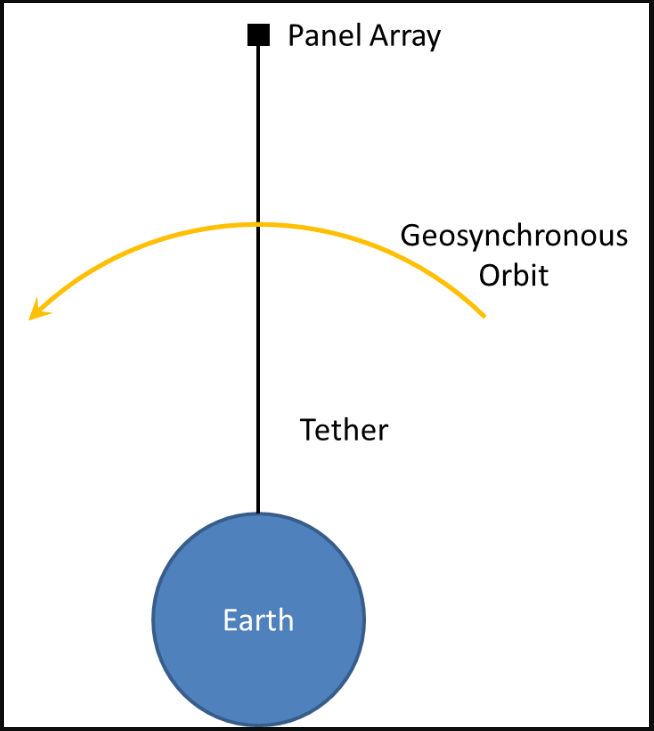
- Sun-Earth distance: 149,600,000 km
- How do we transfer energy such a far distance back to Earth?
- Methods are difficult and highly expensive, rely on futuristic technology
- System vulnerable to impact

Geosynchronous tether

- Photovoltaic panel array in space
- Physical tether connecting satellites to earth
- Low losses in energy transfer
- Satellite remains in same point above Earth's surface

Geosynchronous tether

- Geosynchronous orbit is 36,000 km above Earth
- Carbon nanotubes required for tether
- Has to be implemented at equator



Geosynchronous tether

Advantages:

- Supplied electricity directly
- Carbon nanotubes are superconductors
- High efficiencies in PV
- Nearly constant sunlight at high orbit

Geosynchronous tether

Disadvantages:

- PV panels vulnerable to impact
- Only countries at equator have direct access to power
- Carbon nanotubes are costly and in theoretical stages

Geosynchronous tether

Economic feasibility:

- High cost to send into high earth orbit
- Carbon nanotubes are extremely expensive
- Tether would cost over $30,000 trillion

Microwave power transfer

- First developed in 1964 by American electrical engineer William C. Brown (1916-1999)
- PV panels collect solar energy in space
- Panels connected to microwave transmitter antennae -> convert electricity to microwaves
- Antennae connected in phase array
- Phase arrays reinforce desirable radiation patterns, suppress undesirable patterns

Microwave power transfer

- Microwave rad. travels through space
- Collected on Earth by rectennae array
- Rectenna: antenna (microwave -> AC)
  rectifier (AC -> DC)
- DC electricity available for use

Microwave power transfer

Advantages:

- Geosynchronous orbit not necessary -> closer orbit, reduces difficulty and $$$
- Closer orbit reduces energy loss
- Technology exists, R&D relatively low
- High efficiency rectennae (>90% possible)
- Low intensity radiation is safe

Microwave power transfer

Disadvantages:

- PV panels vulnerable to impact + weight may cause problems
- Highly accurate tracking is required
- Lack of GSO reduces sunlight availability -> mitigated by batteries (?)
- High area of rectennae: 10 km diameter for 750 MW power

Microwave power transfer

Economic feasibility:

- Little information -> hard to estimate
- Many PV panels required $$$
- High efficiency panels required -> still being researched
- Rectennae are cheap, but array will be large -> likely means high cost $$$

Direct solar

- Using large space based mirrors rather than PV panels
- Solar energy is directed at the earth to increase the efficiency of Earth based solar systems
- This would act as a secondary “Sun”

Direct solar

- Russian “Novey Svet” (new light) experiment in 1992 proved feasibility

Direct solar

- Larger mirror systems with a concentrating mirror could power solar thermal insulations

Direct solar

Advantages:

- Reflective foil MUCH lighter than PV panels, weighing in at 12g/m3
- Steam turbine efficiencies at ~40%
- Easily scalable to large systems
- Technology to implement this type of system exists today

Direct solar

Disadvantages:

- Vulnerable to solar flares and solar winds.
- Requires advanced station keeping and tracking to assure success
- Slightly unsafe if tracking system malfunctioned

Direct solar

Economic feasibility

- Research and Development costs would me minimal compared to other ideas
- Low weight represents a low cost to get into orbit.
- Feasible in the coming decades (10-20)

Direct Solar

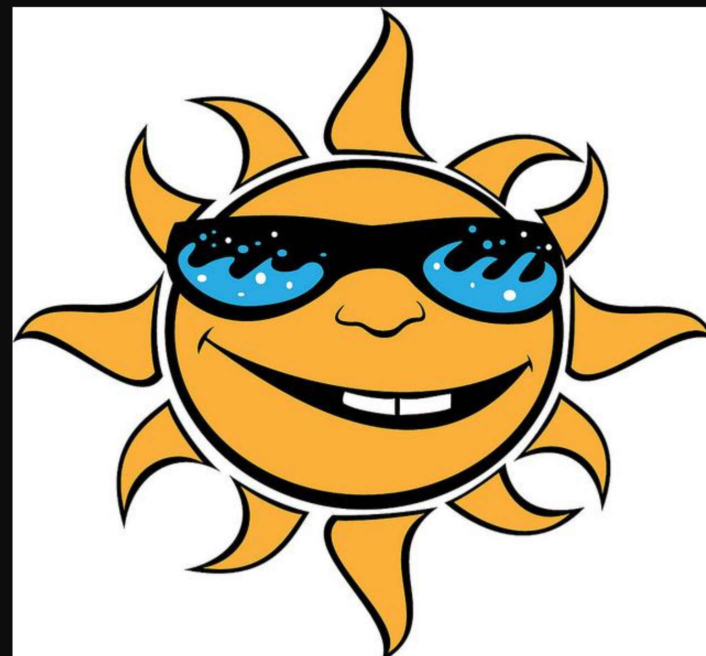
Economic feasibility

- Possible military applications could fund the majority of the project

Conclusions

- Not economically viable today
- Could be implemented in the coming decades
- Microwaves and Direct Solar feasible in the long term
- Geosynchronous Tether highly impractical.

Thanks for listening !!!



Questions?