Re: Solar powered lasers in space

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- *From*: Ian Parker <ianparker2@xxxxxxxxx>
- *Date*: Mon, 17 Sep 2007 03:40:02 −0700

On 14 Sep, 20:30, Willie.Moo...@xxxxxxxxx wrote:

> On Sep 14, 9:33 am, Ian Parker <ianpark...@xxxxxxxxx> wrote:
>
>> 40% seems a very high efficiency for a laser, but even if this figure is accepted there is one overiding problem. At noon in a desert you have about 1kw/m^2 coming in through solar power anyway. The obvious question to me is why not have solar power in the desrt and be done with it. Lets generate power and split water into hydrogen and oxygen in the desert using the energy that comes from the Sun anyway. Why have a space laser as an intermediate stage?
>>
>> Is it to get power 24/7? Well you have to be above LEO to effectively extend the desert day.
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> You add the satellite to lower costs... that's the point. You lower costs by increasing the capital utilization of the equipment.
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> BACKGROUND − SOLAR PANELS
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> PHYSICS
> The sun is a thermal source emitting all colors. Silicon has a specific bandgap energy at 1,108 nm which absorbs all wavelengths shorter than that bandgap color, and converts each color with an efficiency of the ratio of the wavelength absorbed relative to the bandgap wavelength. So, 1,100 nm is almost perfectly absorbed. 550 nm is converted to electrical action at 50% efficiency 275 nm is converted to electrical action at 25% efficiency − because the bandgap energy is fixed. ALL the energy of wavelengths longer than 1108 nm is lost − its converted with 0% efficiency. Summing across all the wavelengths in a real system − you get about 180 watts electrical for each 1000 watts solar put in.

Could I say at once as a general preamble that I feel we should keep an open mind on all possible systems. In talkinf avout 1108nm you are assuming two things − Photovoltaics & Silicon for photovoltaics. If that is true then you are correct. There are however alternatives.

1) Biological − Here yellow is the wavelength for photosynthesis, just over 500nm.
2) Raise steam & drive a turbine− Here wavelength is unimportant.

> UTILIZATION
> Now in a desert region we have in North America the equivalanet of 1,600 hours of sunlight per year. That's because of seasonal variation and cosine effects. The sun at dawn and dusk illuminates the terrain at an angle. Its only at noon at certain times of the year that you get peak power. All other times light comes in at an angle and is lower intensity. So, you have an effective peak power output of 1,600 hours.

This is true. You are now thalking about GEO. Some earlier postings mentioned LEO. At GEO utilisation is indeed 24/7 (almost) there is an eclipse season. At the equinoxes this is about 1hr 10min per night around midnight. Away from equinoxes you have 24/7.

> OUTPUT AND COSTS
> Energy is measured in kWh. So, each kW of panel from sunlight produces in this scenario 1,600 kWh.
>
> The cost of this system is lets say $1,000 per peak kilo−watt − and it has a lifetime of 20 years. That means you're paying $50.00 a year for the equipment. If you borrowed the money and paid it back over 20 years, you'd pay more like $100.00 a year for the equipment. Lets say there are no other costs to keep it simple − since these are the main costs. Then you're paying $100 for 1,600 kWh − that's 6.25 cents per kWh.
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> BACKGROUND LASER POWER SAT
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> LASER POWER PHYSICS
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> Lets ADD a powersat that beam laser energy at 1,000 nm (1 um) onto this same panel array. The laser energy is converted by the silicon with nearly perfect efficiency. 1,0000 nm / 1,108 nm = 90.25% − scattering in the air subtracts another 5% − So, for each 1,000 watts of laser you get 850 watts electrical.
>
> INTENSITY
> If we decide to emit the same 1,000 watts per square meter the sun produces, using a solar pumped laser in space, then we obtain 850 watts electrical per square meter on the ground. This adds to the 180

watts electrical each square meter produces from sunlight.

COST OF PEAK WATT ON THE GROUND
This is the first advantage of a power sat. We said it cost $1 per peak watt for the solar panel installation in our example above. This is $180 per square meter of panels. Reusing the same installation for a solar power receiver at the intensity described above means that $180 per square meter is spread across 850 watts electrical output from the satellite. So, the ground station costs are reduced from $1 per peak watt to ,

$180/850 = $0.212

21.2 cents per peak watt − for the ground statoin side − or $212 per peak kW.

UTILIZATION

The solar pumped laser is at GEO − hovering stationary above the panel array. The laser satellite illuminates the panels nearly all the time and totals.nearly 8,766 hours per year − except for a few minutes when Earth's shadow eclipses the satellite.

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OUTPUT AND COSTS
Like the solar panels, the energy is kWh, so each kW of panels and satellite produces a total of 8,766 hours of satellite power per year.

Lets say that each kilowatt of solar laser power on orbit costs $6,000. A satellite is mostly thin film highly reflective plastic focusing sunlight onto a special device called a fabrey−perot cell − filled with materials that lase at 1,000 nm. This laser beam passes through a window of special adaptive optical window that adjusts the beam in response to a controlling pilot beam from the panel array on the ground so that the power safely and reliably falls on the panels and nowhere else.

This is quite interesting. I feel that this concept should be extended further. A set of lasers such as you describe can be made much more capable with a few changes. These changes are quite compliocated and perhaps a little bit difficule to understand but they would not add greatly to the cost. What you weant on your window is a piezoelectric system capable of putting a delay of half a wavelength in or out.

If you take a pattern at infinity (in fact the Earth will still be in the Fresnel region − not quite infinity) and take a Fourier Transform you get the pattern that has to transmitted. One thing − The radiation intensity is real (we are not worried about the phase (angle in Argand diagram). Our laser outlets are only capable of varying phase angle not intensity. However by giving freedom to phase we can achieve a general pattern by varying phases alone. This means.

1) The system is capable of being focussed either into a very small region or into a more diffuse region.

2) The system will focus on a number of spots simultanously some diffuse some points.

Thought − Could an asteroid be moved by concentrating laser light onto it?

http://groups.google.co.uk/group/sci.space.policy/browse_frm/thread/42e13e471f66cc4f/fb4819c47855f36a?lnk=st&q=

Lasers were not mentioned in the NASA report, perhaps they should have been. I think too it was a great pity that Rand Simberg saw fit to hijack the discussion.

Personally I am not sure I like the idea of nuclear bombs, where there is an alternative.

Actually the concepts of LISA, the concept of a large space (fragmented) telescope and the concept of laser arrays are very much bound up. With active phase control you can always reach the diffraction limit and you can work out with 1.22lambda/d just what that is.

> Launch costs are approximately $10,000 per kg and construction costs in the aerospace business are around $2,500 per kg. The costs of raw materials are nil compared to these costs. The bulk of the weight of the satellite is the thin film material − and so knowing the thickness of this the efficiency of converting sunlight to laser light − we can compute the area of the film and its weight − and add a correction to estimate what the laser and controls would weigh − and multiply by the figures above to get a preliminary estimate of satellite costs − and see that $5 per watt is accurate.

Launch costs is again an interesting one. If you have an energy system it will (I presume) go from LEO to GEO using ion drive.

− Ian Parker

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