

Power Satellites or Replacing Fossil Fuels with Economical Solar Energy from Space

Reaction Engines, Ltd

March 4, 2016

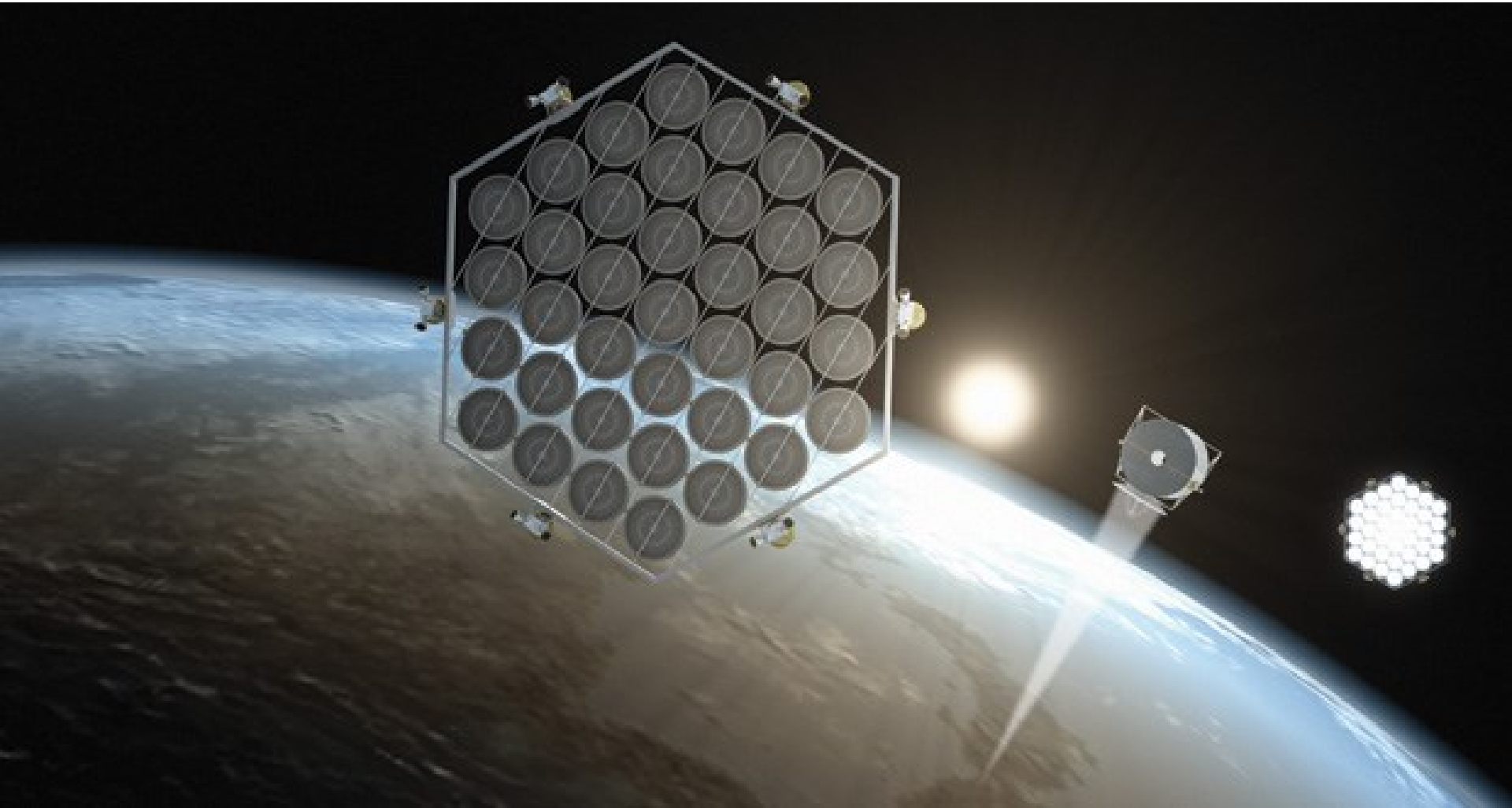
Keith Henson, Founder, L5 Society

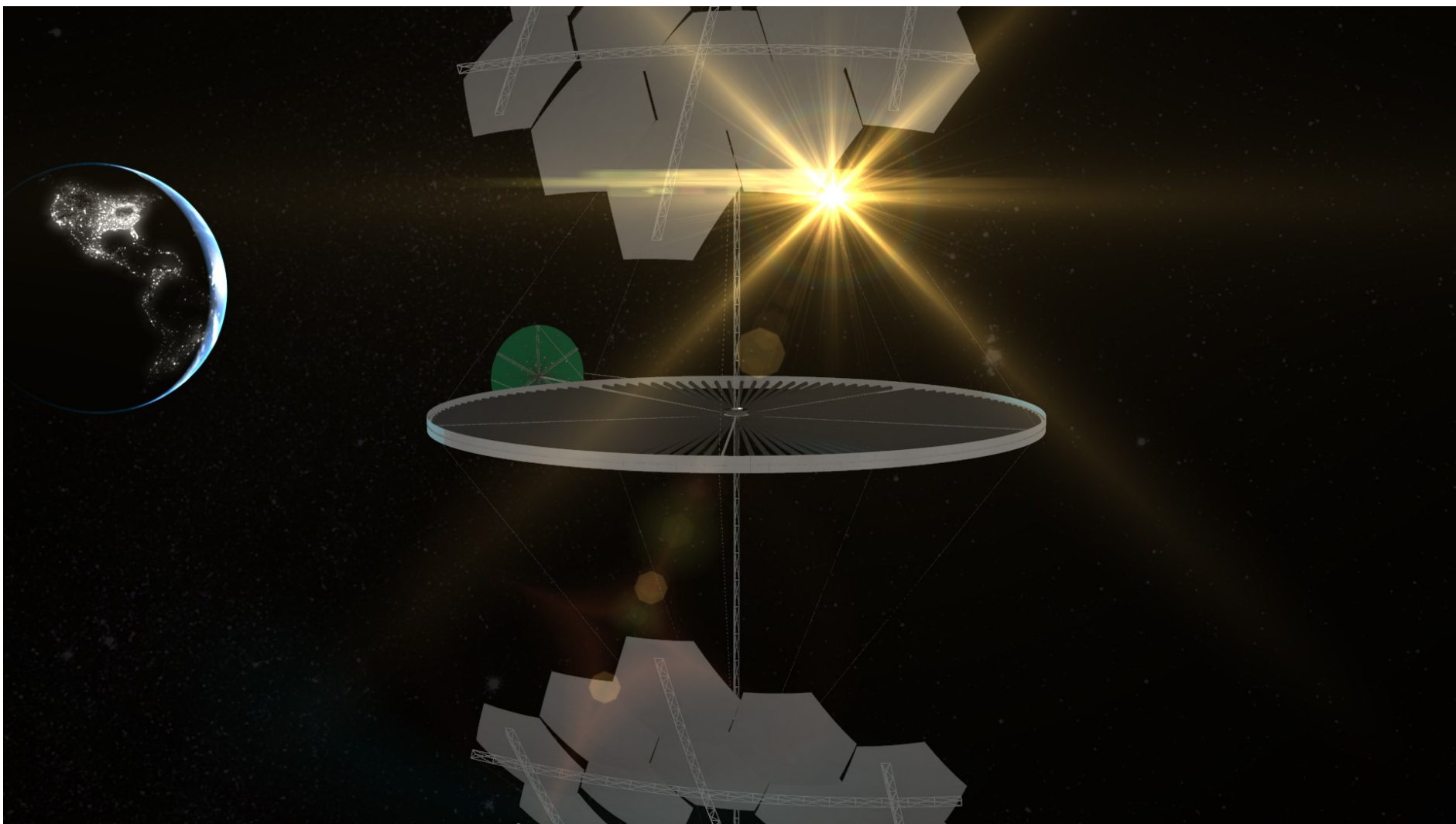
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How Japan Plans to Build an Orbital Solar Farm

IEEE Spectrum, May 2014

JAXA wants to make the sci-fi idea of space-based solar power a reality



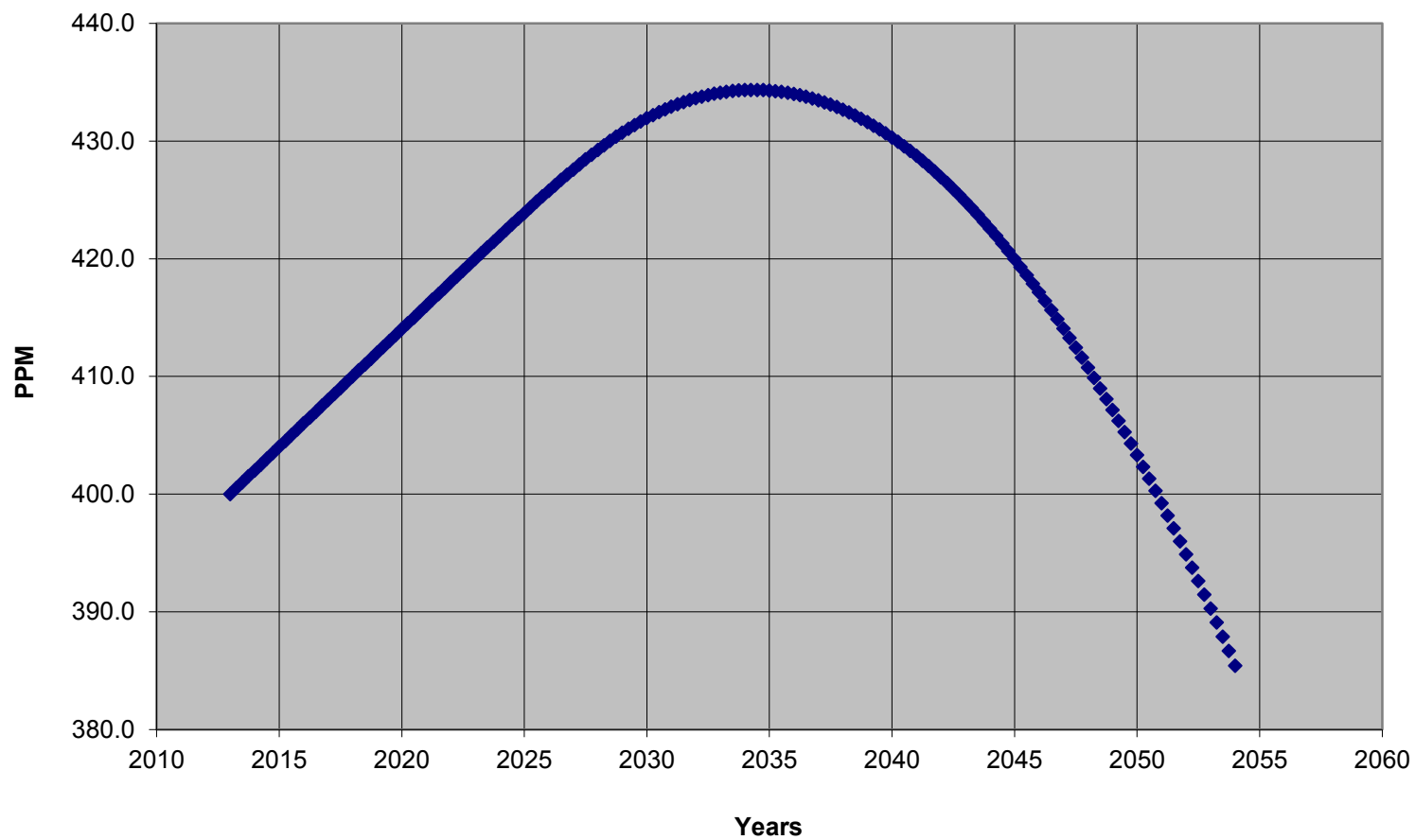


Why power satellites?

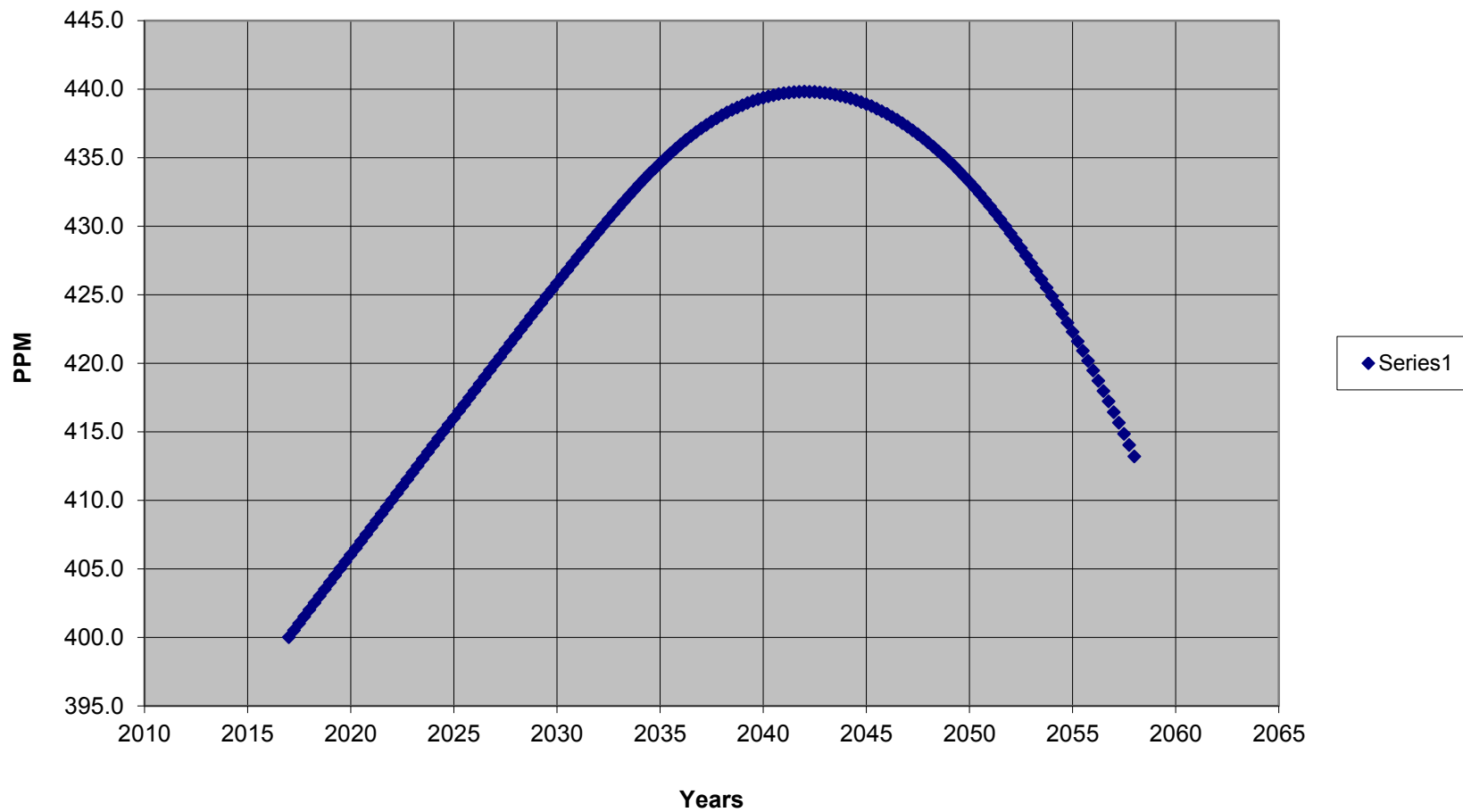
They get humanity off fossil fuels

This is important if you consider the
CO₂ build up to be a serious problem

Projected CO2 ppm aggressive expansion



CO2 ppm



They solve energy concerns without subsidies and make a *lot* of money. Low energy cost makes everyone better off

Initial target cost is 3 cents per kWh to undercut coal, 2 cents or less to replace oil

Is it possible to replace oil?

Synthetic Oil from electricity

Hydrogen in a bbl of oil takes ~20
MWh. At two cents, \$40/bbl.

Capital \$10/bbl based on this plant



How much can we spend on
power satellites?

For low maintenance & zero fuel
cost, the Levelized Cost of
Electricity is capital cost/80,000
That is \$2400/kW for the target of
three cents per kWh

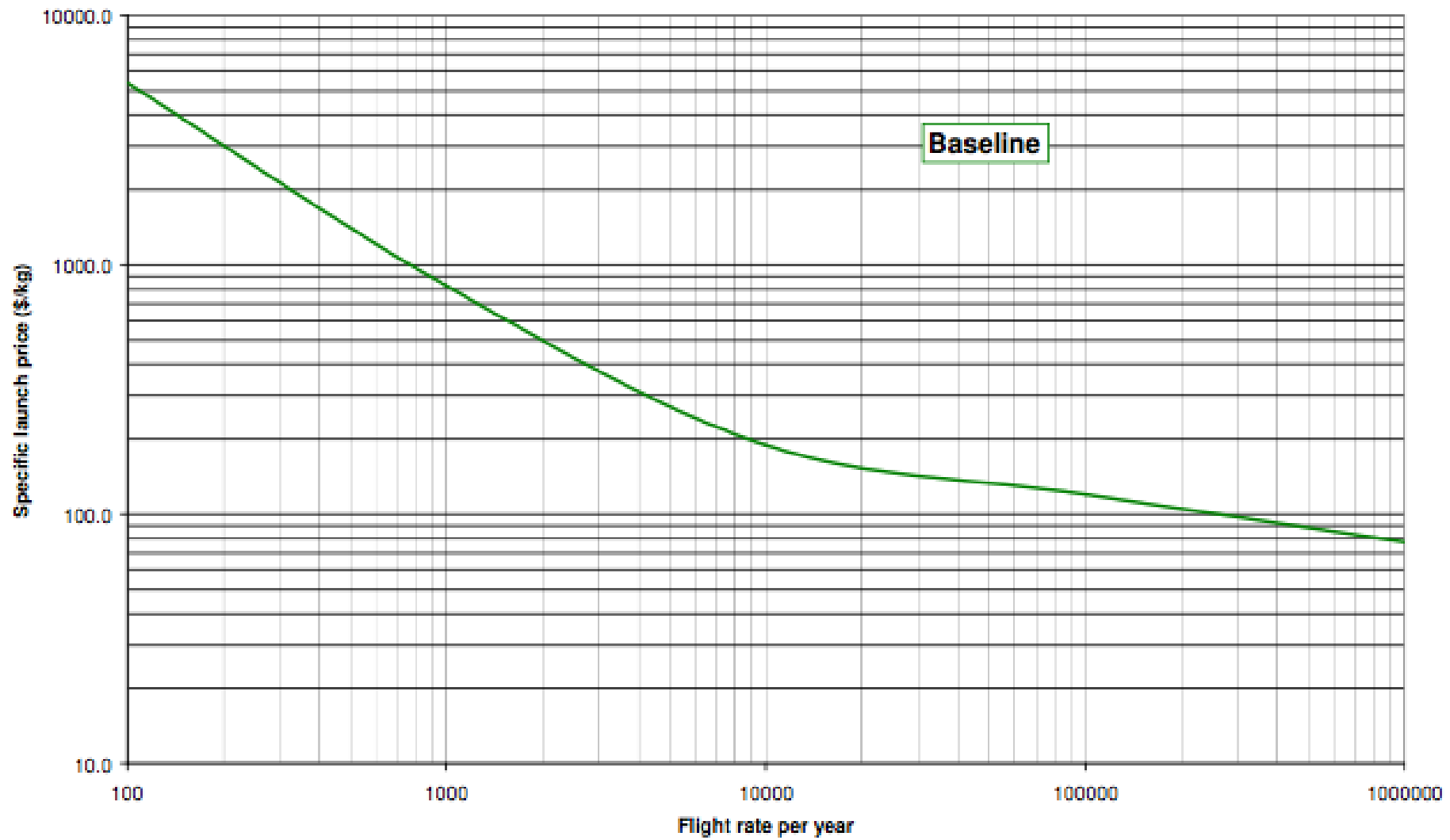
\$2400/kW is split \$200/kW for the rectenna, \$900/kw for the power satellite parts. That leaves \$1300/kw for transport.

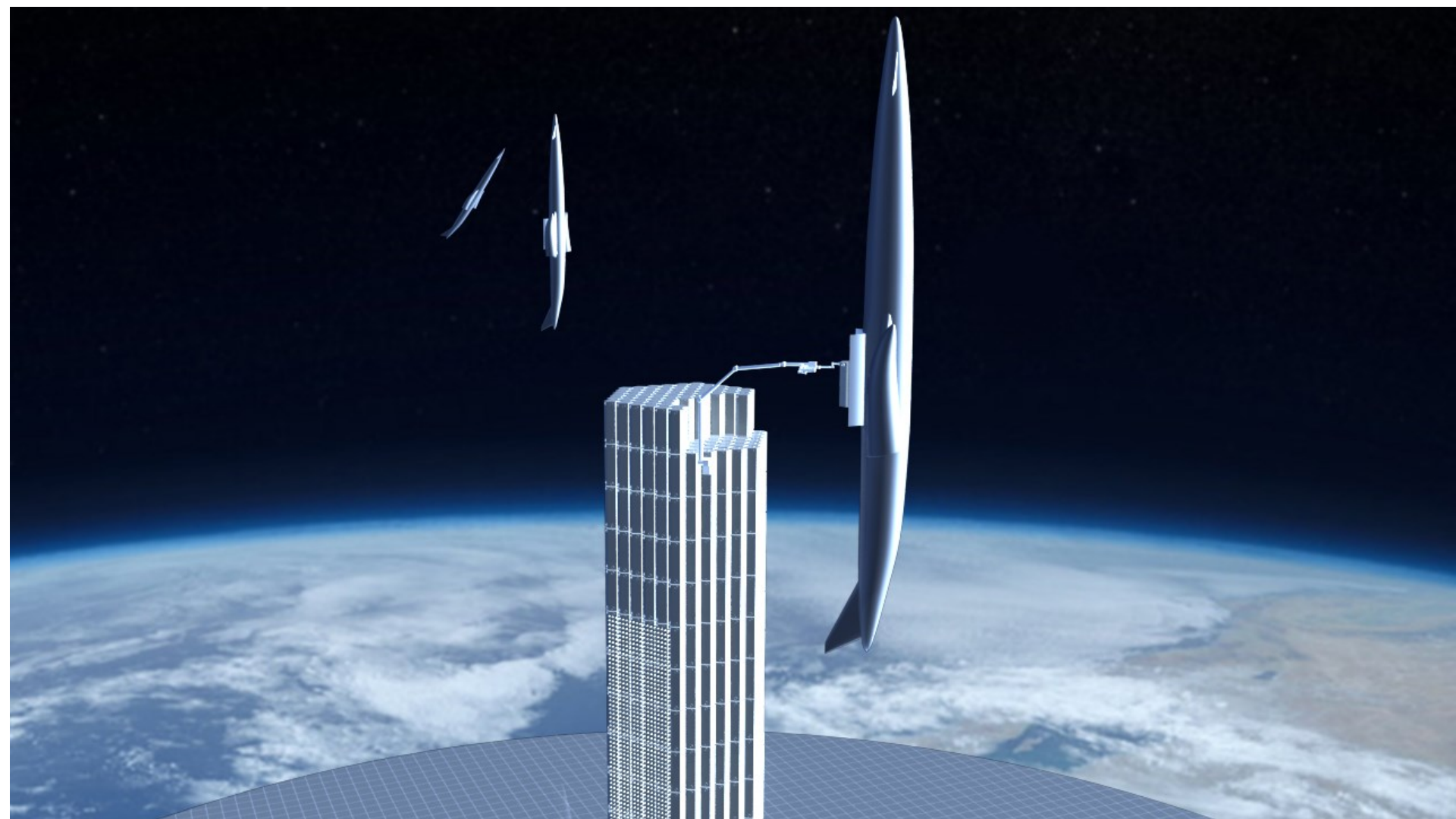
At 6.5kg/kW, that's \$200/kg about
a 100 to 1 reduction over current
cost to haul comm sats to GEO.

You cannot build in LEO and fly
a power satellite out to GEO on
it's own power, there is too much
space junk and takes too long.
(Boeing, 1970s, hit 40 times)

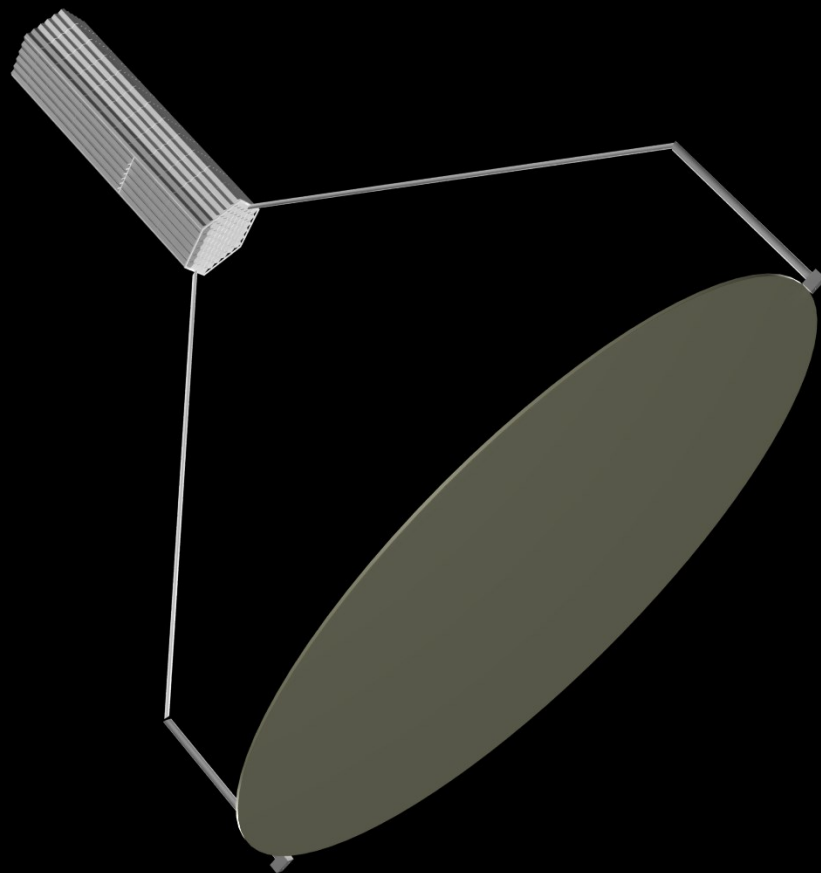
First to LEO

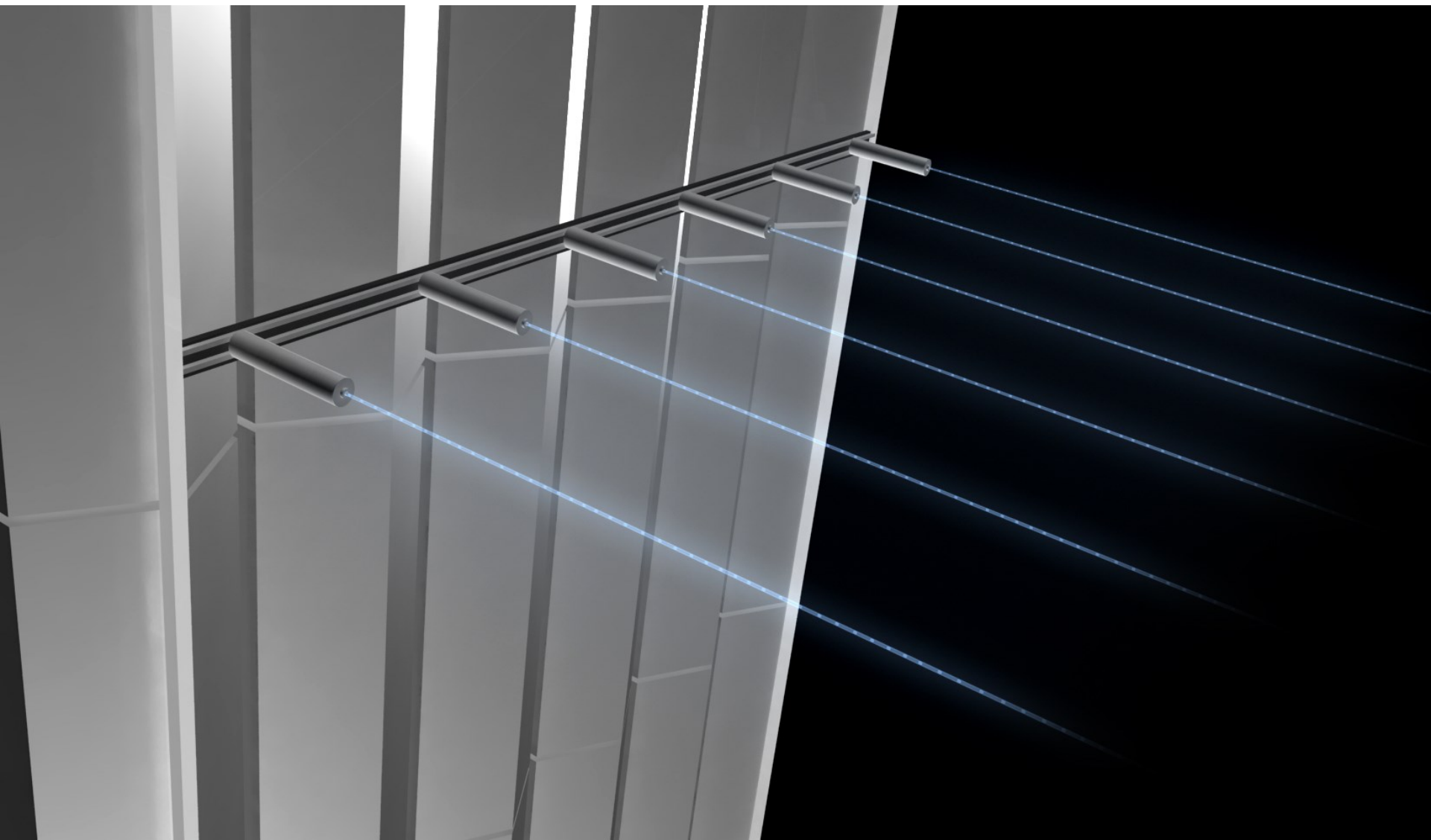


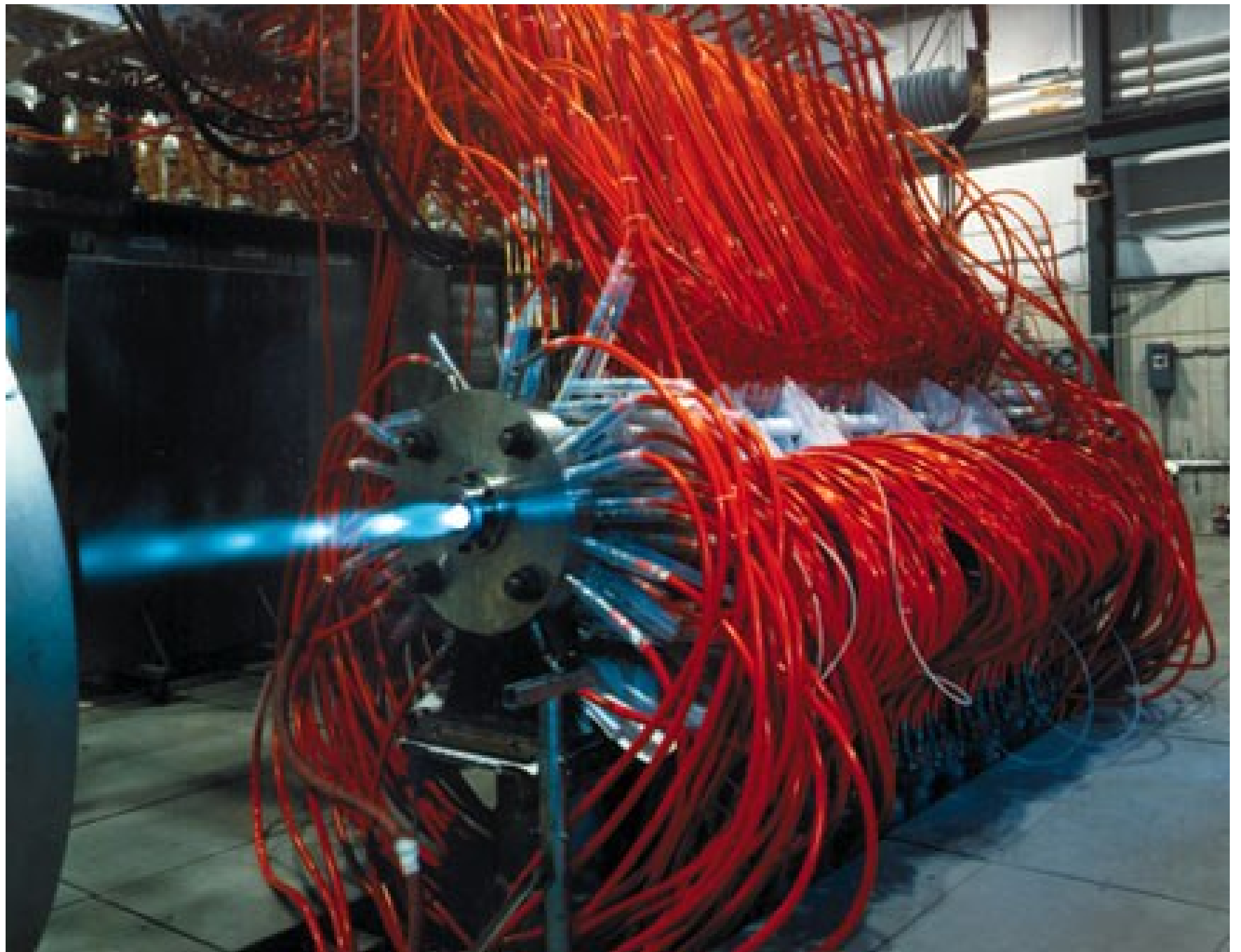






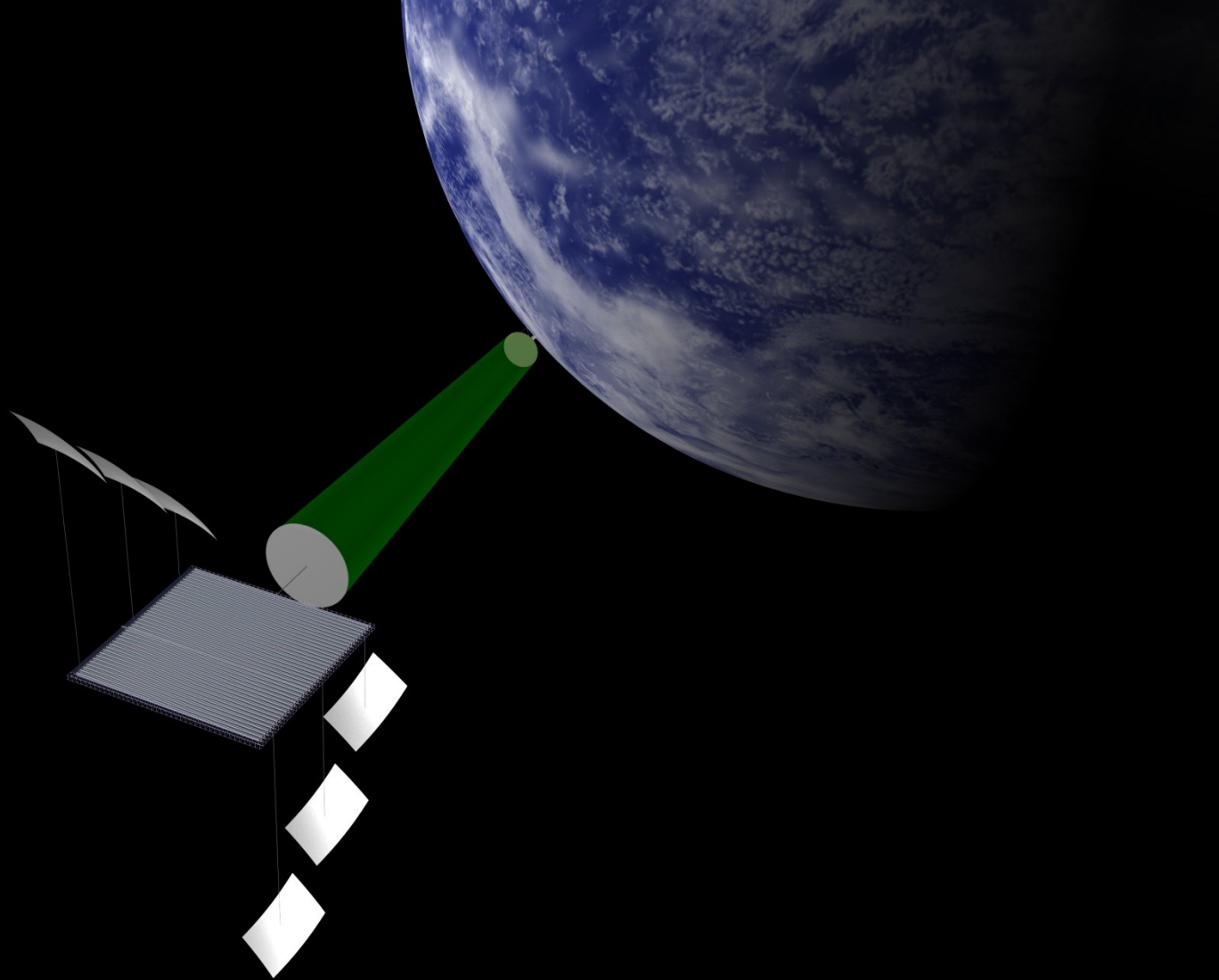




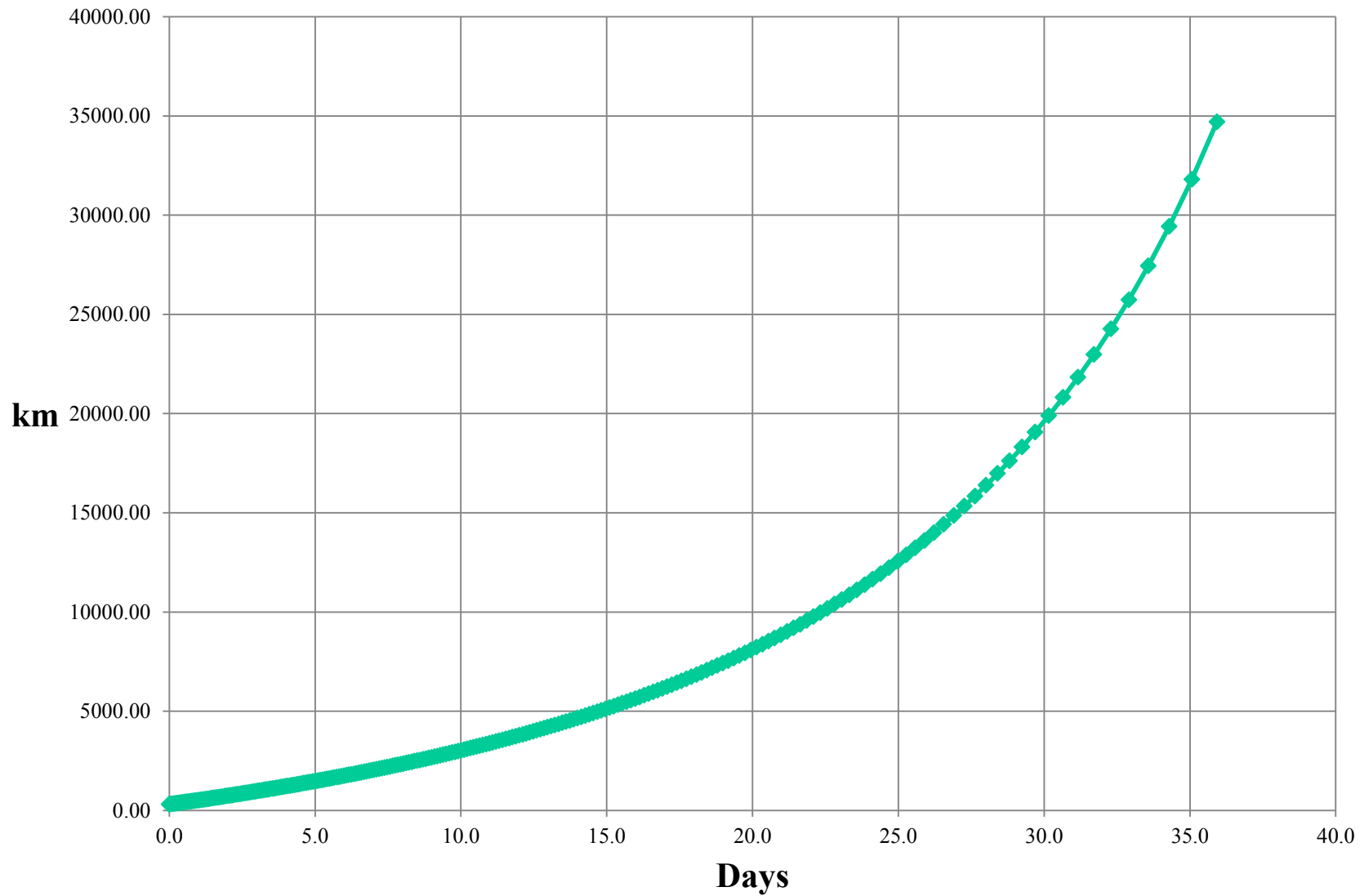


Arcjets are power hogs
How can we power them?

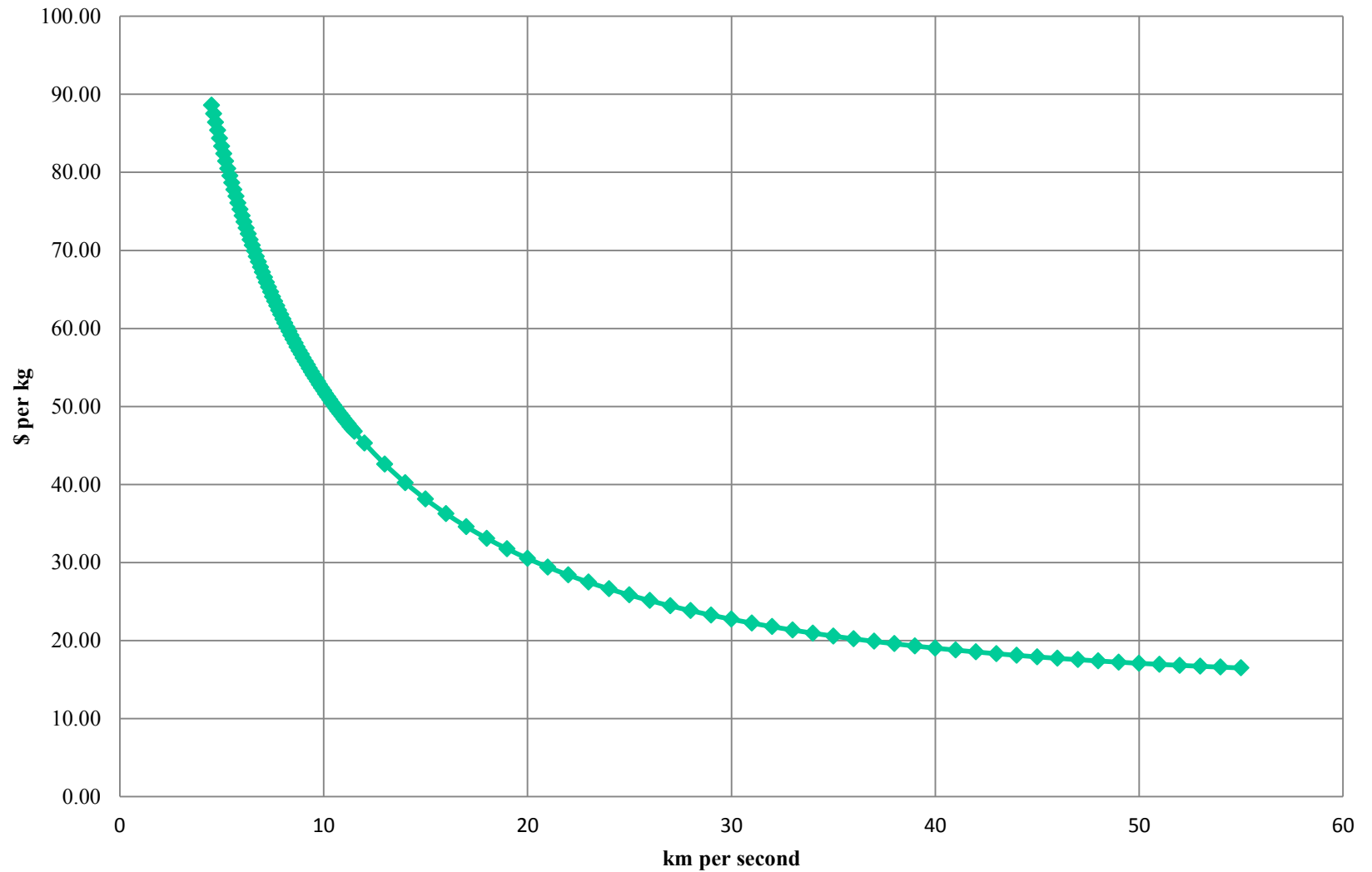
(A mini power satellite obviously)



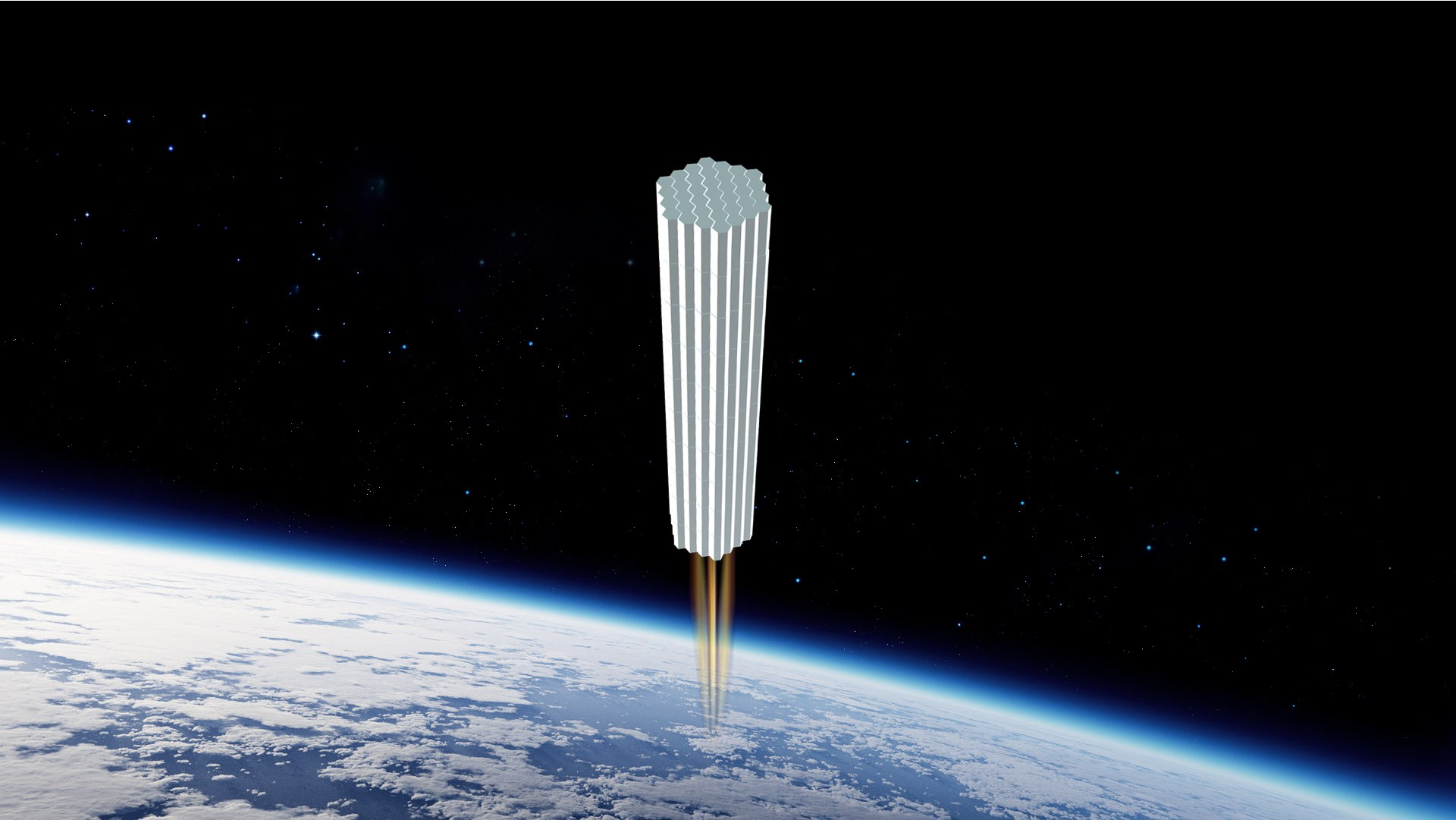
Days for a given altitude, 15,000 tons, 400 MW



\$/kg vs exhaust velocity

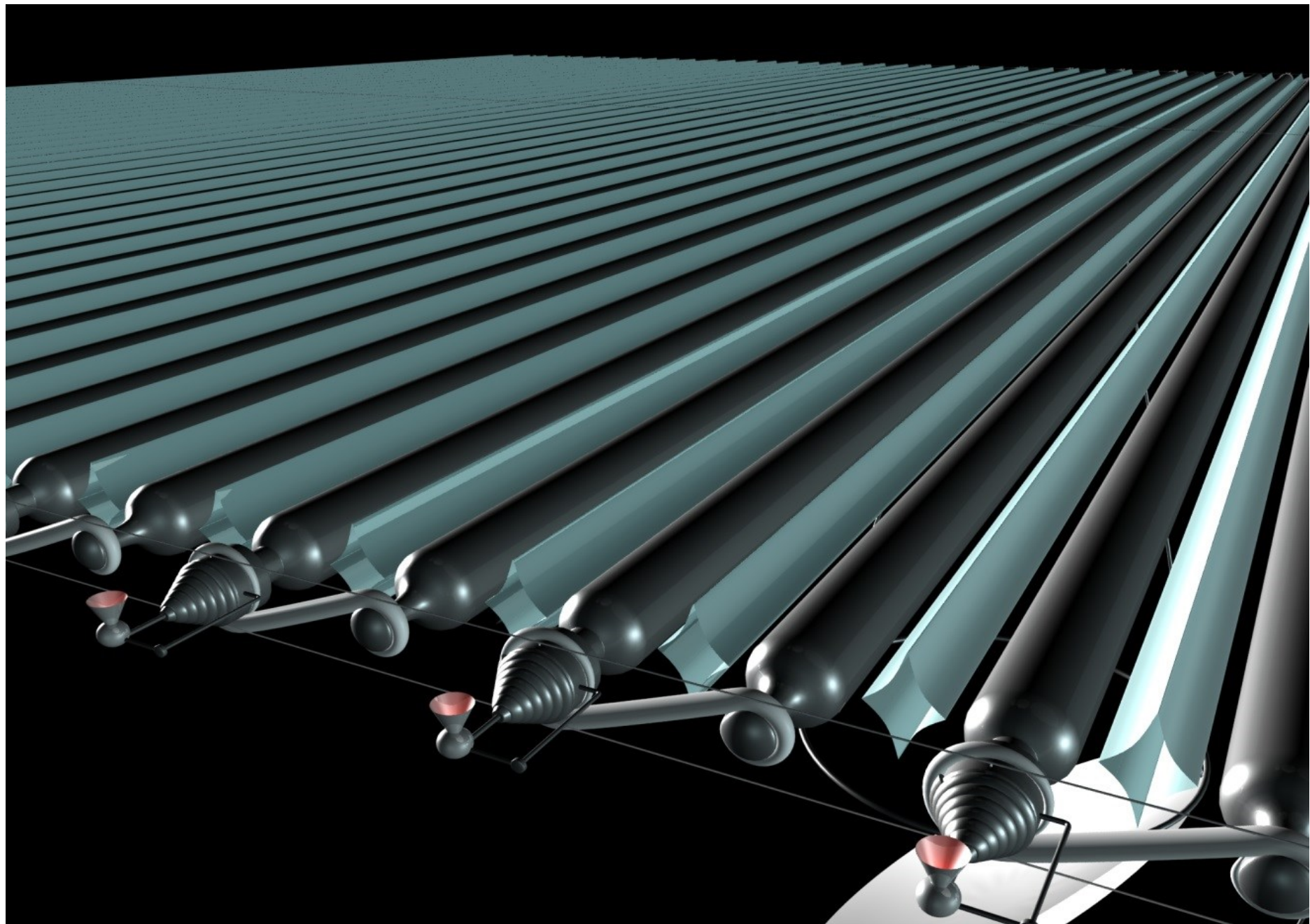


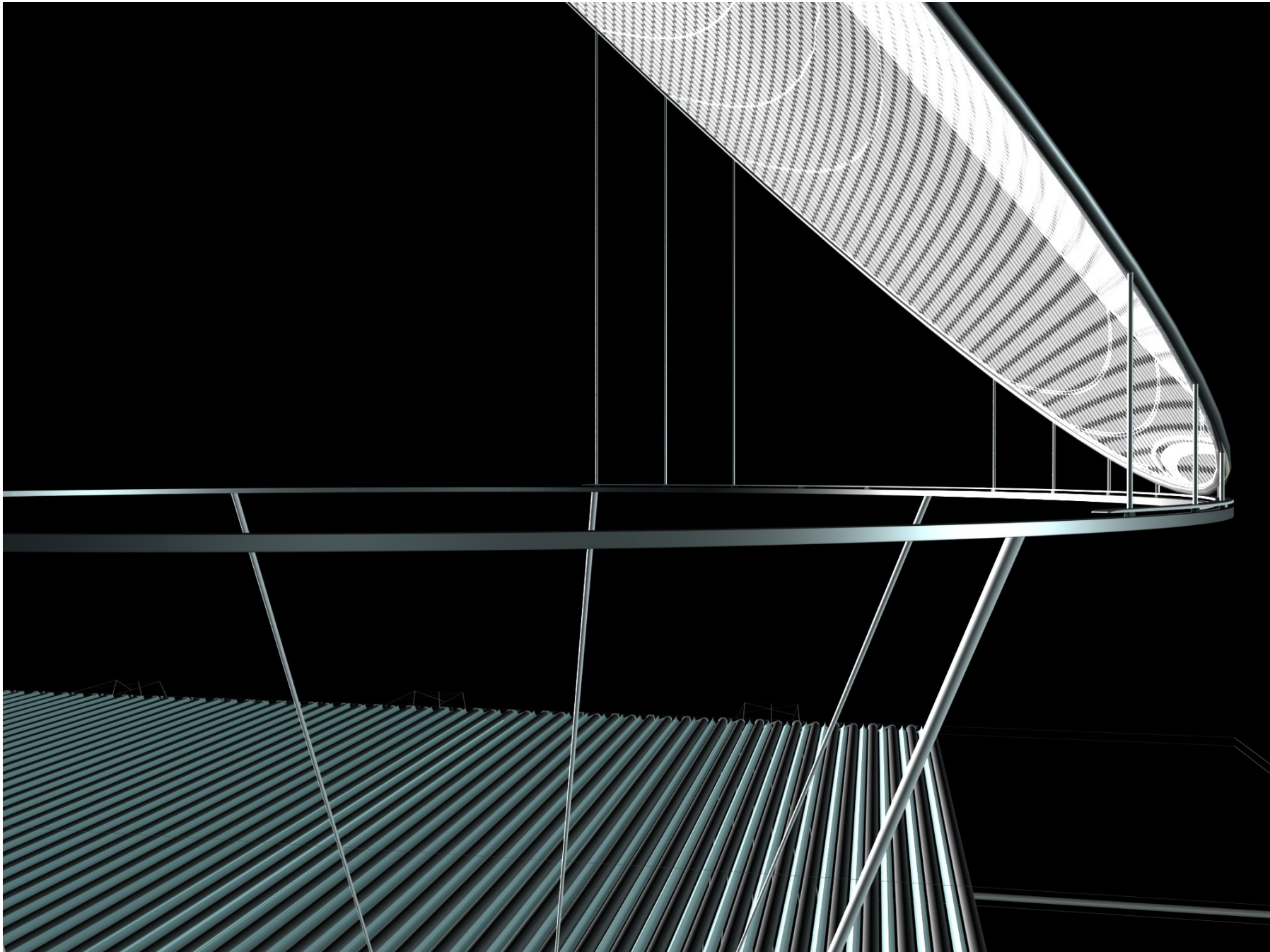
We have the same problem with a mini power satellite that we had for a full sized one, it gets to many space junk hits on the way up. Most of the junk is below 2000 km so the plan is to use chemical rockets to 2000 km

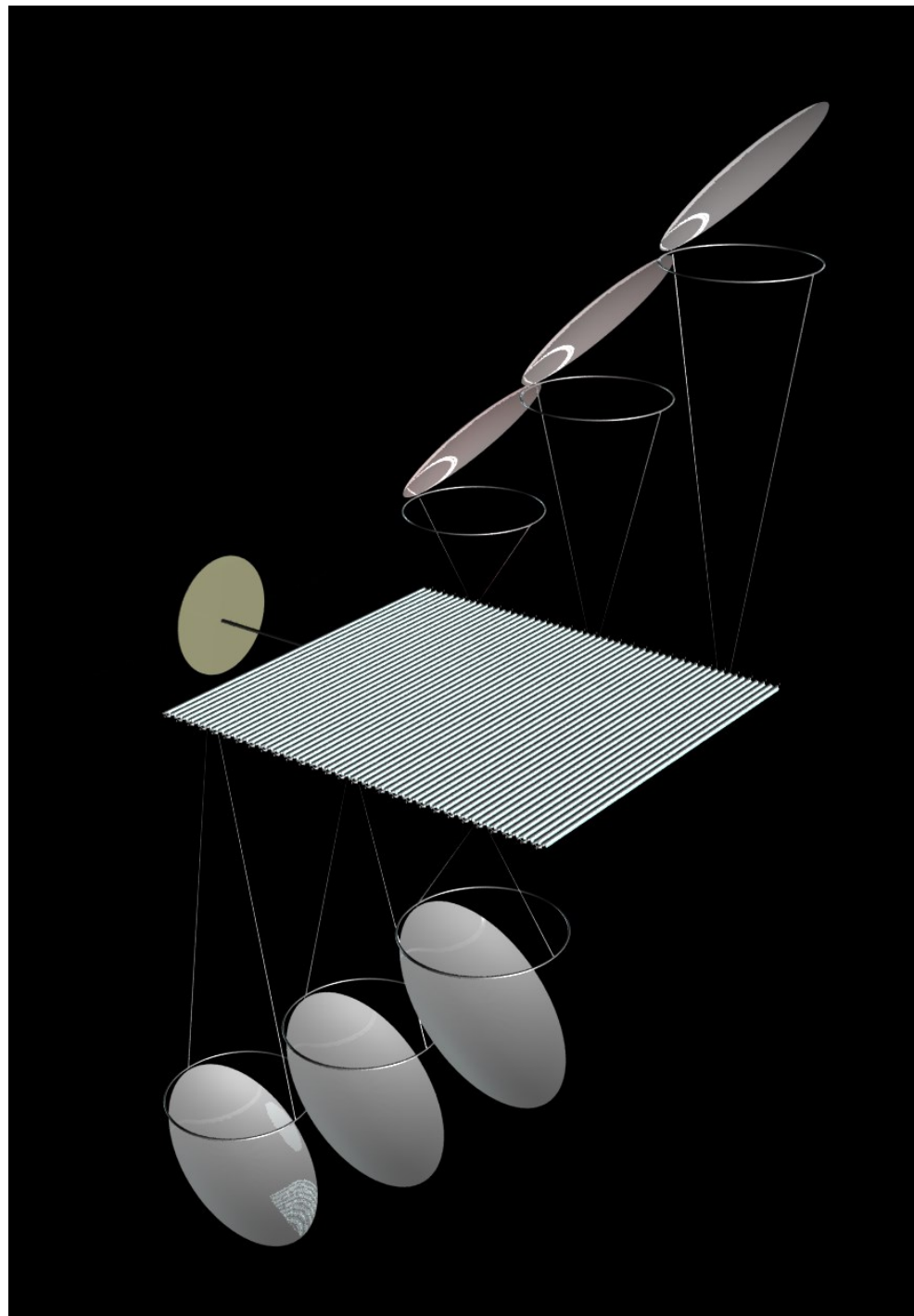


At 2000 km, the stack unfolds to
make a propulsion power satellite

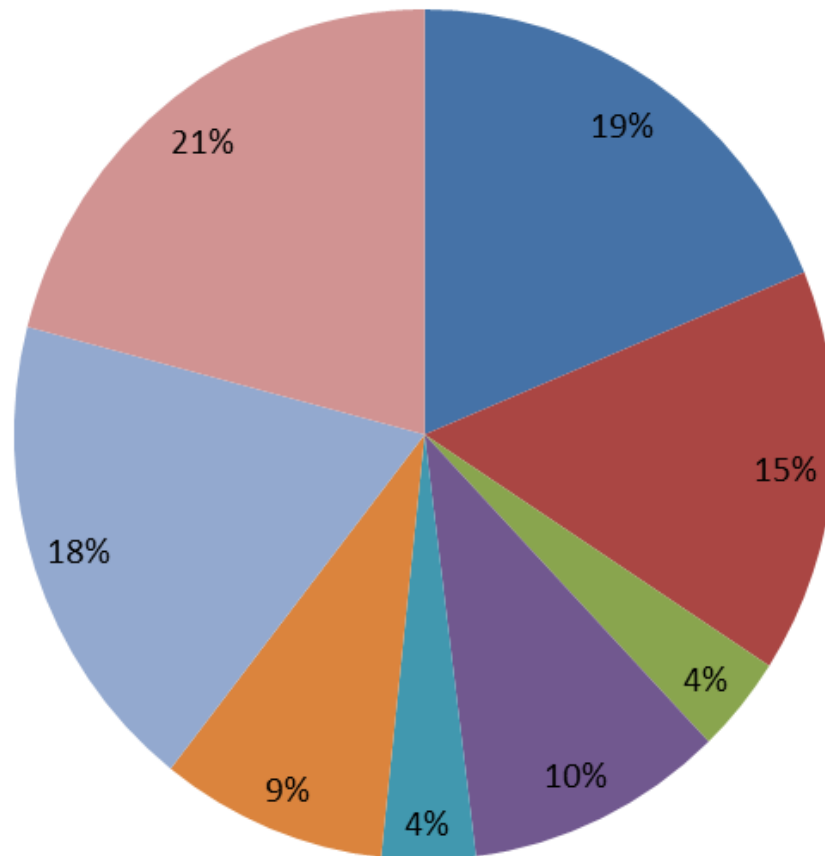
It looks like we can get the cost to well under \$200/kg to GEO, not LEO where cost are usually quoted. Can we get the mass to 6.5 kg/kW? (32,500 tons for 5 GW)







Thermal Power Satellite Mass Allocation

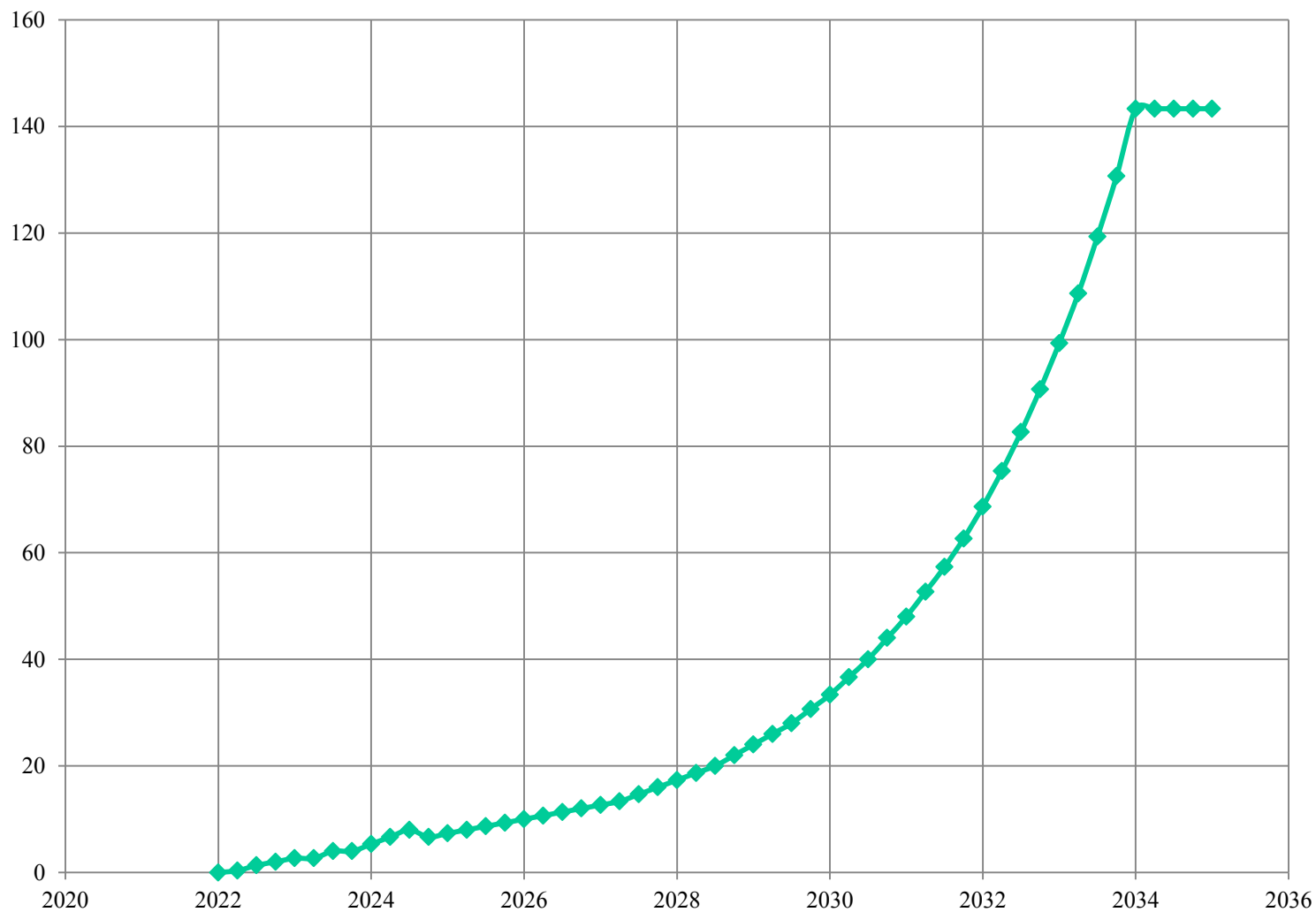


- 6100 tons of collector surfaces and supports
- 5000 tons of boilers and steam generators
- 1200 tons turbines, compressors, feed water pumps
- 3300 tons of electrical generators and wiring
- 1200 tons frame
- 2900 tons radiators
- 6000 tons transmitter
- 6800 tons margin

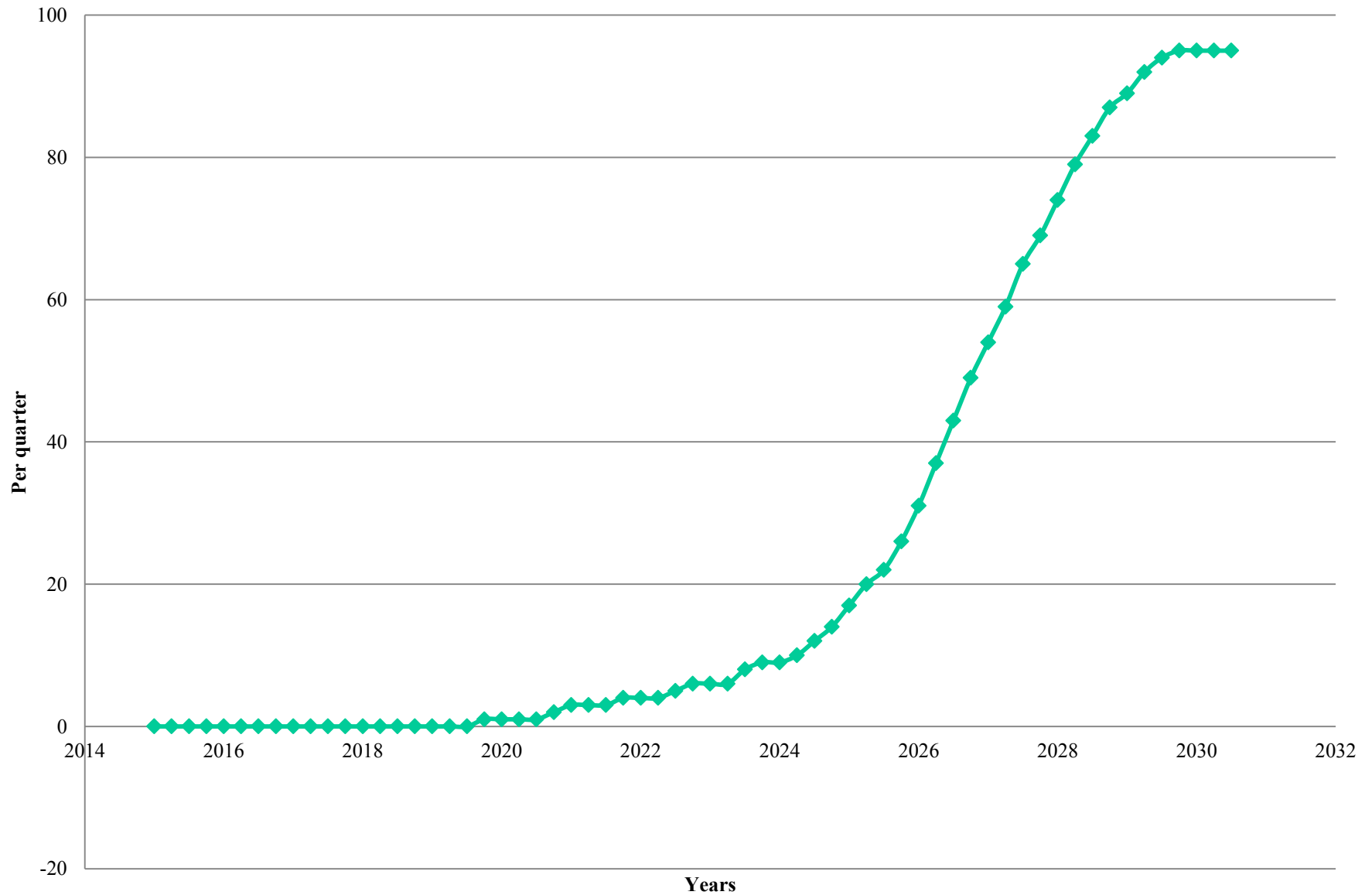
Can we build power satellites
fast enough to make a
difference?

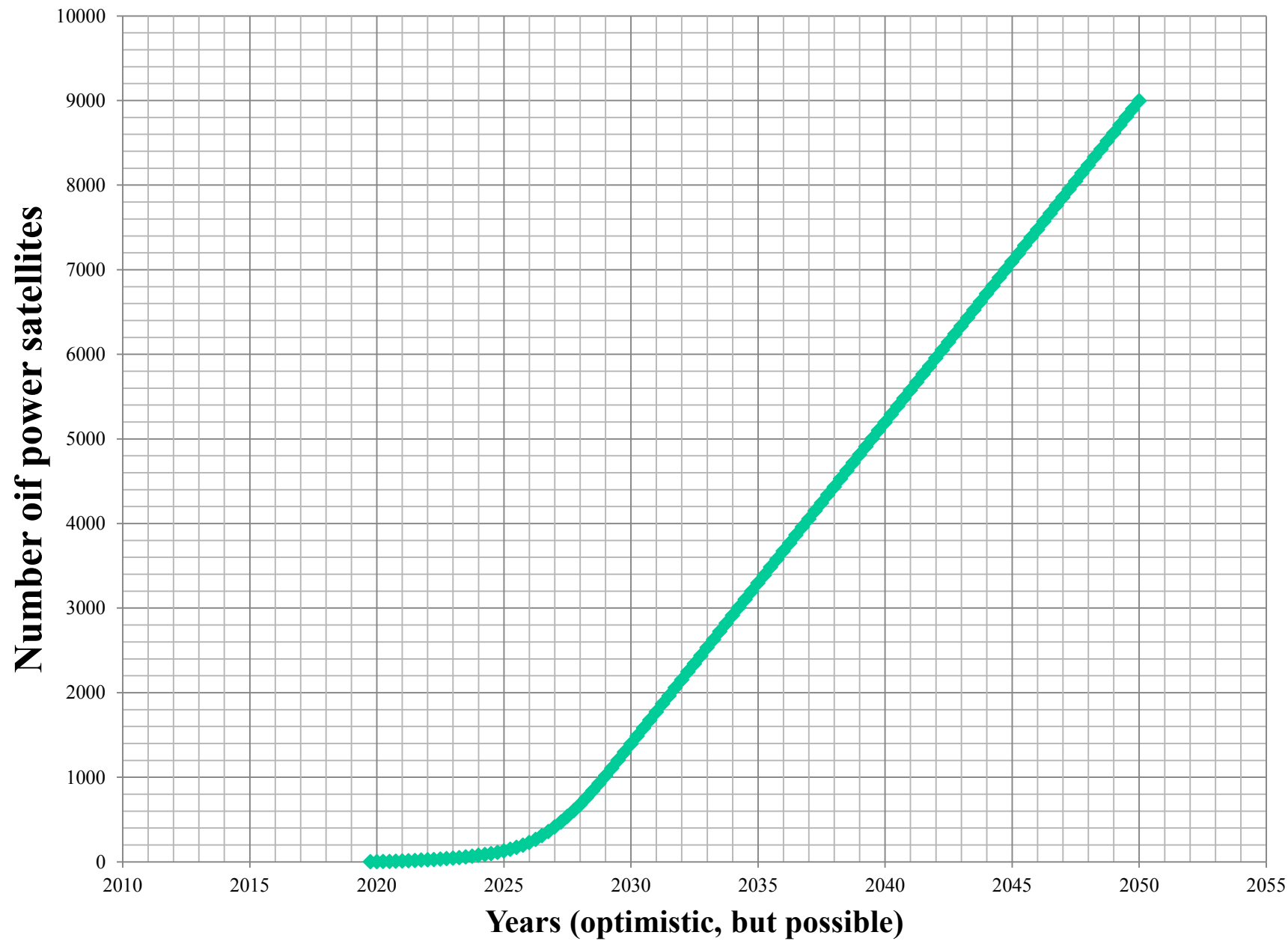
Depends on how fast Skylon production
can be ramped up and if we run into
NOx/ozone environmental limits from
>100,000 reentering Skylons per year

Monthly Skylon production

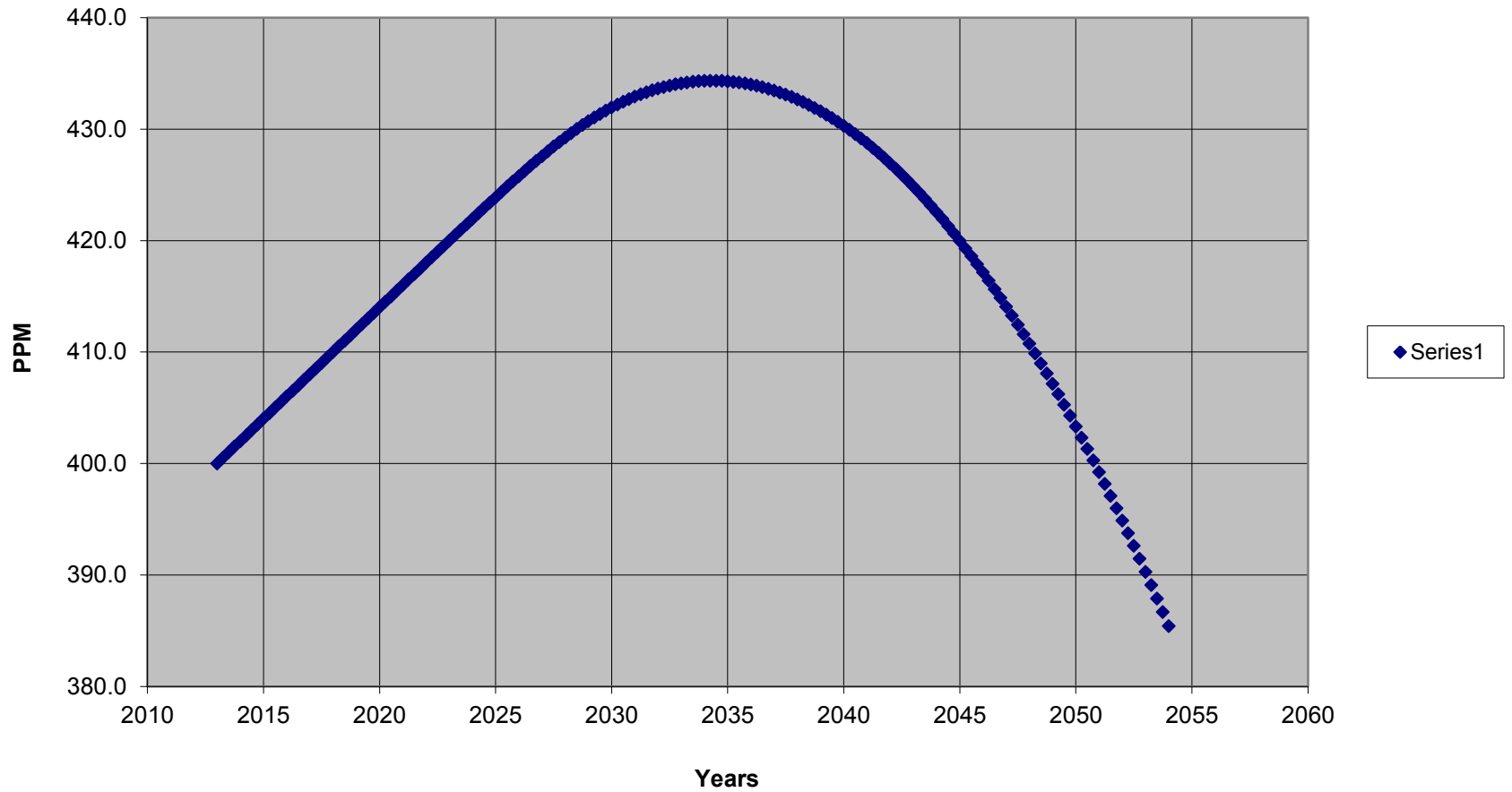


Power satellite construction rate per quarter





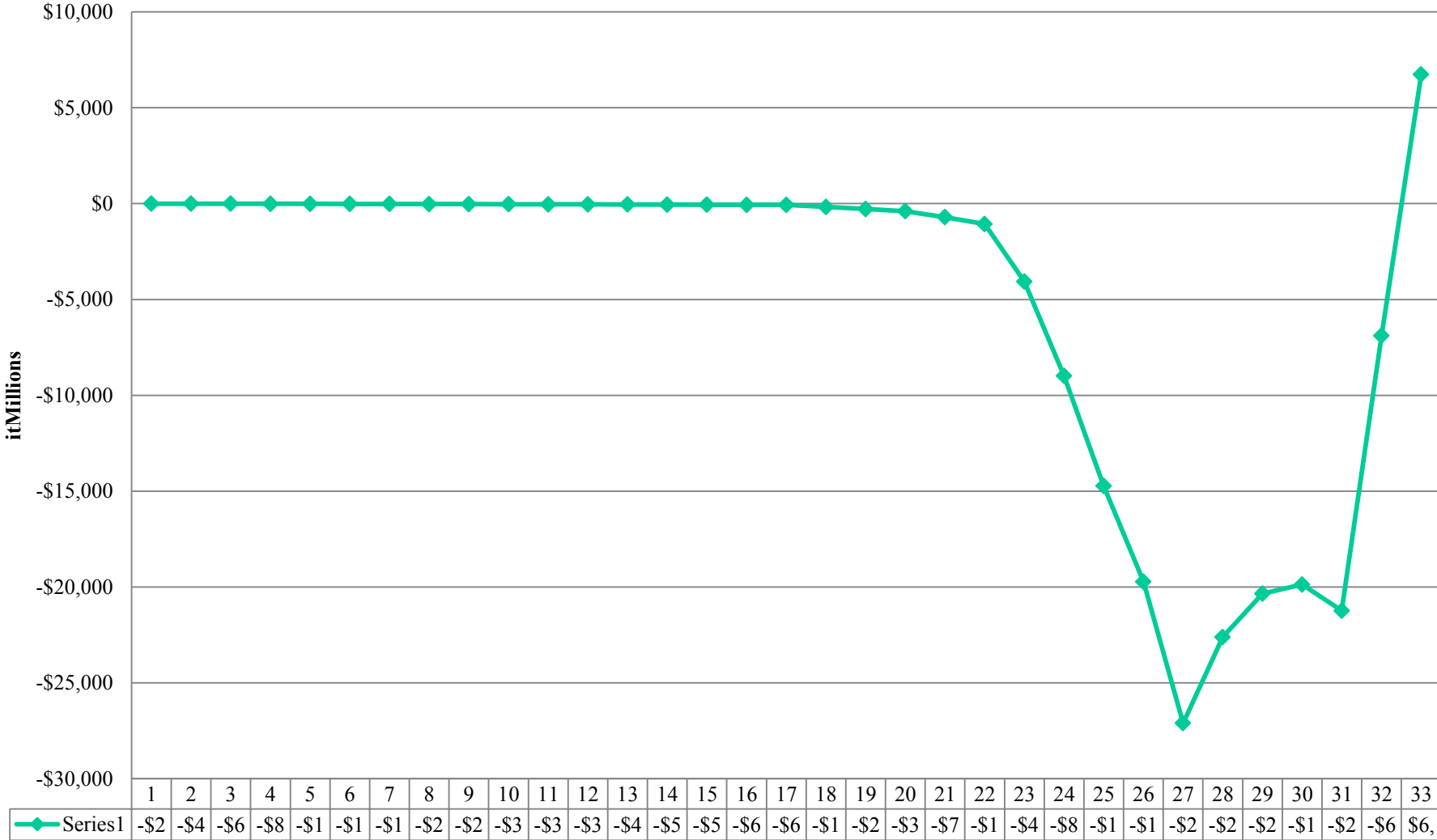
CO2 ppm

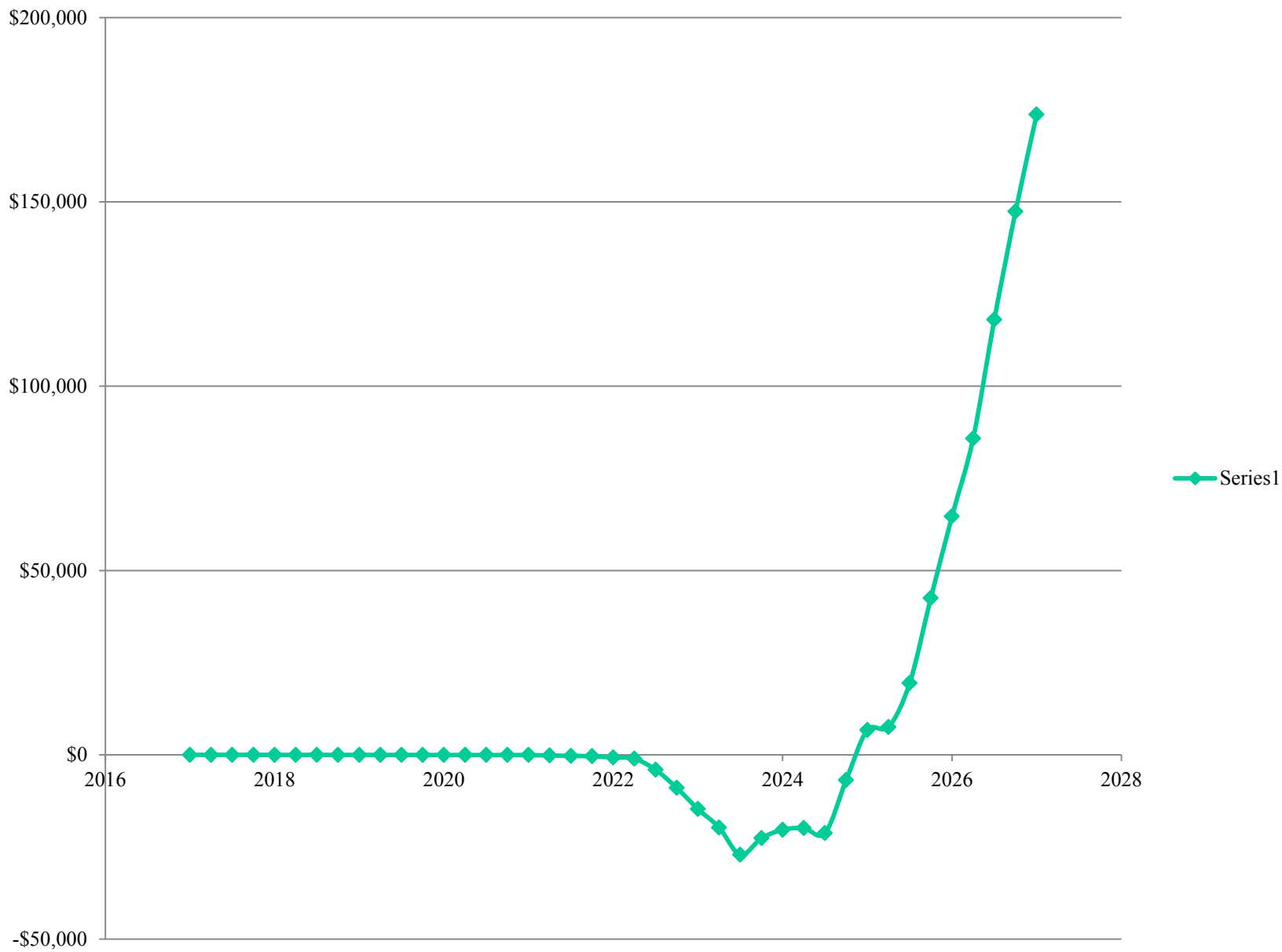


This proposal looks like it can be done and will solve the CO2 problem. How much will it cost is the next question. The next charts (not checked) do not include the \$10 B development cost for the Skylon

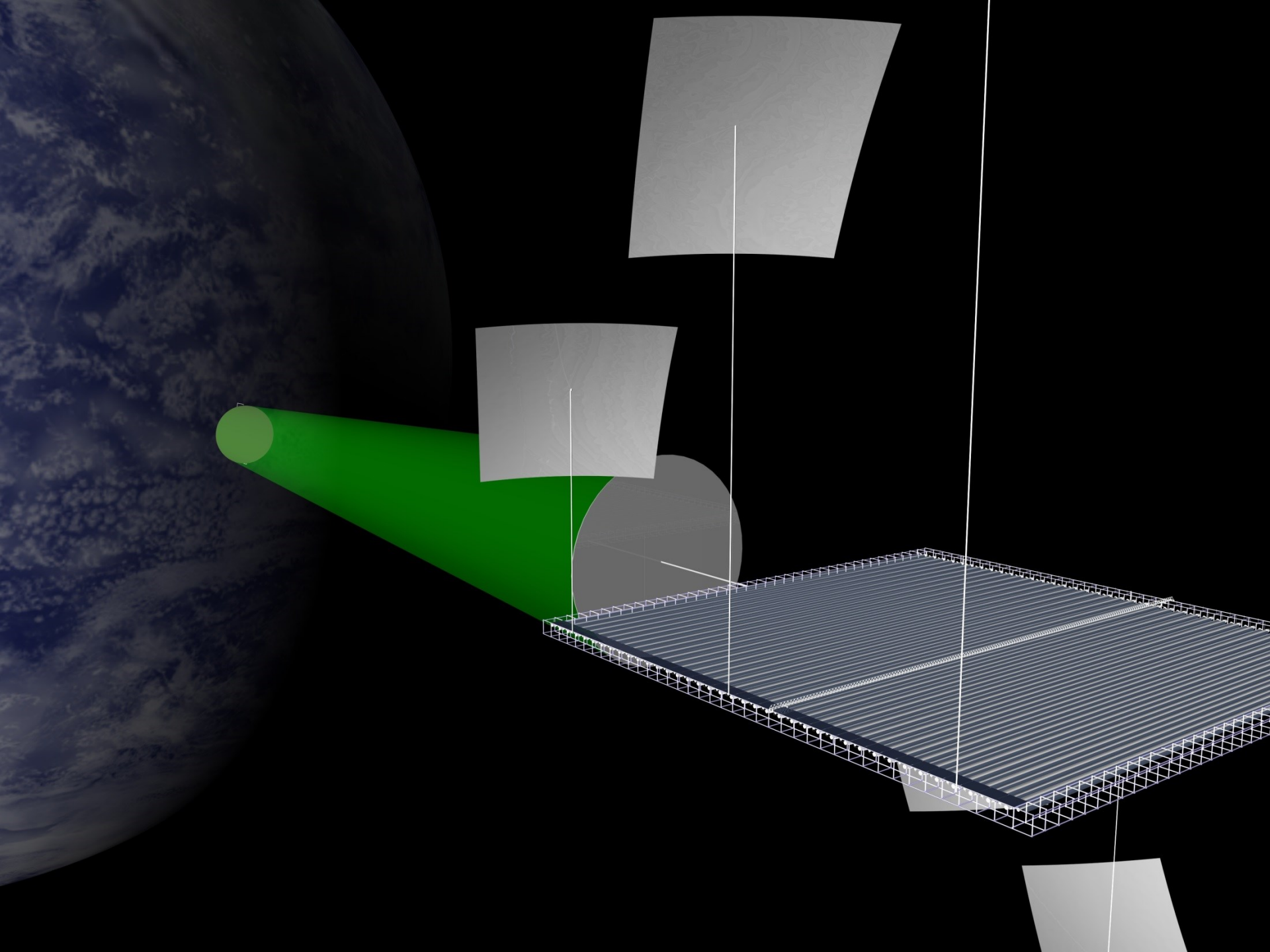
The odd shape is due to rapidly reducing the cost of power satellites to customers (a marketing decision)

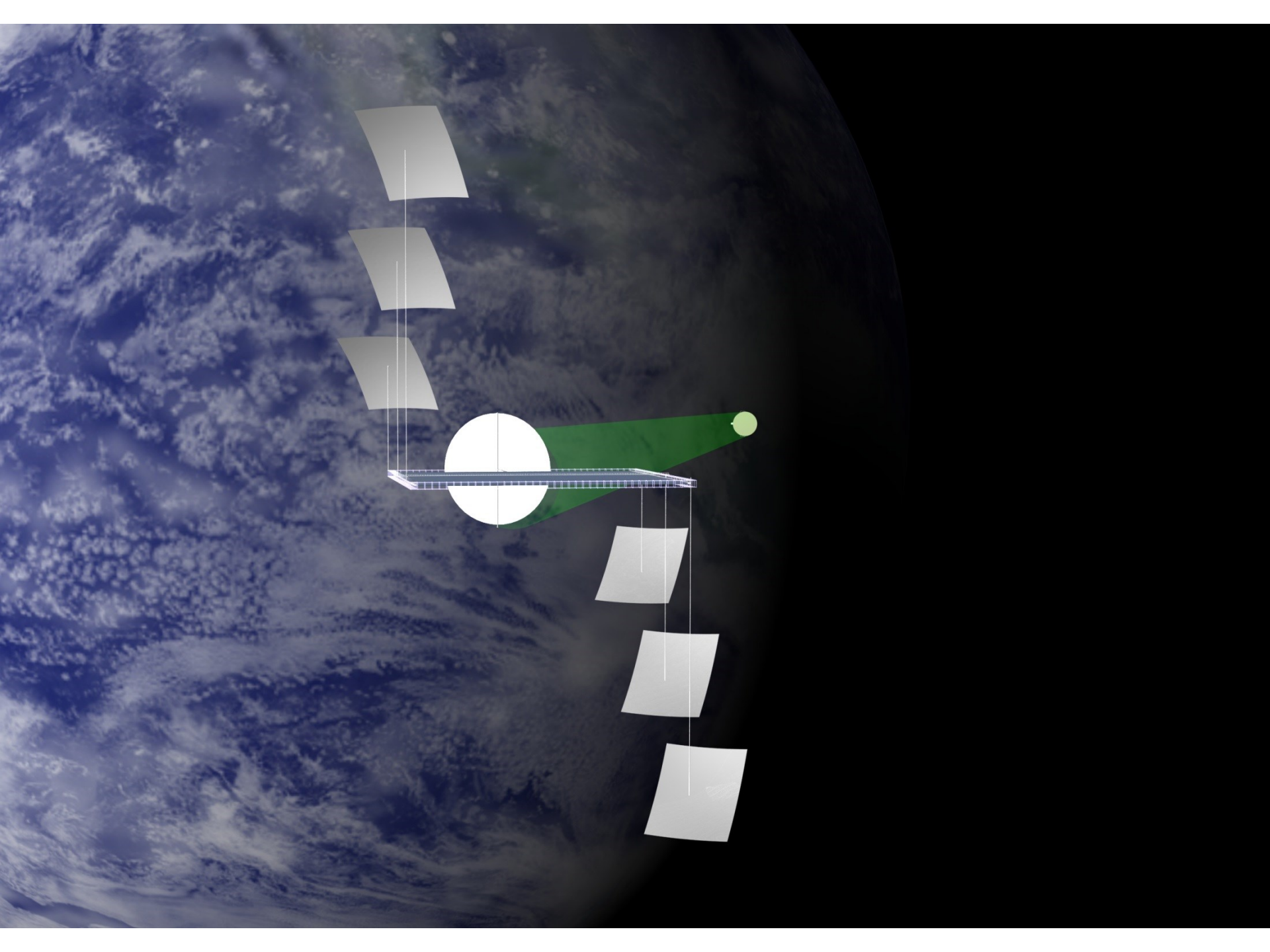
Cumulative P&L

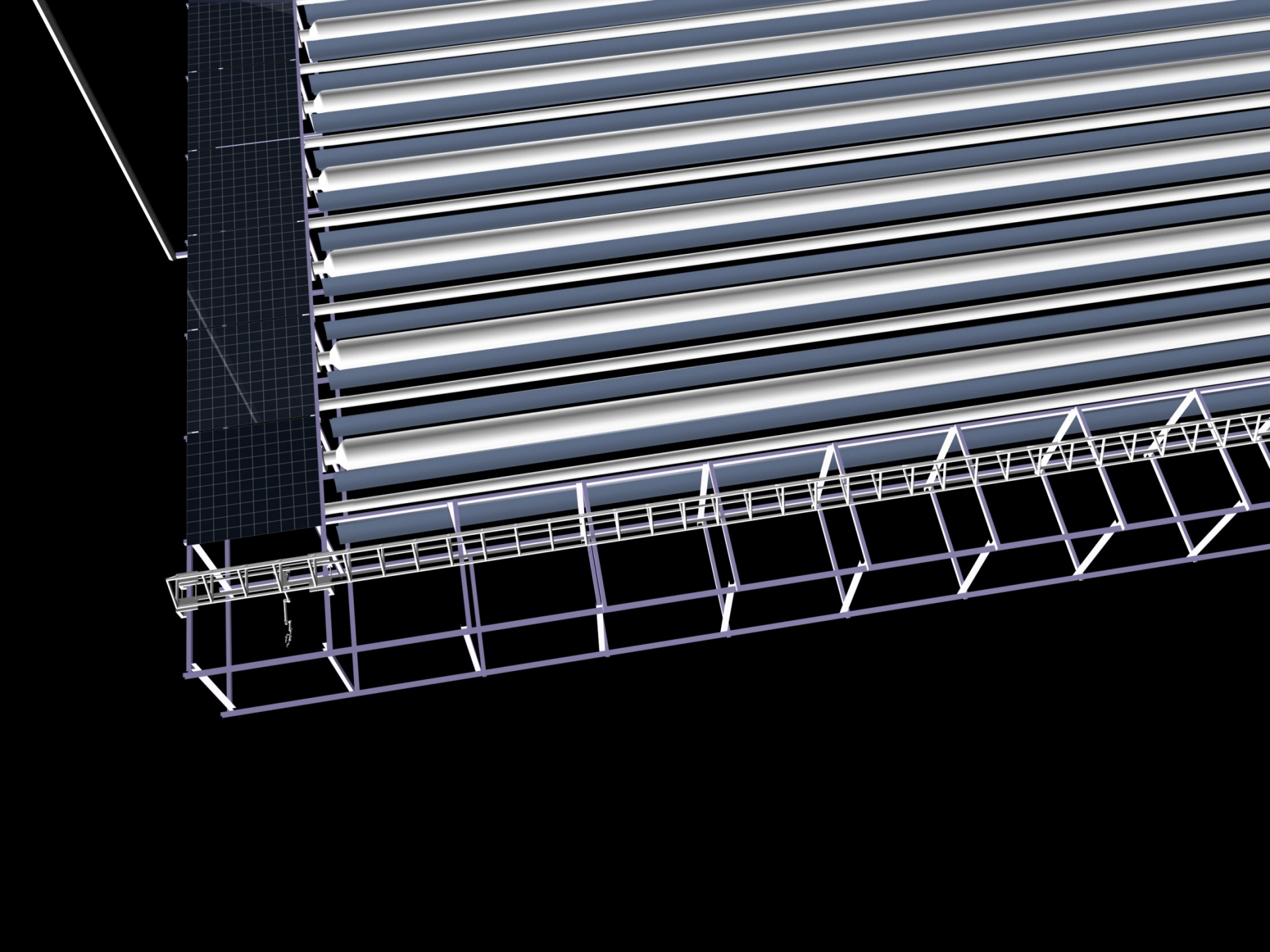


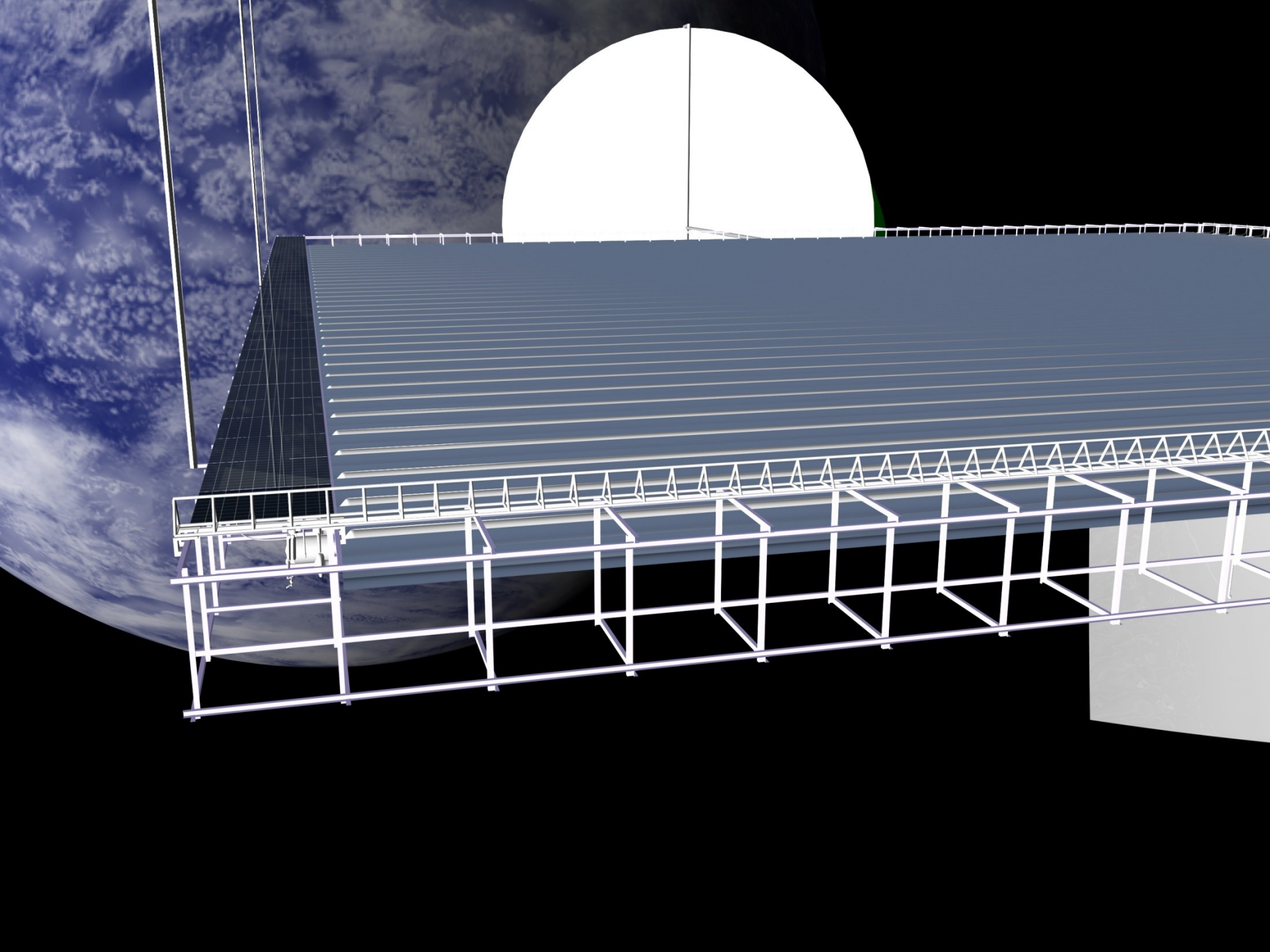


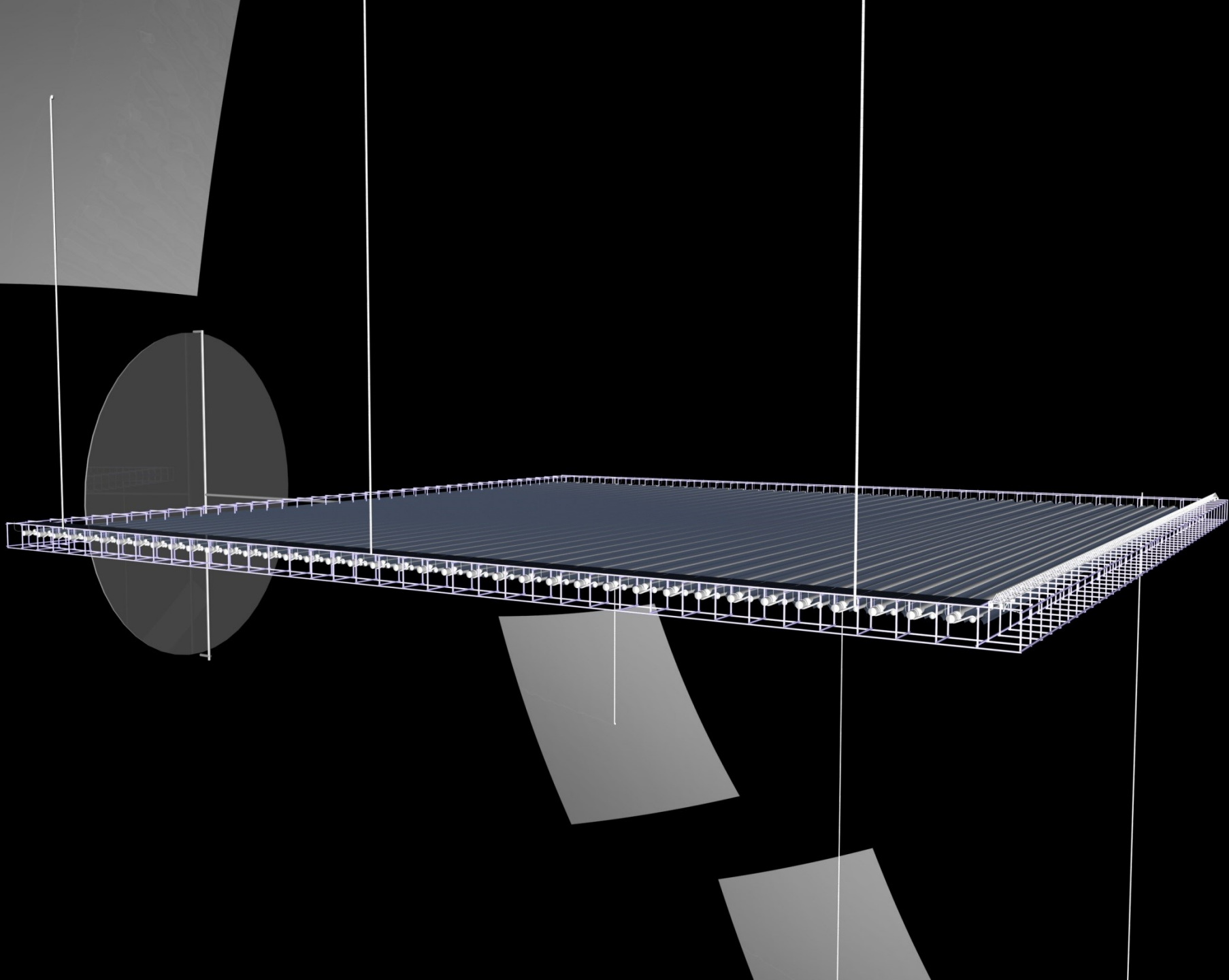
Artwork for pretty

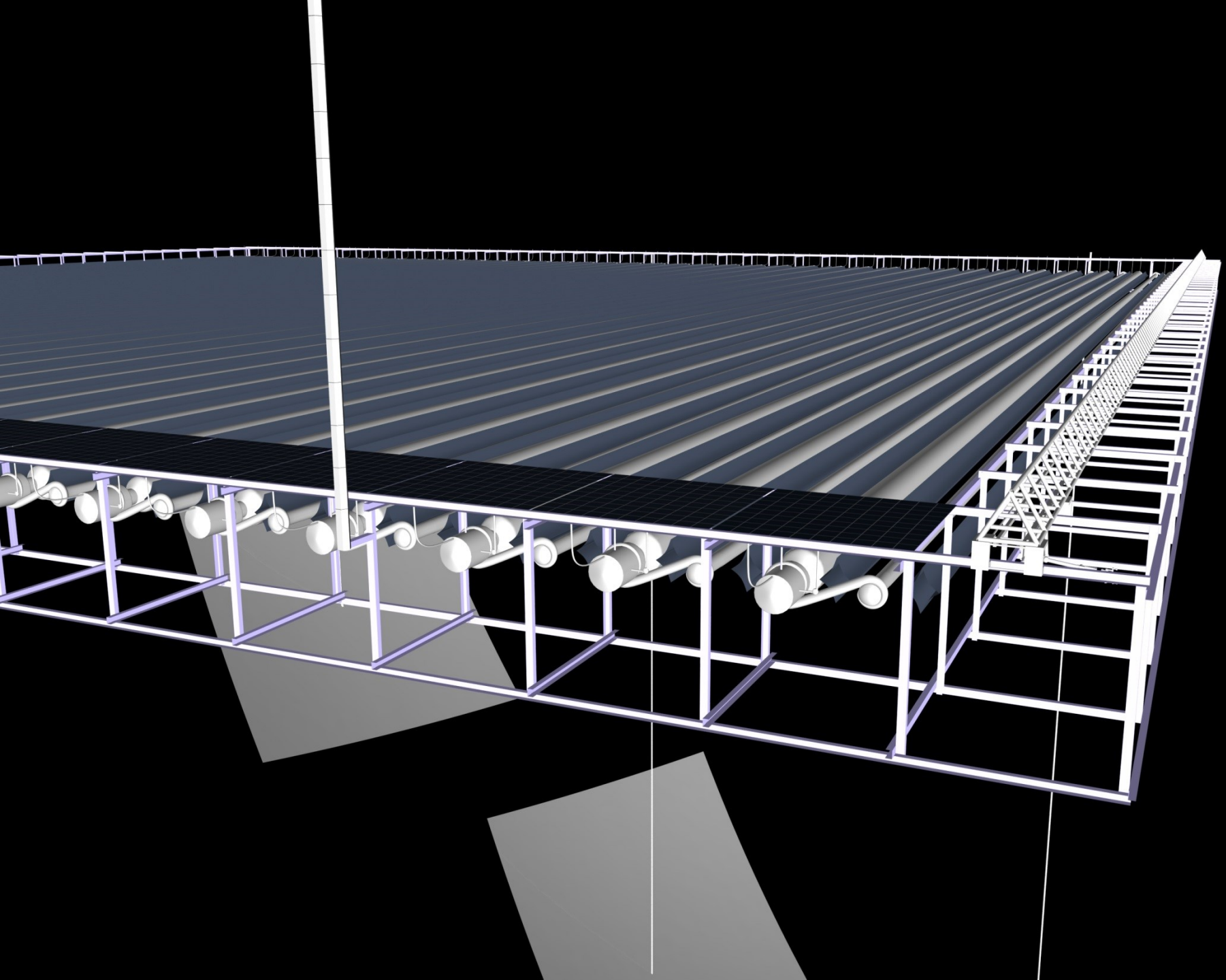


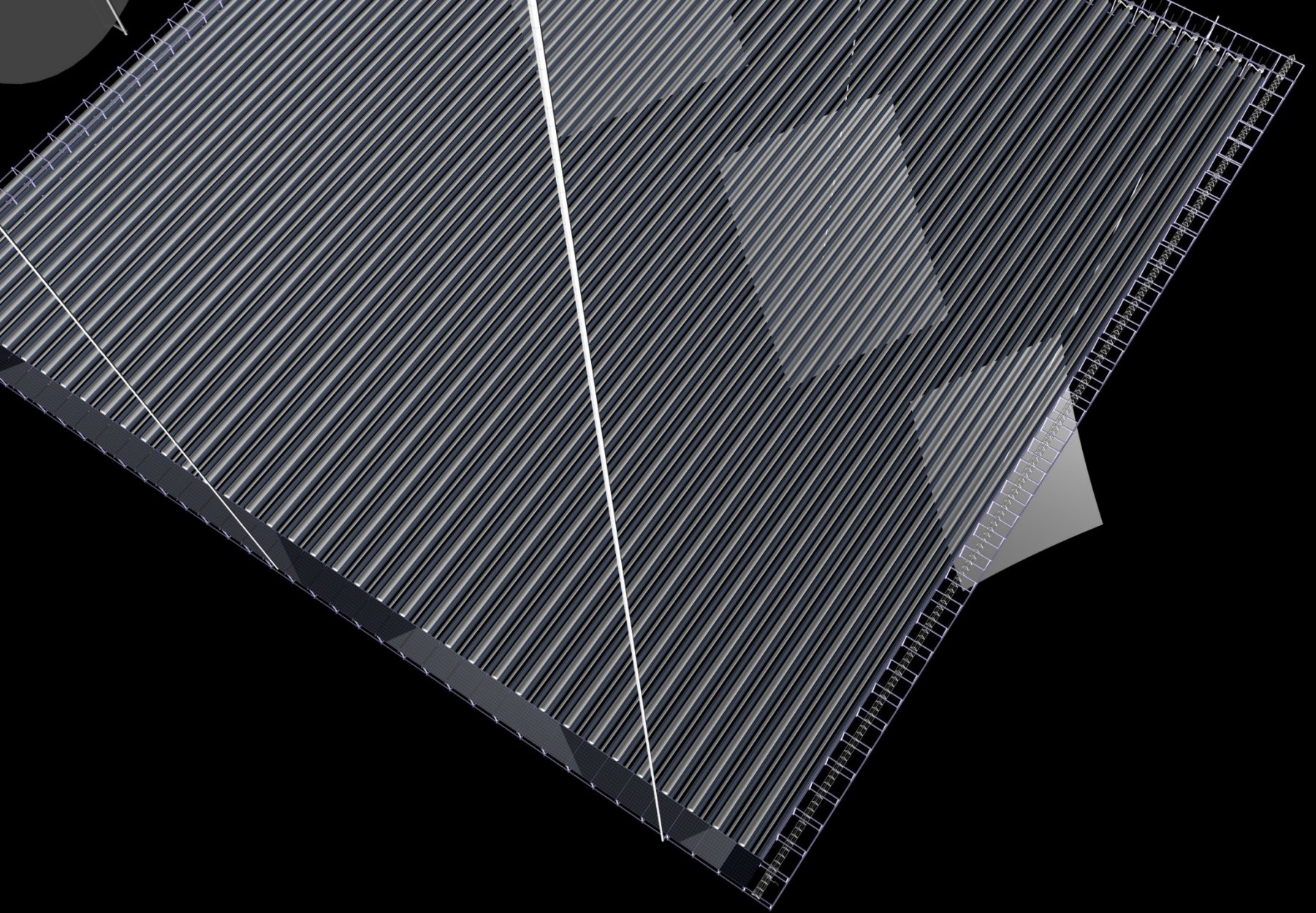


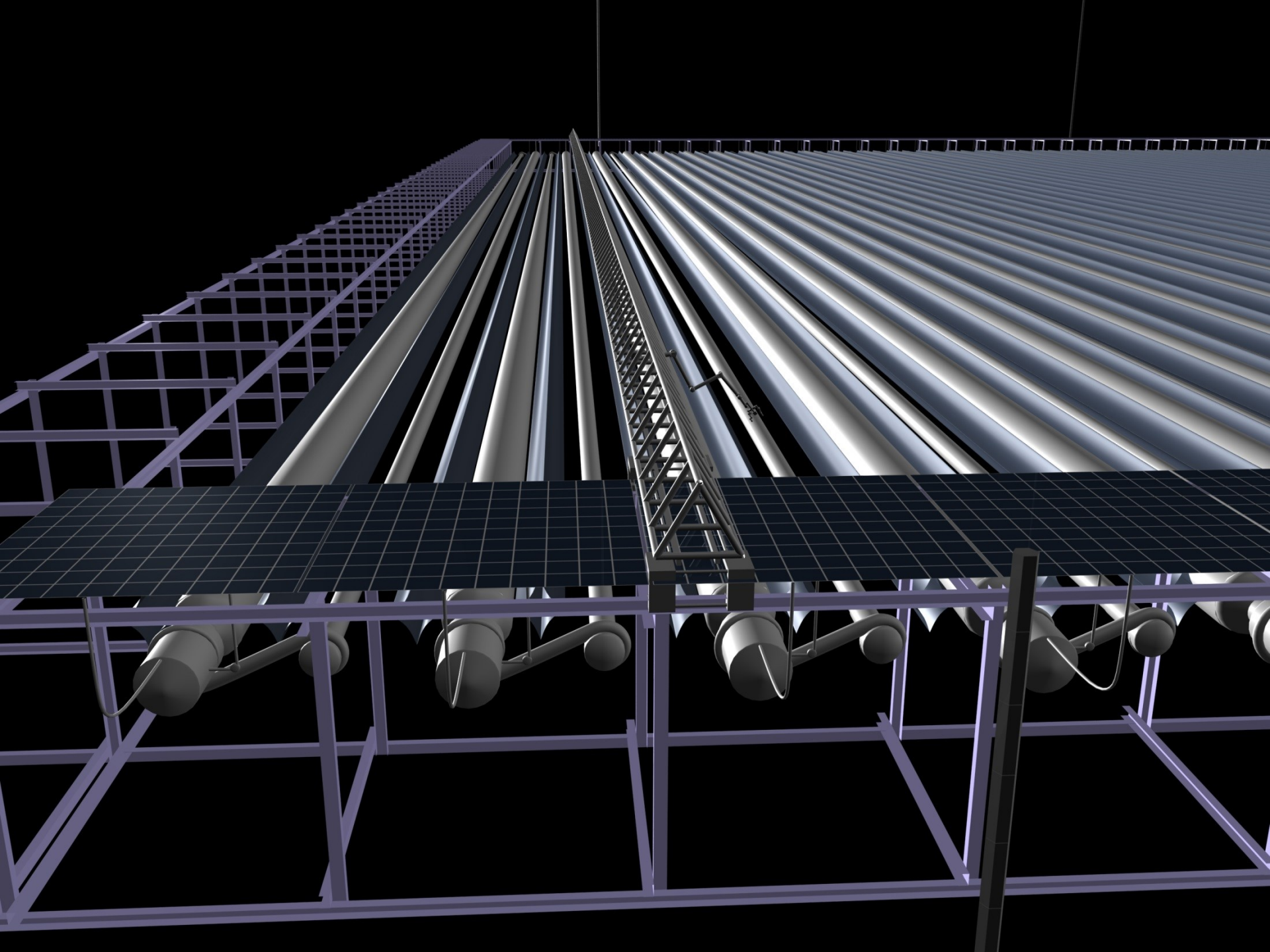


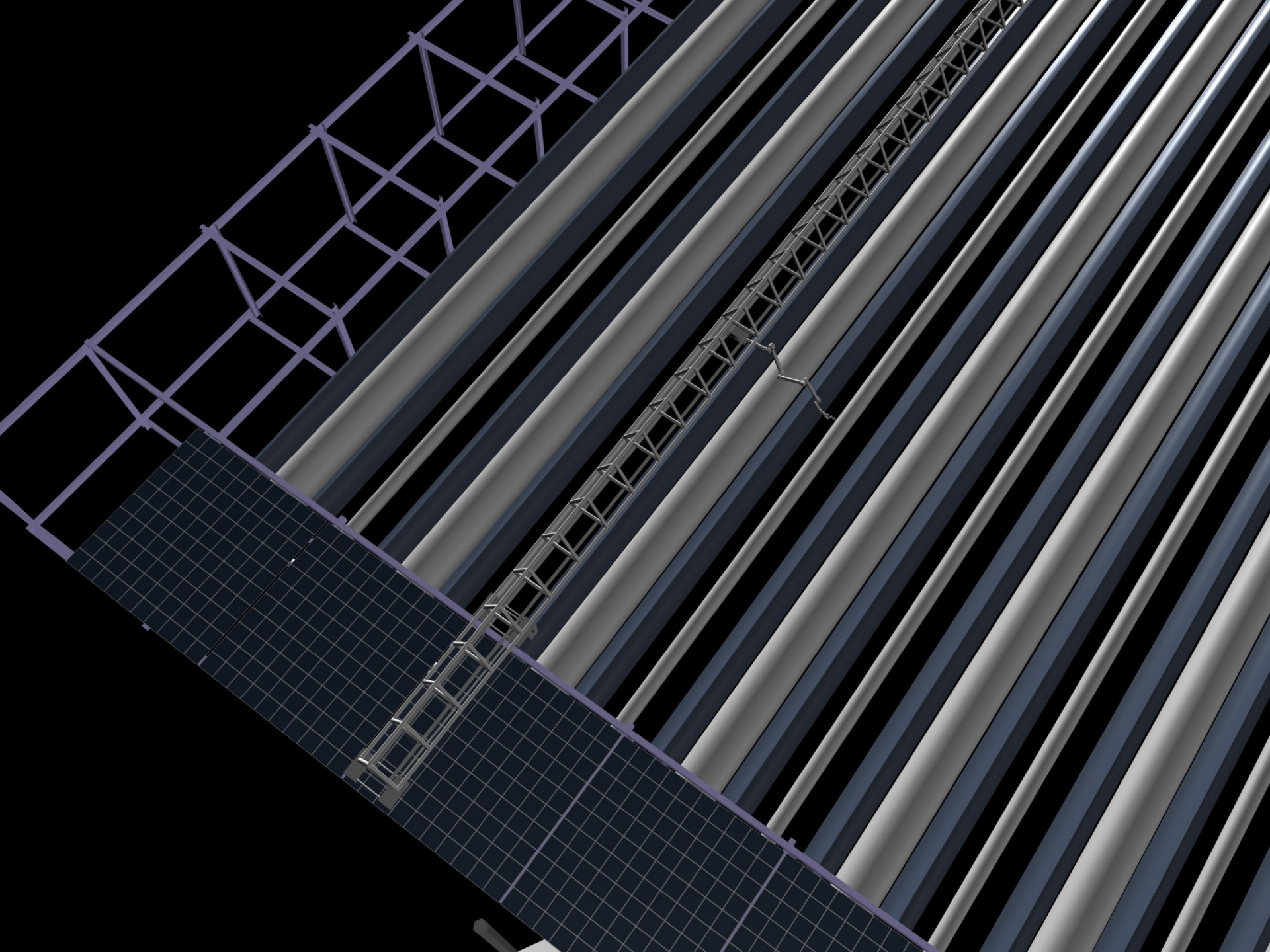


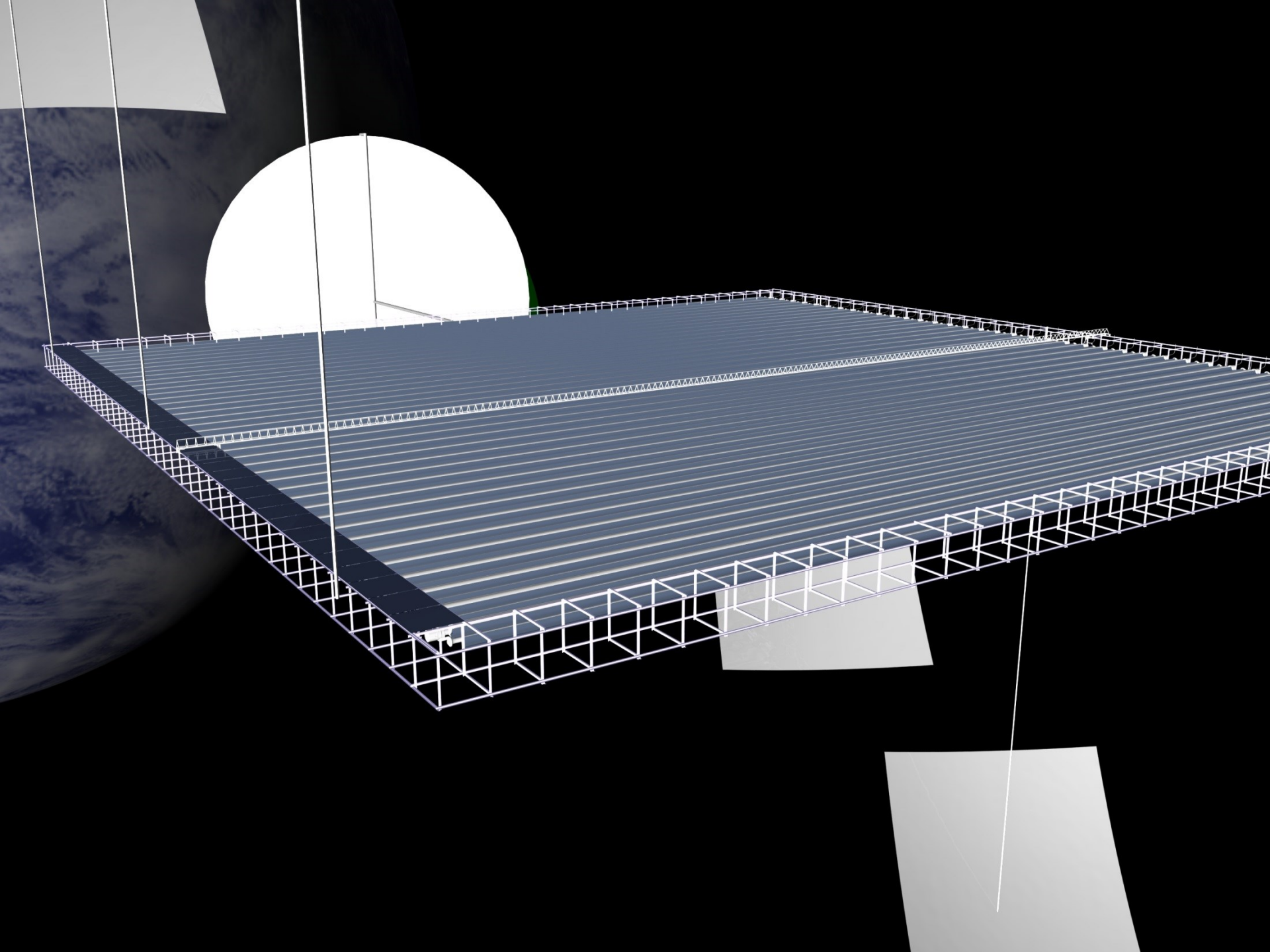












Designs for these propulsion power satellites use concentrated PV and large radiators to get rid of the waste heat from the 40% efficient cells. Where clouds are rare, (like in space) CPV works better than regular PV

Green Energy and Technology

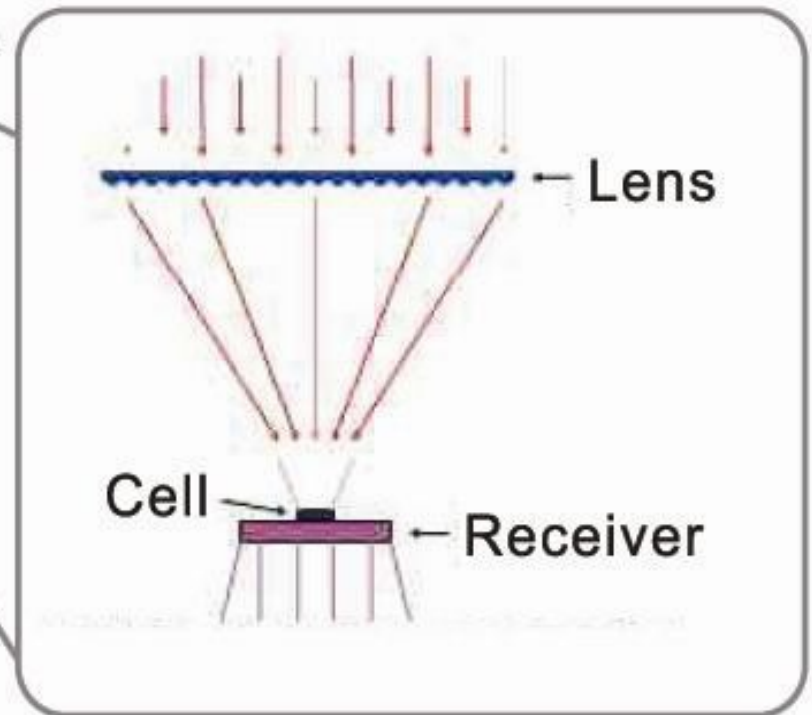
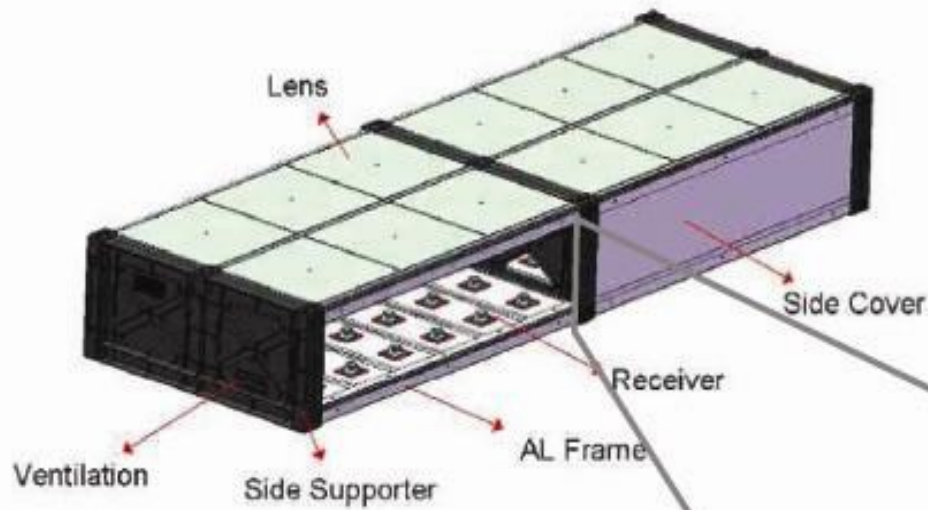
Pedro Pérez-Higueras
Eduardo F. Fernández *Editors*

High Concentrator Photovoltaics

Fundamentals, Engineering and Power
Plants

 Springer

The composition of HCPV



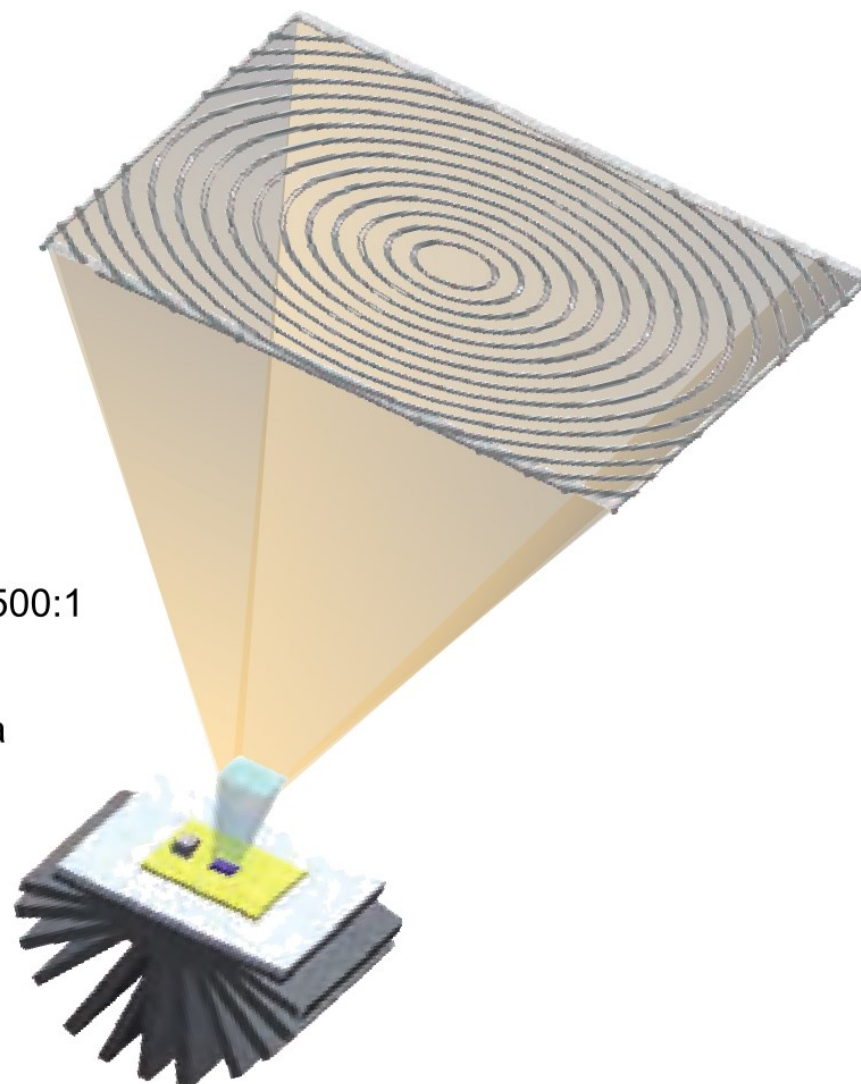
Lente fresnel

Concentrazione 500:1

Ottica secondaria

Cella

Dissipatore
di calore





END

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<http://htyp.org/dtc>