Solar constant: $S_\odot \approx 1361\ \mathrm{W/m^2}$
(incoming solar *energy per surface area* at Earth's mean distance to the sun and outside the atmosphere.)

presumed solar panel efficiency: $\eta \approx 0.25$ (higher than most panels used)

chosen consumed = incoming power: $P_{\mathrm{cpu}} = 1\ \mathrm{TW}$ (Elon Musk thinks he can realise this)

required solar panel surface area: $A_\odot = \frac{P_{\mathrm{cpu}}}{\eta S_\odot} \approx \mathbf{54 \times 54\ km^2}$

The computer centre should get rid of all *heat* produced by utilising the electric power. You may have learned *heat transport* can be done in three ways: *conduction*, *convection*, and *radiation*. However, *convection* is not true *heat* transport, but only relocation of *mass containing* the *heat*. **Assuming** lossless internal *conduction*, the *heat capacity* of a surrounding medium determines how much *heat* it can accept, or better said, how much *power = heat per time span*. In general, the *denser* this medium is, the more it can accept. A liquid cools WAY more efficiently than a gas. Transporting this medium (for example by using a fan which creates something similar to *convection*) then truly carries the *heat* away. The greatest efficacy is achieved using a flowing cooling liquid, medium efficacy with a flowing gas, and *radiation* is the very *least efficient* way of getting rid of superfluous *heat*. **Empty space** contains **nothing** (material) at all. Therefore, it can neither *conduct* nor *convect* any *heat*, leaving only very ***in***efficient *radiation*. Isn't it the quintessence of a thermos that the actual isolation "consists" of vacuum?

There exists the Stafen-Boltzmann law which tells how much thermal *energy*

is radiated per surface area: $S_* = \sigma_{\mathrm{SB}} T^4$

Stafen-Boltzmann constant: $\sigma_{\mathrm{SB}} \approx 5.67 \times 10^{-8}\ \mathrm{W/m^2/K^4}$

radiated power: $P_* = A_* S_*$

equating both powers: $P_* = P_{\mathrm{cpu}}$

renders: $A_* = \frac{P_{\mathrm{cpu}}}{S_*} = \frac{P_{\mathrm{cpu}}}{\sigma_{\mathrm{SB}} T_{\mathrm{cpu}}^4}$

presumed operating temperature: $T_{\mathrm{cpu}} \approx 85°\mathrm{C} \approx 358\ \mathrm{K}$ (to be considered a maximum!)

required radiating surface area: $A_* \approx \frac{P_{\mathrm{cpu}}}{931\ \mathrm{W/m^2}} \approx \mathbf{33 \times 33\ km^2}$

In practice, internal *heat conduction* & *convection* within a dense medium (certainly stony stuff, be it melted or not) is quite low. Internal *heat* can hardly reach the outer surface, the only place where it can be radiated. If the thing is more or less spherical, it has the smallest possible *surface area* for the given *volume*, further reducing *radiation*. Earth's core still is around 6000 kelvins, isn't it? Yes, it isn't[1], is it?

Do you realise the above derivation is incomplete? If we consider the solar panel a so-called *black body*[2], it fully absorbs ***all*** incoming radiation and converts only η to electrickery.

This grand total: $P_{\mathrm{in}} = A_\odot S_\odot$
must be radiated away, yielding
an equilibrium temperature of: $T_{\mathrm{eq}} = \sqrt[4]{S_\odot / \sigma_{\mathrm{SB}}} \approx 393.6\ \mathrm{K} \approx 120.5°\mathrm{C}$
which is way above said *maximum operating temperature*,
hence the thing should radiate all incoming power at T_{cpu}.

Therefore, we require: $P_{\mathrm{out}} = P_{\mathrm{in}}$

i.e.: $A_{\mathrm{out}} \sigma_{\mathrm{SB}} T_{\mathrm{cpu}}^4 = A_\odot S_\odot$

hence: $\frac{A_{\mathrm{out}}}{A_\odot} = \frac{S_\odot}{\sigma_{\mathrm{SB}} T_{\mathrm{cpu}}^4} \approx 1.46$

The radiating surface area must be roughly one and a half times that of the solar panel area!

[1] See https://henk-reints.nl/HR-Earth-core-temperature.pdf
[2] A *black body* has 0% *reflectivity* and 0% *transparency*, hence 100% *absorbance*, but it *is* able to *emit* radiation! Most solar panels have a *reflectivity* of well below 10%.

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For the chosen consumed power above, we obtain: $\boldsymbol{A_{\text{out}} = \frac{S_\odot}{\sigma_{\text{SB}} T_{\text{cpu}}^4} A_\odot = \frac{P_{\text{cpu}}}{\eta \sigma_{\text{SB}} T_{\text{cpu}}^4} \approx 66 \times 66\ \text{km}^2}$

Cf. said solar panel area: $\boldsymbol{A_\odot \approx 54 \times 54\ \text{km}^2}$

Solar panels have a surface density of roughly 11 to 15 kg/m^2, but let's calculate with a light-weight space version having 10 kg/m^2.

The *total mass* of only the panel/radiator thing to be launched into space would be: $\boldsymbol{M} = A_{\text{out}} \times 10\text{kg/m}^2 \approx 43 \times 10^9$ kg $= \mathbf{43\ million\ metric\ tonnes}$.

The Falcon Heavy can lift roughly 64 tonnes, SpaceX Starship is designed for a payload of 100 to 150 tonnes. Let's calculate with the latter.

Said solar panel thing would need **287 000** (two hundred eighty seven thousand) **150 tonne SpaceX Starship launches**. This vehicle needs 5250 tonnes of propellant per launch, i.e. a total of **1.5 billion tonnes of propellant** are required to bring the panels & radiator contraption into space. The same mass of water has a *size* (*volume*) of roughly (11.5 km ≈ 7.1 mi) cubed.

All of the above is only about the solar panels, i.e. excluding the actual computer centre. A single modern AI-focused GPU rack consumes roughly 100 kW and it has a mass of roughly 1500 kg $=$ 1.5 tonnes. For the chosen total power of: $P_{\text{cpu}} = 1$ TW we require $10^7 =$ ten million racks, hence the total mass would be 15 million tonnes. Hence, the panel/radiator contraption wins this little game, but the ***total mass*** to be brought into space becomes **58 million tonnes** and probably, this still is incomplete, don't you think? It raises the aforementioned propellant requirement by a factor of $58/43 \approx 1.35$, hence adding 35%.

The *temperature* of outer space is practically always misunderstood and wrongly explained. Restricting ourselves to gaseous media, *temperature* essentially is the *mean kinetic energy* of the frequently colliding molecules contained in this gas or plasma.

It's a **BIG MISTAKE** is to convert ***all*** *kinetic energy* to a *temperature* via: $\overline{E_{\text{k}}} = \frac{3}{2} k_{\text{B}} T$.

I distinguish between two types of *kinetic energy*: *ballistic* and *stochastic*.

With *stochastic kinetic energy* I mean the motion of molecules with respect to each other, or better said with respect to the barycentre of the finite amount of molecules that are continually colliding and exchanging *energy*. It is about *internal* motion *within* the macroscopic body only and not about the motion of this body as perceived from its outside. The latter is the motion ***of*** the barycentre. *Stochastic kinetic energy* or *temperature* is molecular motion ***w.r.t.*** the barycentre. The thinner a gas, the less senseful the notion of *temperature* gets, since there hardly are any molecular collisions. *Temperature* gradually becomes a *totally meaningless* concept.

Ballistic kinetic energy has *nothing* to do with *temperature*, it merely concerns a body's motion. Since cosmic particles usually move very fast, they've got a load of *ballistic kinetic energy*. Would we **incorrectly!** convert that to a *temperature*, we'd arrive at over a million kelvins. **HOT, pfffffew.** However, these hardly ever colliding particles cannot be considered molecules of a gas, so it merely is some *senselessly* calculated *senseless* value found by *senseless* people *senselessly* doing something *senseless*. Might they be astrophysicists? It has no physical meaning whatsoever! This very same brave achievement also applies to the solar corona, actually being merely 6.5 kelvin.[3] It hardly has any mass to absorb solar *irradiation*. Would *YOU* however go there, urh, good luck!

Empty space does not *have* a *temperature* at all. But *bodies in* empty space undergo *irradiation* which — far away from nearby radiators — mainly consists of the *CMB*, the *Cosmic Background Radiation*. Hence, these bodies will ultimately arrive at the *CMB temperature* of just over 2.7 kelvins. Therefore, we can say space is truly **COLD, brrrrrrr**. However, it hardly cools neither some body nor any body. It essentially cools no body at all and this applies to every body.

[3] See also: https://henk-reints.nl/astro/HR-solar-corona.pdf.

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