Will nuclear fusion ever work on earth? A few simple clues as why it never will.

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Introduction. For years and years, yes even decades every now and then we are told that nuclear fusion would be an unlimited source of energy just like on the sun.

But also for years and years progress is very limited, in this small article we will make some extremely simple calculations and estimations explaining why it will be extremely hard to make a reliable nuclear fusion power station.

First problem: the longevity of the sun.
The earth is now between 4 and 5 billion years of age and let's assume for simplicity that our sun has a lifespan of more or less precise 10 billion years before she runs out of fuel.

Turned the other way around, if we look at 1 kilo of sun mass (plasma, protons mixed with electrons), on average in one year of time only a small fraction $1/10^{10}$ will be burned in the process of nuclear fusion.
That is a tiny amount of mass: 10^{-10} kg per kg plasma.
How much energy is that? Using the famous Einstein equation $E = mc^2$ with c is the speed of light or $c = 300,000$ km/sec $= 3 \cdot 10^8$ m/sec we get

$$E = mc^2 = 10^{-10} \cdot 9 \cdot 10^{16} = 9 \text{ million Joule}$$

(Remark that in practice we also have leftover mass from the Helium that is formed. Therefore using the Einstein equation suggests one 100% efficiency...)
So on average, one kilo of solar plasma generates 9

million Joules a year. How much water can you boil with that if the initial water temperature is 0° Celsius?
Heating one kg of water one degree takes about 4200 Joules, so we can boil about

$$\frac{9,000,000}{420,000} \approx 21 \text{ kg water}$$

This is a disastrous result: with one kilo of plasma, in a year time you can only boil 21 kilo of water if your efficiency is about 100%.

Of course the sun has the most nuclear fusion in it's center so under the conditions in the center of the sun it will be a little bit better... (But there will be leftover mass also.)

The sun burns on the tunneling effect.

Most people think that the sun simply burns because it is so hot and the pressure is so high. This is wrong, the sun burns on the quantum tunneling effect:
Over a year time our kilo of sun plasma has a tremendous amount of collisions between the particles, only a very tiny fraction of those collisions result in the formation of a Helium nucleus.
This extremely tiny fraction is explained by the quantum tunneling effect and in turn this tunneling effect is the reason our sun burns so smoothly.
Ok there are so called 'solar storms' but all in all the sun burns extremely smooth.

So if we on earth think that we can make nuclear fusion, we need to pump up the pressure and temperature far beyond the kernel of our sun.
From the science of cosmology we know that extremely large stars burn in just a couple of millions of years, so we would need stuff (pressure and temperature) like that.
That would jack up the energy production with a factor of about one thousand, so with one kilo of our superheated overpressured plasma we can now boil 21 thousand kilo of water.
That would amount to about 60 kilo (or liter) a day, but the average person needs more especially in the winter

when you need to heat your house...
So if we have a city of lets say 5 million people and for every person we need a few kilo of plasma, we are talking about thousands and thousands ton's of plasma.

Question: Do you want to live next to such an amount of extremely high pressured plasma?
One tiny accident and the entire city is exploded away...

The sun is a giant reservoir of heat.

Our earth produces a lot of heat inside it's iron kernel via all kind of radioactive processes, but we know it is more or less stable: the temperature does not increase or decrease.
That means every year, or day, the amount of heat that leaks out at the surface equals the amount of produced heat.
Yet there is a giant reservoir of heat in the form of molten rock under our feet.

For the sun goes the same: the amount of heat and light radiated equals the amount of energy produced per unit of time, but the sun itself is just a giant reservoir of trapped heat.