

# Dispelling the myths about fusion power 2980

[Engineering](#)



**ASSIGN  
BUSTER**

Over the past four or five decades, and especially in recent years, there has been a lot of talk among the scientific community and in everyday life about the development of nuclear fusion as an energy source. It seems that the everyday person has some sort of fairy tale image of fusion power in the back of their head. When they hear about dwindling unrenewable resources such as coal, oil, and natural gas, they just sort of file it away with the hope that fusion power will come flying down with a big F on its chest just in time to save the world when the problem worsens. This misconception couldn't be further from the truth. Fusion power will have and is having just as many if not more problems than every existing energy resource.

First of all, this notion of fusion as an "energy Superman" is incorrect. The basic problem with fusion is not that the technology isn't possible, it's that it just isn't economical. We could have fusion power plants right now but they would cost us an arm and a leg and wouldn't even be competitive with other energy resources. Perhaps in thirty to a hundred years from now, fusion will become as inexpensive as other existing resources, and then its efficiency will begin to skyrocket, but it will not be an instant saviour and we should not think of it that way.

The second common misconception about fusion power is that it is a completely safe method of generating energy. While it is true that with proper reactor construction and safety procedures in place, there is no reasonable way of a meltdown occurring, we need only look at the problems with our own CANDU fission reactors, which are also supposedly safe. As we saw in class on a video, many safety regulations are now being violated. Also, radioactive tritium will be a major source of fuel for the reactors and is

<https://assignbuster.com/dispelling-the-myths-about-fusion-power-2980/>

just as dangerous biologically as fission products. And there are other hazards predicted that will be discussed later and likely there will be some unexpected ones too. Fusion's danger must be taken seriously for it to be guarded against.

The final great confusion regarding fusion is its cost. Just as was predicted with fission power, people are saying fusion will cost just pennies. Although fusion's main fuel element, deuterium is found in ordinary water and is virtually free, the other costs of fusion are really what's keeping it off the market. The building of reactors, heating of plasma, and other initial start-up costs stand as the major roadblock in fusion's progress right now more than anything else.

To understand what works about fusion and what does not, you should first understand what should work in theory. The basic idea of nuclear fusion is just as it sounds; it is the fusion of two nuclei to form a third nucleus, sometimes emitting a neutron. The amount of energy produced by fusion is unfathomable; in fact it produces over a million times as much energy as the strongest exothermic chemical reaction known to man. The most important elements for fusion will be the three isotopes of hydrogen: H-1, or the proton, D-2, the deuteron, which has one more neutron, and T-3, the triton, which has two neutrons. Two forces act on the nuclei in a nuclear reaction: the strong electric Coulomb repulsive forces, which when broken give way to the weaker attractive nuclear forces. To overcome the Coulomb forces, the isotopes need great speed, which can of course be attained by increasing the temperature of the plasma (hot mixture of positive nuclei and negative electrons). This is called a thermonuclear reaction, obviously due to the fact <https://assignbuster.com/dispelling-the-myths-about-fusion-power-2980/>

it requires a lot of heat and it is a nuclear reaction. Thermonuclear reactions depend on nuclei involved, pressure and temperature of the plasma. For a contrast of thermonuclear reactions, consider a star, nature's fusion reactor. It takes a star millions of years to undergo in a controlled fashion what a Hydrogen bomb can do uncontrollably in less than one millionth of a second. The reason is the bomb is under great pressure and is heated by a fission reaction inside it, which as you probably already know, produces a lot of energy in itself. The problem facing scientists is how to control this reaction to make it useful.

Back to how fusion creates so much energy. Here are the two major fusion reactions:

$D-2 + D-2 \rightarrow T-3 + H-1 + 4.83 \text{ MeV of energy}$

$D-2 + D-2 \rightarrow He-3 + n-1 + 3.27 \text{ MeV of energy}$

Just as in a fission reaction, the energy is produced from the small loss of mass ( $E=mc^2$ ). The difference from a chemical reaction is that new nuclei are actually produced.

Earlier, it was mentioned that "fusion fuel is free". Deuterium, the main fusion fuel source, is found in heavy water (D<sub>2</sub>O). 1 mol per 6500 of water is heavy, yet if all the deuterium in one litre of water underwent a fusion reaction, it could boil seven thousand litres of water! This gives the evidence that if one day fusion reactions can be economical and controlled, the Earth's energy problems would be solved due to our nearly infinite supply of water.

Back to the temperature required for an effective fusion reaction... one hundred million degrees Kelvin, and that's only for a perfect theoretical reaction. Even greater temperatures will be required for practical application of fusion reactions. The major problem caused by these enormous temperatures is containment. At that temperature, the plasma would dissolve any material vessel it came into contact with in less than a second. Electric fields cannot be used because they attract one sort of charge and repel another, so only one kind of charge could be used, which is of course impossible. Gravitational fields also separate positive and negative and they're unstable. The agreed-upon method is through magnetic fields which can have alternating electric fields around them. These fields exert energy and pressure on plasma to confine it.

The first significant date in fusion history would have to be 1932. H. C. Urey discovered deuterium, which as aforementioned is quite important to fusion! The first attempts at producing fusion in the laboratory were performed in 1934 by E. Rutherford and W. H. Bennett, who attempted the now famous (in the world of nuclear physics at least) linear pinch experiment. Further advancements were impeded by military secrecy as countries tried to determine the destructive applications of nuclear technology. In 1942, two scientists named Fermi and Teller were trying to dismiss the possibility of fusion being a useful source of energy but actually disproved themselves through their experiment. However, in the 1950's, many problems were identified and in the 1970's, plans for designing plants were abandoned until more could be learned about the concepts, especially regarding plasma. In the 1980's, old principles were re- applied in concert with newly understood

ones. The general reactor plan that has been developed was initiated by the U. S. S. R. but now is applied by many countries. These tokamaks, or toroid chamber magnet coil reactors, will be discussed a bit later. A major source of theory behind these reactors has been a book by Bateman which was entirely about plasma stability, a major stumbling block to researchers in the 70's. He provided some general guidelines to produce stable plasma.

As for the theory behind the actual reactors, here are some general guidelines. First of all, large size is desirable because energy will increase proportionally to the volume cubed, while cost will only increase to the volume squared. Obviously, big reactors will provide power at a cheaper per unit price. However, the reactors cannot become too big or the strength of the containing walls will be compromised. It was mentioned that the temperatures must be higher than one hundred million Kelvin. This is so such things as heat loss through bremsstrahlung, or braking radiation, caused by impurities in the plasma, must be overcome. However, the temperature must not go so high as to cause the reaction rate to drop, as we learned about the production of urea. In fact, tritium can decay under high temperatures. Also, the containment times for each reactor will have to be calculated perfectly based on densities, temperatures, etc. The maximum reaction rate and heat have to be obtained so as to limit the energy put in to heat the plasma further. And the containment field has to be enormous to generate enough pressure to contain the plasma. Tritium is another concern to reactor efficiency. It is not nearly as abundant in nature as deuterium, so it will have to be bred in reactors using a lithium reaction with deuterium. The basic principle is that a bit over five percent of the fuel should burn while between

one and two times as much tritium needs to be bred per part of deuterium. Without breeding, tritium will cost over one million dollars a day, obviously rendering the plant's efficiency null. Here are the two major breeding reactions:

$$n-1 + \text{Li-6} \rightarrow \text{He-4} + \text{T-3} + 4.785 \text{ MeV of energy}$$
$$n-1 + \text{Li-7} \rightarrow 2.5 \text{ MeV of energy} + \text{He-4} + \text{T-3} + n-1$$

Now back to tokamaks, which are basically the modern-day practical application of the principles we have discussed so far. First of all, it has been discovered that even if all of the technological problems of fusion reactors are solved, the cost will still be over two thirds of the cost of today's fast fission reactors. This will not be extremely useful. Solar power may actually be more efficient due to the fact that the sun gives more energy in a day than the entire Earth uses in a year. Fusion may become more economical in about a century when our resources are depleted, but we seem to be stubborn about having it before then. Another problem is that since we have never actually had a fully functional fusion reactor in use as a power source, we cannot predict all of the problems one will cause or have. It is an accepted fact that many experiments of all kinds have resulted differently than hypothesized. In fact, Fermi and Teller's research is a perfect example of this. One problem that could be foreseen is that of tritium's toxicity. Security measures will be needed, and they must be enforced. See Appendix A for more on tokamaks.

Some new technologies to apply to fusion reactors have been developed in recent years. First of all is secondary containment systems. The gravitational  
<https://assignbuster.com/dispelling-the-myths-about-fusion-power-2980/>

field can not be trusted on its own so a strong " first wall" is necessary. These walls must have a vacuum system to flush away impurities from the plasma and be chemically cleaned and baked at 450 degrees Celsius, so as not to contaminate the plasma, reducing its efficiency. These walls will preferably be made of metal, i. e. stainless steel, although ceramic and glass models have been used in test runs.

Another secondary containment system which may or may not be necessary, is the divertor. A divertor is a device which produces a separatrix which carries escaping plasma to a " burial chamber" to avoid contamination. Appendix B shows some basic divertor designs.

The other major technological development in recent years has been the form of heating proposed. Up until very recently, the proposed method of heating has been " neutral-beam heating". Basically, what it is is the injection of energetic neutral hydrogen isotopes, which become trapped in the confinement area, ionize, and collide with plasma. This is a somewhat impractical method due to the high energy required to do it. The new method being discussed is that of " frozen pellet injection". Which will do basically the same thing except the fuel will be injected by..... frozen pellets!

There are six major areas of danger for fusion power:

1. Tritium - it can get into the cooling water which could wreak havoc on the environment, as mentioned before, many barriers will be necessary to prevent this.



2. Radioactive structure - not really a big concern as meltdown is nearly impossible
3. Magnets - they will come in to contact with so much energy they could be destroyed, and cause the first wall to be destroyed
4. Hydrogen - obviously if this flammable element catches fire, bad things will happen, leaks need to be identified immediately
5. Nature - any power plant is susceptible to acts of God
6. Weapons - not a big concern as fusion reactors are a very inefficient way to produce weapons

All in all, fusion actually is a fairly safe power source, in fact biologically, it is considered between ten and a hundred times less hazardous than fission.

" Efficient energy conversion should ultimately be possible". Eventually the problems stopping fusion will be overcome, or else it will become our best source of energy by default. Although it will be a hard journey, fusion will eventually become the best source of energy we can afford!