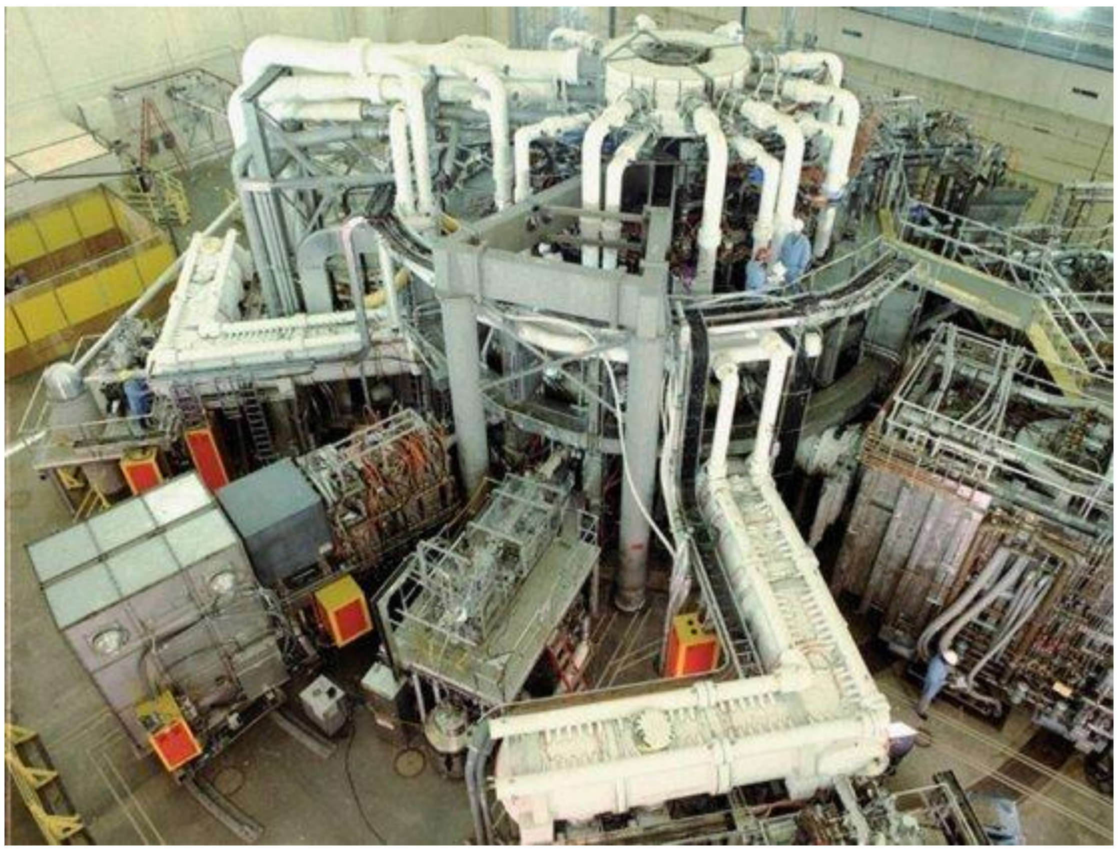
NUCLEAR FUSION
Six Blocking Factors



TFTR at PPPL 1982–1997

Six strikes against nuclear fusion power

New Ice Age Ahead

The Above photo is of the TFTR, one of America early milestones in fusion power experiments, and one of the early examples of the giant machines. It produced the 1994 world-record 10.7 megawatts of fusion power and achieved plasma temperature of 510 million degrees centigrade. To date 60 nuclear fusion experiments are operating and planned worldwide to date (see list). None have no far achieved energy break even or solved any of the numerous underlying problems for which no solutions are yet in sight. The following is a list of the problems.

The First strike against practical fusion power

... is that it takes more energy to make the fusion happen than it gives back. The current front-line experiments run at a 10-fold energy loss (or less, depending on what is measured). At the very minimum of a two-fold energy gain is required to break even, given the inefficiencies involved in thermal to electric energy conversion. Anything greater would be a gain. The colossal ITER project promises a 10-fold gain with a 500 megawatt output (50 megawatt input), for a gain of 200 megawatt of usable excess energy.

No experiment to date, or planned fir the near future, actually aims at producing electric energy, as sustainable energy output has not been achieved. The current world record for sustained fusion is half a second. ITER hopes to expand this to 1000 seconds, if the operational problems can all be resolved.

Exotic options are pursued to increase the efficiency and burn-duration. The current experience has been that any breakout from the barrier against energy gain requires the scale of the equipment and the control efforts to be increasing almost exponentially. Thus, even as the operational issues might thereby be resolved, the increasing scale of the equipment promises to make the process increasingly impractical.

The international ITER machine will be a technological miracle that will stand 120 feet tall when completed in 2020. It is hoped that it will offer a platform for producing 200 megawatt of usable output (in principle). It would produce this at the ITER at a cost of app. $30 billion (primarily due to the cost of construction and materials). On this platform any actual power production would be so enormously expensive that windmills and solar panels, which are the most expensive energy producers in the world today, would appear cheap in comparison, by a wide margin.

For example, in May 2010, Sempra Energy announced it would build a windmill-energy farm in Baja California, with a capacity of at least 1,000 MW, at a cost of $5.5 billion. Global wind-power has generated in 2009 globally 340 Twh (per year) or 39 GW equivalent, achieved with an installed capacity of 175 GW (22% utilization), amounting to 2% of the world's electricity generated. This is roughly 1/10th of the worldwide nuclear power output. Considering the average 22% utilization, the capital cost for wind power averages $25 billion per GW (5 to 16 times the cost of conventional power).

As of Jan 19, 2011 442 nuclear power plant units were in operation in 30 countries with an installed electric net capacity of about 375 GW. In addition 65 plants with an installed capacity of 63 GW are under construction in 16 countries. (see European Nuclear Society)

The world solar power production is small as an energy source. A mere 4.8 Twh were produced in 2009, with the typical construction the cost per watt raining between $7 to $9. On this basis a solar farm of 1,000 MW costs between $7 billion to $9 billion to build. Assuming a 50% utilization the actual cost is double.

The construction cost for conventional power, including nuclear plants, ranges between $1,500 to $5,000 per kilowatt or $1.5 to $5 billion per 1,000 MW (the least costly option). (See Comparison table)

In comparing these options, 2-5 for conventional and nuclear, 25 for wind-power, 20 for solar-power, and 150 for fusion-power (in billions of dollars) with the fusion-power plant based on the ITER model (if its fusion-power by some miracle should became operationally practical). On the ITER basis a 1,000 MW plant would cost $150 billion, which puts it way out of the range of ever becoming a practical option even when construction and design are optimized..

The second strike against practical nuclear-fusion power

... is that its energy output, the produced neutron flux carries a 100-times greater wallop than what is experienced in normal fission nuclear reactors. Its energy is so intense (14 MeV) that it destroys the metals of the reactor that produces the reaction. It dislodges the atoms in a metal's lattice structure, and also makes the reactors intensely radioactive. The second fusion product, helium, carries an energy 'punch' of 3.5 MeV that impacts with the reactor walls. It is uncertain whether materials exist or can be created that can withstand the enormous neutron stress that is 100-times greater than what is encountered in normal nuclear reactors, and that in addition are able to carry the immense thermal load that the continuous operation of a high-power commercial reactor would impose. The current would record of a half-second fusion burn with 10 megawatt output by JET, which already causes major problems, is miles away in comparison, from a 4 gigawatt reactor operating continuously.

The third strike against practical nuclear- fusion power

... is that the isotopes of heavy hydrogen (the charged batteries) are rare. Deuterium, though plentiful in the oceans, comes is such a minuscule concentration that tens of millions of tons of water needs to be processed for the extraction of deuterium for a single ton of fusion fuel. The density of deuterium in the hydrogen portion of seawater is 1 in 3,200 of the water molecules, of which 5.5% is deuterium. This means it would take 58,000 tons of water to produce 1 ton of deuterium at 100% efficiency. In practice only one out 6 of the deuterium containing molecules are actually 'captured.' The Bruce Heavy Water Plant in Ontario, Canada, is the world's largest producer of D2O (see: Heavy Water and Production) had required 340,000 tons of feed water per ton of heavy water which contains 20% deuterium, or 1.7 million tons of water to extract one ton of deuterium. This small ratio doesn't pose a problem for the bomb makers, or to provide enough for the fusion experiments, since practicality is not a factor in these cases. But for practical applications the fuel factor becomes a large one, even while the production efficiency will no doubt improve. It may some day be possible to produce the deuterium portion for one ton of fusion fuel with the processing of half a million tons of water.

It was the enormous cost of producing the heavy water that caused the construction of heavy water moderated nuclear-fission power plants to be abandoned in favor of the light-water moderated plants, even though the light-water plants require a 5-times enriched uranium fuel in the range of 3.5% of U235 vs 0.7% (natural uranium) that the heavy-water plans use. In spite of the high cost of the uranium enrichment process the light water plant turned out to more economical than the heavy water plant.

The case for tritium production (the second component of the fusion fuel) is still worse. Tritium is produced from lithium-6 in standard nuclear reactors. Lithium-6 is a rare isotope (7.5% in volume in comparison with lithium-7). The Ontario Power Generation's "Tritium Removal Facility" currently processes up to 2,500 tons of heavy water a year, and removes from it out about 2.5 kg (5.5 lb) of tritium. The current price is $30,000 per gram ($30 billion per ton). It would take a ton of deuterium/tritium fusion fuel to power a 1 gigawatt reactor for a year. There is enough of lithium on the planet to supply the fusion power industry if it even became practical. There are over 10 million tons in known reserves and 230 billion tons in seawater at a concentration of 1.4-2.5 parts per ten million. However, the mass production of the actual tritium for the fusion fuel is such a precarious process that the entire U.S. production of 40 years from 1955 to 1996 amounted to only 225 Kg, or a quarter of a ton.

Fusion fuel consists of 40% deuterium and 60% tritium. A ton of fusion fuel can produce 2.7 gigawatts of energy for a year, or roughly 1 gigawatt of electricity, at the currently projected best case in fuel efficiency (roughly equal to U235).

It is hoped that placing lithium-7 within the reaction chamber will make the rectors self-breeding in lithium. Whether the tritium breeding process is possible will be determined during the 20-year experimental stage of the international experimental reactor ITER expected to be operational for experiments in 2020. There are a lot of ifs and dreams attached to this project for which no solutions are presently in sight. For example it is not known if metals or materials can be created that are able to withstand the neutron stress, the radiation damage, and the super-high heat flux that result in high-power applications. These questions won't be answered until the 2020s to 2050s timeframe when the related experiments can be performed.

Other fuels cycles are theoretically possible, but require radically greater energy input for the fuel confinement pressure to cause fusion to occur. The pure deuterium-deuterium reaction requires energy confinement to be 30 times greater than that required for the D-T reaction while the power produced would be 68 times less. Another type of fusion is possible that does not produce neutrons, called aneutronic fusion. The most promising candidate here is the Hydrogen-1/boron reaction. It would produce energetic helium as output, but requires its energy confinement to be 500 times greater than than what required for the D-T reaction, and the power output density would be 2500 times lower than for the D-T reaction. Unless radically new energy confinement principles can be discovered and implemented, these exotic fusion concepts will all remain in the land of dreams

The general experience has been that every step forward revealed greater barriers ahead.

The fourth strike against practical nuclear- fusion power

... even if some of the problems can be resolved, is delivered by the radically more-efficient option of thorium nuclear-fission power that is available, such as the Liquid Fluoride Thorium Reactor (LFTR) or simply called the Molten Salt Reactor (MSR) that is safe, doesn't produce long-lived nuclear waste, is self-breeding, in inexpensive to construct, can be scaled to any size, and produces high-temperature process heat. And the best of it is, the design is sitting on the shelf ready to be used, for which the USA all by itself has 900,000 tons of fuel available, and this with the same deliverable energy contents than fusion is promising but cannot deliver. The thorium powered nuclear fission reactor clocks in at 13 GWh/kg of fuel (46TJ - 56% of that of uranium) or 673 kg for a 1 gigawatt reactor per year.

The comparison with Uranium fission becomes vastly more dramatic when one considers that of the natural uranium only 0.7% is fissionable (in practice only app. 0.5% is actually burned), while thorium (when activated to U233) is 100% fissionable, or 200-times the amount (in practice somewhat less). In addition, thorium is 3.5 times more abundant. The reluctance of the nuclear power industry to move in this direction may be due to the low cost in the fuel fabrication, vs the high cost for uranium fuel that comes with a large profit potential. Nevertheless, the tide is changing. China, India, and Japan to develop a new generation of MSRs. Nuclear-fusion power becomes increasingly less attractive, even if by some miracle it could be made to work.

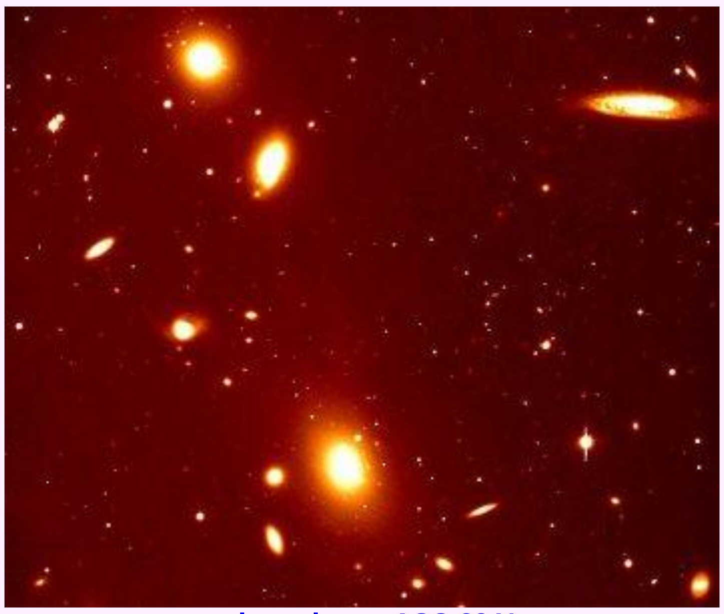
Per ton, the current nuclear-fusion fuel, the deuterium/tritium combination, contains five times the energy than uranium 235 per kilogram (481 TJ of energy per kilogram for D-T, versus 82 TJ of energy for uranium) The advantage in the fusion fuel is more than used up by the inherent inefficiency of the fusion power process in which the fusion 'explosion' blows the fuel apart before all of it is used up. At NIF (The National Ignition Facility) the fuel capsule typically contains 0.238 mg of fuel for an expected energy yield of 20 MJ, which will likely be achieved. This adds up to only 17% of the energy recovered that is contained in the fuel as a result of the basic nature of the ignition process. The end result is that according to the best projection to date the fusion process would yield 81.7 TJ of energy per ton of fuel, thereby offering no advantage at all in terms of effective fuel-energy density.

The fifth strike against practical nuclear- fusion power

... promises to strike it down completely. This would happen if a serious effort would be made to utilize the electric energy the surrounds our planet in space, which also powers the Sun. And the day for that may not be too far off. A large body of evidence exists that far greater sources are available to us on this path then we will likely ever be able to use. On this path, nuclear-fusion power becomes essentially a dead issue.

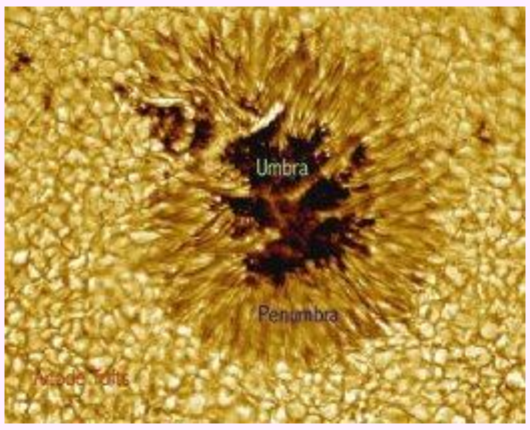
The sixth strike against practical nuclear- fusion power

... lies in the evident fact that nuclear-fusion power production isn't happening naturally anywhere in the Universe. For one thing, as we have already discovered, the Universe has created immensely formidable protective barriers against its atoms fusing into each other. And the second reason is that the Universe has no need for nuclear-fusion power. It is flush with power. So, why would a principle for fusion-power exist? And without a universal principle for its existing, why would we bother to explore it? If were serious in searching for unlimited power resources wouldn't we focus our research onto areas where these resources are known to exist, such as electric power streams that pervade the cosmos and have the galaxies organized in long filamentary strings of electric plasma currents, which also power our Sun?



galaxy cluster ACO 3341

The notion that nuclear fusion is the power source that heats up the Sun is refuted by by numerous forms of evidence to the contrary, such as the visible evidence in the sunspots where the surface below the luminous photosphere is exposed - and behold, the layer below is visually much darker, and plainly so for all to see, which should be immensely brighter if the Sun was heated from the inside.



The notion of the fusion Sun is also further refuted by the simple fact that the fusion-process itself does not produce energy, which is merely released energy in the form of previously invested energy, and this investment, evidently cannot come from the Sun itself.

While evidence exists that nuclear fusion is occurring to some degree on the surface of the Sun, as the presence of 67 of the 100+ known elements have been detected there, no evidence exists that the occurring fusion is an energy contributor to the high intensity electric process that illumines the Sun. The minuscule amount of neutrino emissions that have been detected (deemed a tell-tale of fusion) may reflect such surface reactions, but fall far short of what they should be for a fusion-sun. For this lack the fusion theories have been updated with exotic 'discoveries' that are cited to rescue to fusion-sun as a basic premise.

With all these many strikes against fusion power as an energy producing process, one wonder why the process is still being pursued. One possible answer is that the driving force is evidently political, for the typical reasons, primarily to prevent mankind from having an energy-rich future to power the needed economic development.. Another answer is that its initial promise was simply too wonderful and too attractive not to be pursued as an option as the barriers hadn't even been imagined in the early stages, much less understood.

Nuclear-fusion power, a dead-end pursuit

Six strikes against nuclear-fusion power

The political driver for dead-end fusion-power

Nuclear-fusion experiments - NIF, ITER

The nuclear-fusion energy is destructive

The paradox of the nuclear-fusion fuel

The paradox of nuclear-fusion power

MSR/LFTR Liquid Fluoride Thorium Reactor

Also see:

2011 - NAWAPA

2011 - Industrial Revolution

2011 - Free Electric Energy

2011 - Nuclear Fusion Power Delusion

2011 - Ice Age anew and Renaissance

2011 - Universal Love

2011 - Empire Religion

2011 - Empire Wars

2011 - Christian Science

2011 - New Science

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with LPAC videos on the Nation, Science, Economics, and Empire

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