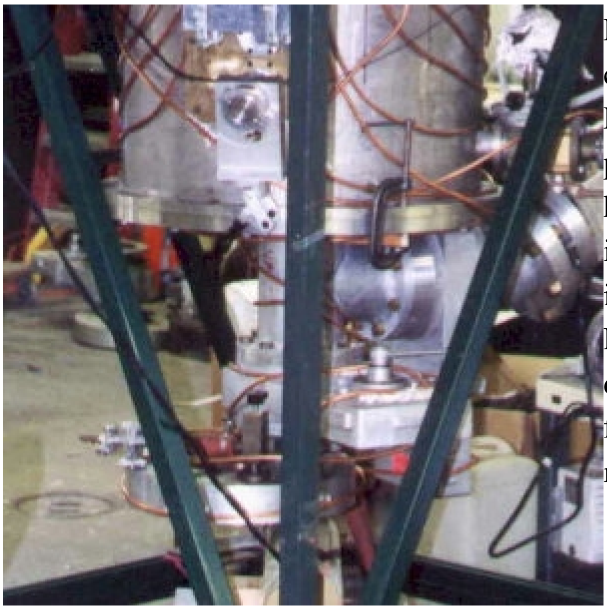

Focus Fusion poses overwhelming competition to $10 billion Tokamak Purports to be a far more feasible and profoundly less expensive approach to hot fusion, in contrast to what the international project (ITER) in France is pursuing. Lawrenceville Plasma Physics is currently researching and developing the Plasma Focus Device for hydrogen-boron nuclear fusion. No response from ITER.

Nov. 2, 2005

Primary Grid Power Potential

(Source)

Focus Fusion poses overwhelming competition to Tokamak

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by Sterling D. Allan
Open Source Energy News -- Exclusive Interview

(Listen to anchor, Charlee Redman introduce this story)

WEST ORANGE, NEW JERSEY, USA -- Imagine a non-polluting power plant, the size of a local gas station, that would quietly and safely power 4,000 homes, for a few tenths of a penny per kilowatt-hour, compared to 4-6 cents/kw-h of coal or natural-gas-powered plants. One technician could operate two dozen of these stations remotely. The fuel, widely available, is barely spent in the clean fusion method, and would only need to be changed annually.

That is what inventor Eric Lerner envisions with his focus fusion technology in which hydrogen and boron combine into helium, while giving off tremendous amounts of energy in the process.

The size and power output would make it ideal for providing localized power, reducing transmission losses and large-grid vulnerabilities. The cost and reliability would make it affordable for developing nations and regions.

Dr. Thomas Valone, of Integrity Research Institute calls it "the most ideal fusion project," and he even points to it as the most feasible, but neglected, energy technology in general. (See interview.)

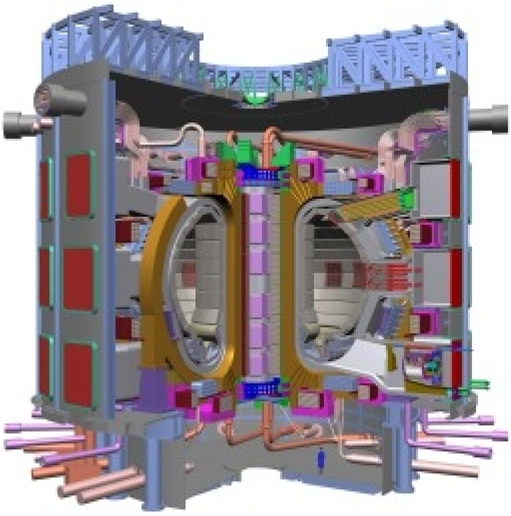
With proper funding, implementation of Lerner's vision could begin within half a decade. The capital investment of a few millions that he needs seems miniscule compared to the 10 billion dollars being pumped into the multinational Tokamak fusion project in France. (Ref.)

While both processes are considered "hot fusion", focus fusion is not "fission." As stated on the focus fusion website: "A fission reactor is the type of nuclear reactor we are all used to, and these use chain reactions which can lead to meltdown. They also have problems with radioactive waste." Focus fusion has no such problems.

Lerner has been pulling together the theoretical basis for this technology for two decades. Since 1994 he has been able to secure funding, beginning with a grant from NASA's Jet Propulsion Laboratory. That initial grant enabled him to test key components of his theory. Though that funding has dried up apparently due to cuts in NASA's propulsion research, Lerner has been able to land ongoing funding to keep the research advancing.

Thomas Valone on Focus Fusion - When asked *'What energy technology looks most promising, that is not getting due attention'*, well-known and revered energy researcher and U.S. Patent reviewer, Tom Valone, Ph.D., answers: "Focus Fusion".

(Sterling Allan's interview with Tom Valone at the ExtraOrdinary Technology conference in Salt Lake City, July 28-31, 2005; produced by *OSEN*.)



Cutaway of the ITER Tokamak

It is no wonder that NASA would be interested, inasmuch as the modeling predicts that a craft using Lerner's technology could reach Mars in just two weeks. The ionic particles would be escaping out the rocket nozzle at 10,000 kilometer per second, compared to the 2 km/s of present rocket propellant.

Efficiency and Safety

In the case of electricity generation, the speeding ionic particles would be coupled directly to the generation of electricity through a beam of ions being coupled by a high tech transformer into currents that are fed to capacitors, which would both pulse the energy back through the device to keep the process going, as well as send excess energy out for use on the grid.

This direct coupling is one of the primary advantages of this technology. It sidesteps the centuries-old approach of converting water to steam in order to drive turbines and generators. That process accounts for 80% of the total capital costs required in a typical power plant. By going straight from the fusion energy to electricity, Lerner's fusion process eliminates that need altogether, enabling streamlining of the process and a much smaller size to achieve equivalent power output.

And his device could be fired up and shut off with the flip of a switch, with no damaging radiation, no threat of meltdown, and no possibility of explosions. It is an all-or-nothing, full-bore or shut-off scenario. Because it can be shut off and turned on so easily, a bank of these could easily accommodate whatever surges and ebbs are faced by the grid on a given day, without wasting unused energy from non-peak times into the environment, which is the case with much of the grid’s energy at present. (Ref.)

How the Theoretical Focus Fusion Reactor Works

The proposed focus-fusion reactor involves two components: the hydrogen-boron fuel, and a plasma focus device. The combination of these into the focus-fusion process is the invention of Eric Lerner.

The plasma-focus technology has been well established elsewhere, and has a forty-year track record. Invented in 1964, the Dense Plasma Focus (DPF) device is used in many types of research. (Ref.)

As described on the Focus Fusion website, the DPF device consists of two cylindrical copper or beryllium electrodes nested inside each other. The outer electrode is generally no more than six to seven inches in diameter and a foot long. The electrodes are enclosed in a vacuum chamber with a low-pressure gas (the fuel for the reaction) filling the space between them.

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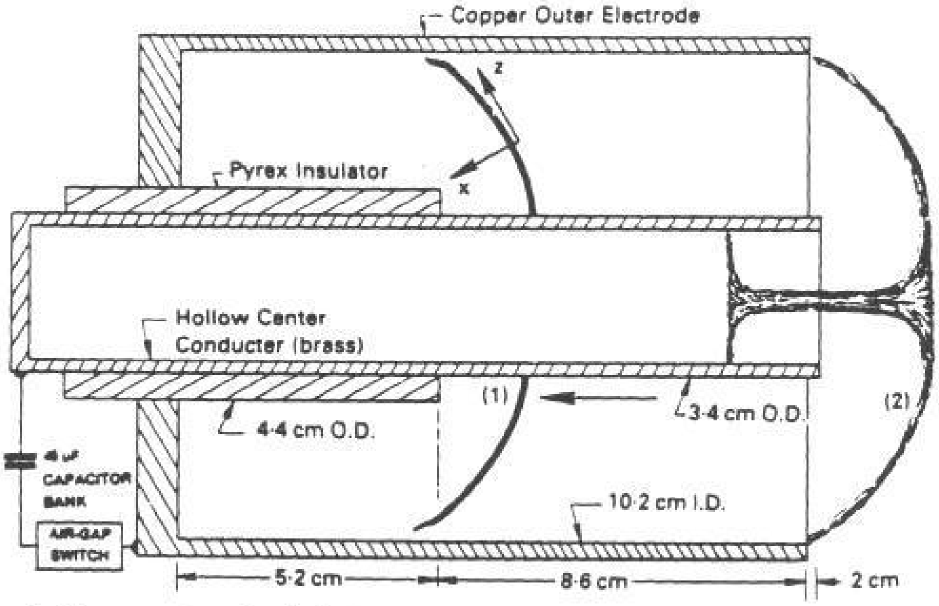


FIGURE 1. Cross section of typical plasma-focus device. Plasma sheath is shown while moving down electrodes and at time when plasmoids are produced.

The Dense Plasma Focus device is roughly the size of a coffee can.

Next comes the fuel. The gas Lerner plans to use in the DPF is a mixture of Hydrogen and Boron. Their site gives an explanation of the research steps needed to use this type of fuel with the DPF. (Ref1; Ref2.)

According to their site, the way the proposed focus fusion reactor would work is as follows:

> A pulse of electricity from a capacitor bank is discharged across the electrodes. For a few millionths of a second, an intense current flows from the outer to the inner electrode through the gas. This current starts to heat the gas and creates an intense magnetic field.
>
> Guided by its own magnetic field, the current forms itself into a thin sheath of tiny filaments -- little whirlwinds of hot, electrically-conducting gas called *plasma*.

Picture of plasma filaments:

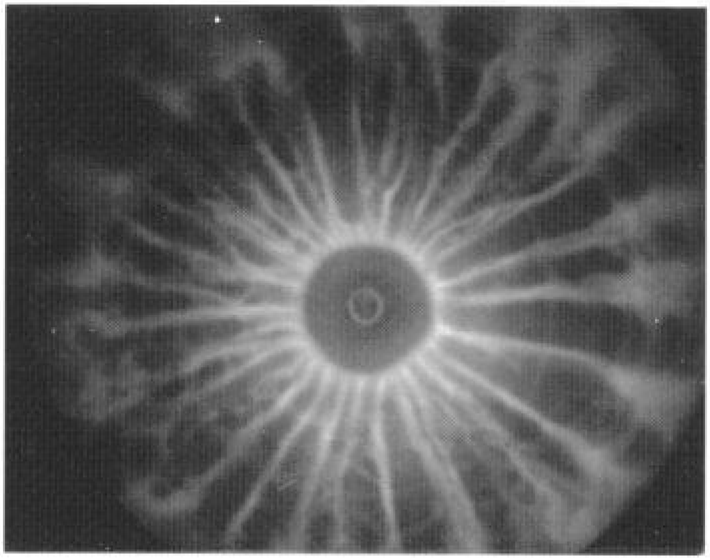


Fig. 6.13a. As the sheath carrying the inward-moving current forms, pairs of vortex filaments are generated.

Schematic drawing of plasma filaments:

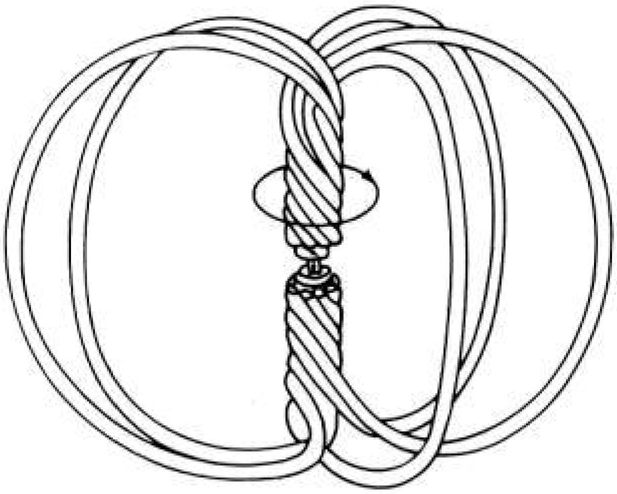
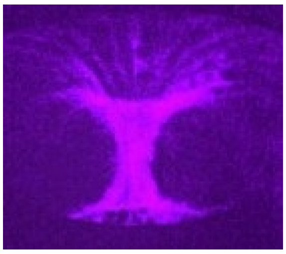


Fig. 6.13b. At the focus, the filaments annihilate each other, leaving only one, which necks off into a plasmoid, shown schematically. As it decays, the plasmoid emits two beams, each made up of tiny filaments organized into a helical pattern.

Photo of hot plasma vortex filaments



Hot plasma vortex filaments pinched together by their own magnetic fields in a plasma focus fusion device.

Photo taken by Winston Bostick & Victorio Nardi using an exposure time of a few nanoseconds. (Ref)

This sheath travels to the end of the inner electrode where the magnetic fields produced by the currents pinch and twist the plasma into a tiny, dense ball only a few thousandths

> of an inch across called a plasmoid. All of this happens without being guided by external magnets.
>
> The magnetic fields very quickly collapse, and these changing magnetic fields induce an electric field which causes a beam of electrons to flow in one direction and a beam of ions (atoms that have lost electrons) in the other. The electron beam heats the plasmoid, thus igniting fusion reactions which add more energy to the plasmoid. So in the end, the ion and electron beams contain more energy than was input by the original electric current.
>
> These beams of charged particles are directed into decelerators which act like particle accelerators in reverse. Instead of using electricity to accelerate charged particles they decelerate charged particles and to produce electricity. (Ref. The above quote was slightly edited.)

Some of this electricity is recycled to power the next fusion pulse, at a frequency expected to be optimal at around 1000 times per second. The excess energy from each pulse is available as net energy, and is output as *product electricity* from the fusion power plant for sale to the grid – or will be, once this is all proven and implemented.

X-Ray Shielding

While the process would not create residual radioactivity, it does give off strong x-ray emissions, which can be harnessed by a high-tech photoelectric cell for additional energy capture in a process similar to a photovoltaic solar cell. The primary difference is in the concentration of particles. "Solar energy is diffuse," said Lerner, explaining that the focus fusion process would be highly concentrated: 10,000 kilowatts per square meter, compared to 1 kw / m^2 with solar. So the cost-to-yield ratio would be extremely favorable in the case of the x-ray energy capture.

There will also need to be shielding from the pulsing electromagnetic fields generated by the reactor.

In addition to x-rays, the process would also yield "low energy neutrons", Lerner said. These would not produce long-lived radioactivity, but at most would only produce "extremely short-lived elements with very short half-lives. Only 1/500th of the total energy would be carried by the neutrons."

"You could walk into the facility a second after turning it off, and would not be able to detect any radiation above background," he said. The materials of which the reactor and facility are constructed would not build up any radioactivity either, even over time.

For safety, Lerner said that a layer of lead and a layer of boron shielding surrounding the reactor would be adequate protection for the focus fusion plant.

As for possible accidents with the reactor, there is "not really anything that could go wrong," and, because of the way the reaction stops immediately, "there is [no possibility] for runaway." Lerner affirms, "It's 100% safe."

Some heat is vented into the environment, but it is not to such an extent that a generating plant could not be situated in a neighborhood, such as where substations presently are located.

About the worst thing that could happen would be a capacitor failure, but that would not even damage the building, he said.

Of course there are always the risks of electrocution, and shorting-out hazards associated with electricity, but those would be present in any power-plant situation.

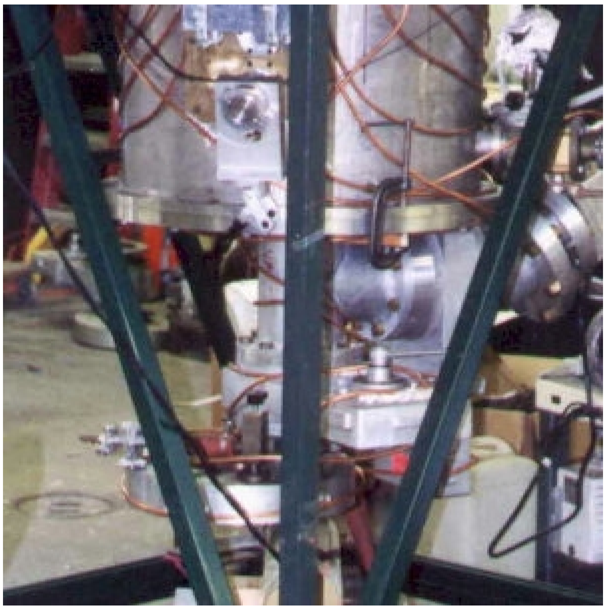
Remember, with this technology, on-site personnel are not needed on a daily basis, reducing the exposure of persons to such hazards. Maintenance would be rare. One technician could operate a dozen facilities by him or herself.

Politics and Present Status

Imagine! At the flip of a switch, going from room temperature (or from the temperature of boiling water in the case of the liquid decaborane fuel), all the way up to a billion degrees, and then up to 6 billion degrees, all in a fraction of a second; then with another flip of the switch, when you are done, going back down to ambient temperature. And in the interim, you have produced excess energy from fusion -- safely, cleanly.

Part of that theoretical equation has been proven. Part has yet to be proven.

Lerner credits the field of astrophysics as playing a significant role in serendipitously developing much of the theoretical basis behind focus fusion, due to the parallels between neutron star research and plasma physics.



Cropped view. The vacuum chamber in Texas with and without insulation. The copper coils were for heating it in preparation for using decaborane fuel. (Ref.)

Mary-Sue Haliburton, chief editor for *PESN* and *OSEN* news, points out that the plasma filaments in the plasma focus are a microcosmic version of the Birkeland currents visible in the sun's corona, as well as in interstellar and even intergalactic space. (Ref [site shows photo of Birkeland current in sun's corona.)

Based on his focus-fusion research done through the grant from JPL at the University of Illinois, his subsequent research at Texas A&M University, and research done at the Los Alamos National Laboratory (LANL), Lerner et al. have proven the ability to attain, and even to surpass, the billion degree benchmark. (Ref)

Valone said that such an achievement should have been front page news in the *NY Times* and *Washington Post*. (Ref.)

Though Lerner and his colleagues went beyond the pre-determined performance standard, NASA chose to not publicize that breakthrough. Instead of honoring Lerner et al. with the accolades they deserved, an administrator at LANL threatened the University and the professor involved, saying that they were not to compare their results with pet-project Tokamak. The professor was so intimidated he stopped working with Lerner.

Lerner's persistent quest to find other federal monies has thus far been unfruitful. "This administration does not want to fund any serious competitor to oil or gas," Lerner said. He has also approached some foreign governments.

Despite the political setbacks, Lerner is pressing forward, and has been successful in acquiring limited funding. However, he needs substantially more to reach the next milestone of building a break-even prototype. To achieve the fusion process with measurable energy output, he needs $1.5 to $2 million dollars. This is a mere pittance compared to the $10 billion being sunk into Tokamak, which Valone considers to be an inferior design.

Once that milestone is accomplished, "funding will not be a problem," Lerner said.

A full proof-of-concept prototype will be next, which will enable the harnessing -- not just measurement -- of the output energy in the form of usable electricity.

Then, it’s a matter of tooling up for production. Lerner expects that the capital cost – estimated at $200,000 to $300,000 for a 20 MW plant – will be much lower than that of traditional electrical generation plants, perhaps only one percent in up-front costs.

Eric Lerner, physicist, inventor

Executive Director of the non-profit, Focus Fusion. He is also President of Lawrenceville Plasma Physics, Inc., the corporate interest bringing this technology forward.

Coming to a Car Near You?

Lerner said that the applications of this technology will be limited on the smaller end to local power-plant-sized operations for the near future, and that putting one of these in your garage or in your car will be years yet into the future. Miniaturization is a long-term dream that is sure to be achieved as the technology takes hold, just as it has in other industries such as computers and batteries.

# # #

SOURCES

- Telephone interview with Eric Learner by Sterling D. Allan (Nov. 1, 2005)
- http://www.focusfusion.org - company website (non-profit, educational)
    - Deuterium-Tritium vs. Hydrogen-Boron
- http://www.lawrencevilleplasmaphysics.com/ - Company corporate website
- Interview with Thomas Valone - Sterling Allan's interview with Tom Valone at the ExtraOrdinary Technology conference in Salt Lake City, July 28-31, 2005. (*OSEN*)
- Lawrenceville Plasma Physics business plan (Revised Dec. 3, 2004)
- http://www.iter.org/index.htm - ITER / Tokomak's official website.
- http://integrityresearchinstitute.org - Tom Valone's Integrity Research Institute website.
- Google > site: user.erols.com/iri/ "Focus Fusion" - Tom Valone's References to "Focus Fusion"

ACKNOWLEDGEMENTS:

- Eric Lerner reviewed this story and offered corrections which have been implemented.
- Mary-Sue Haliburton provided outstanding editorial input.
- Marcus Cameron produced the OSEN video footage.
- Matthew L. Carson shot the OSEN video footage.
- Spurring article: Focusfusion.org updates - Focus fusion recently updated their site with new info regarding the project's current status. In addition to talking about recent collaboration with the Latin American Focus group, they highlighted some of their group's attempts at fundraising. (*ZPEnergy*; Oct. 28, 2005)

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No Response from ITER

ITER was approached on Nov. 2, 2005 for comment regarding Focus Fusion, but they have not responded as of Nov. 5, 2005. We placed three emails, one phone call, and filled out their online media contact form, and have not yet received a reply. -- Sterling D. Allan

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Lerner's Publications

(Not a complete listing.)

Some of Lerner's results have been recorded in a paper published in the 2003 Proceedings of the *Fifth Symposium on Current Trends in Fusion Research*, held in Washington, D.C.

Electron, ion energy >100keV in a dense plasma (arxiv.org)

> **Abstract:**
> Controlled fusion with advanced fuels requires average electron and ion energies above 100 keV (equivalent to 1.1 billion K) in a dense plasma. We have met this requirement and demonstrated electron and ion energies over 100 keV in a compact and inexpensive dense plasma focus device. We have achieved this in plasma "hot spots" or plasmoids that, in our best results, had a density/confinement-time/energy product of 5.0 x1015 keVsec/cm3, a record for any fusion experiment. We measured the electron energies with an x-ray detector instrument that demonstrated conclusively that the hard x-rays were generated by the hot spots.

Prospects for P11B Fusion with the Dense Plasma Focus: New Results (arxiv.org)
25 pages, 6 figures. Invited presentation, 5th Symposium "Current Trends in International Fusion Research: A Review" March 24-28, 2003, Washington, D.C V.2 corrected typos

> **Abstract:**
> Fusion with p11B has many advantages, including the almost complete lack of radioactivity and the possibility of direct conversion of charged particle energy to electricity, without expensive steam turbines and generators. But two major challenges must be overcome to achieve this goal: obtaining average ion energies well above 100keV and minimizing losses by bremsstrahlung x-rays. Recent experimental and theoretical work indicates that these challenges may be overcome with the dense plasma focus. DPF experiments at Texas A&M University have demonstrated ion and electron average energies above 100keV in several-micron-sized hot-spots or plasmoids. These had density-confinement-time-energy products as high as 5.0 x10^15 keVsec/cm^3. In these experiments we clearly distinguished between x-rays coming from the hot-spots and the harder radiation coming from electron beam collisions with the anode. In addition, new theoretical work shows that extremely high magnetic fields, which appear achievable in DPF plasmoids, will strongly reduce collisional energy transfer from ions

to electrons. This reduction has been studied in the context of neutron stars and occurs when ion velocities are too small to efficiently excite electron transitions between Landau levels. It becomes a major effect for fields above 5 gigagauss. This effect will allow average electron energies to stay far below average ion energies and will thus reduce x-ray cooling of p11B. In this case, fusion power will very significantly exceed x-ray emitted power. While fields of only 0.4 gigagauss have so far been demonstrated with the DPF, scaling laws indicate that much higher fields can be reached.

Comparison of Focus Fusion to the Tokamak

From http://users.erols.com/iri/FocusFusion-Ver6.htm

Reactor Type	**Plasma Focus Fusion**	**Tokamak**
Fuel	Hydrogen-boron	Deuterium-tritium
Fuel availability	Abundantly available	Tritium must be bred
Long-lived radioactivity	None	Considerable
Radioactivity of structure	None	Considerable
Power output per unit	2 MW and up	500 MW and up
Unit size	3x3x9 feet	70x70x80 feet
Capital Cost per kW	$100 - $200	$2000 – 3000
Electricity conversion	Direct induction	Steam cycle