White Paper

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Title: Six-kilowatt Power Supply using the Colliding EST Fusion Reactor

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Abstract:

We are developing a six-kw power supply that is non-polluting, and uses no fossil fuels or nuclear fuels. In production it will cost about the same as present gasoline powered six-kw power supplies, but will run for a year continuously on about a kilogram (2.2 pounds) of hydrogen and boron, compared to 7300 gallons of gasoline. It can be scaled up into a larger generating plant where it will produce electricity for about $0.0005 per kw-hr, compared to $0.05 per kw-hr today. This white paper describes a three-year project to build a prototype 6-kw power supply.

The basis for this new power supply is a newly discovered stable plasma toroid, the electron spiral toroid (EST). We make EST's that remain stable in air with no magnetic fields for containment. This opens the possibility of a fusion reactor with no containment. The first step has been to accelerate EST's magnetically, which we presently do. We plan to collide two EST's together at high velocity. The EST can be added to well-known technology to build a fusion reactor.

One EST will be made in a hydrogen background to trap protons (hydrogen ions) inside the EST. A second EST will be made in a ^{11}B arc to trap ^{11}B ions inside the EST. Both EST's will be separately accelerated, then collided together to cause their internal ions to collide in a fusion reaction. We consider the p,^{11}B fusion cycle for this analysis since it is not radioactive.

The colliding EST fusion reactor (CESTFR) has several potential advantages over other fusion reactors such as the colliding beam, inertial fusion, and Tokamak reactors. First, it needs no external magnetic fields for containment, a great advantage in cost and size. Second, EST's are small, so the process can occur in small increments, avoiding the need for a large container of heated plasma. Third, the EST is charge neutral and so has ion densities many orders of magnitude greater than that of ion beams.

Creating EST's: EST's are produced in the initiating apparatus of EPS [Seward 2002]. EST's have a surface of electrons and are filled with ions at nearly the same quantity as electrons. This makes the EST a charge neutral accumulation of charged particles, and allows the EST ion density to be many orders of magnitude greater than in a non-neutral ion beam. EST's are now produced in atmospheres of nitrogen, argon, helium, and air, and this can be readily done in hydrogen or boron.

Accelerating EST's: EST's are presently accelerated utilizing magnetic field pressure [Seward 2002]. Chen, an independent consultant, suggests we can accelerate EST's to greater than 1,000,000 m/s. In similar work, compact toroids (CT's) were accelerated over 1,000,000 m/s at Kirtland AFB [Kittu 1994], [Degnan 1993], proving this can be done. Note: the Kirtland work was done in vacuum since CT's only exist in vacuum, while the EST work is done in partial atmosphere since pressure provides the stability.

For the p,^{11}B fusion reaction, the particles need 148keV total energy at collision [Nevins 2000]. We split this to ensure both have equal velocity of 1.54E6 m/s. This is a reasonable extension from the velocities achieved in the compact toroid work reported.

Lawson criterion: Chen calculates that the colliding EST fusion reactor approach will result in a fusion initiation requirement about three to four orders of magnitude less than present day Tokamaks. Hugill details the Lawson criterion equation for fusion [Hugill 1981]. The numerator is 3kT, where k is Boltzmann's constant, and T is particle energy. T for a Tokamak is about 10,000eV, while for the EST it is about 8eV. With all else the same, this gives a 1250x reduction for the initiating condition using a colliding EST fusion reactor.

Colliding EST's: An ESTp (EST with protons internally) can be collided with an ESTb (EST with boron) using EPS proprietary technology. A significant advantage of the colliding EST fusion reactor is that it is energized in small, distinct packets, as opposed to a large plasma volume inside of a Tokamak reactor. This reduces the amount of energy required to initiate a reaction, and also eliminates the containment problems.

Fusion Reaction: As the ESTp and ESTb collide together; there will be collisions between the internal accumulations of ions. If initial conditions are established correctly, each p,^{11}B collision will release 8.7 MeV of energy. A 1-cm orbit diameter ESTp will typically contain 1.85E20 ions, and the ESTb will have a similar amount. The maximum energy of fusion available is thus 1.6E27 eV per collision of ESTp with ESTb, or 2.6E8 joules. This is the maximum available energy.

System energy gain: For the reactor to be practical, the energy of forming and accelerating the EST must be less than the energy of fusion, and this is the case. Formation energy is the energy per particle times the number of particles. For 8eV per particle, and 1.85E20 particles, an EST has a minimum energy of formation of 1.48E21 eV, or 234 joules per EST. With a 1% efficiency factor, formation energy is 2.34E4 joules per EST, or 4.64E4 joules total for the two EST's.

Acceleration energy of the two EST's is 148,000 eV, and is 1.85E20 times 148,000 eV or 2.7E25 eV. The efficiency of the process to accelerate an EST is estimated to be 70% for this analysis, for energy of acceleration of 6.26E6 joules for each pair of EST's.

Fusion energy for the maximum collisions is 5.22E8 joules. This is greater than the 6.26E6 joules of acceleration, as long as more than 1.2% of the colliding particles react. Assuming 10% collision rate, this yields a net 4.6E7 joules/EST collision.

Process scale up: EST's are presently made in rapid manner. We estimate this can be done at 200 EST's/second, while improving the initiation efficiency to 10%. If we multiply the net energy gain per collision in joules 4.6E7 by 200 EST's/second, this sets a maximum available energy for this approach at 9.2E9 joules/second. This is a lot of energy. It can be controlled by reducing the rate of EST production, and can be increased by various means.

System Estimate for a 6,000-watt reactor: The colliding EST fusion reactor can be used as the basis for an electric generator. As an example, we estimate the components of a 6-kw portable generator set, and compare it to a 6-kw gasoline-powered generator set used to power a house in event of a power failure.

The 6-kw generator set used for comparison is a Sears Craftsman 6000 watt generator. It weighs 86kg, and provides six hours of full load on five gallons of gasoline. The 6-kw CESTFR generator set would have these items:

1. ESTp source: Estimated mass is 2kg (similar to present EPS setup).
2. ESTb source: Estimated mass is 2kg.
3. Propulsion coils: The accelerating coils are estimated as one meter in length with mass of 25 kg for the wires required to carry the magnetic field current.
4. Reactor heat collector: Similar to an oil burner, with mass of 25 kg.
5. Power generator: The electricity generator for this example is similar to a backup generator set. To convert heat into power, the CESTFR would use a Stirling engine of similar size and mass of a gasoline engine, and an electric generator of the same size.
6. Total system mass (less fuel): 54kg reactor plus the generator set of 86 kg, or 140kg. The fusion reactor generator set will have approximately 62% greater mass than the gasoline generator set in this example.
7. Fuels: One year at 6000 watts would require 7300 gallons of gasoline, or about 19,909 kg of fuel. The fusion supply will need about one kg of fuel.
8. System specific energy: One year at 6000 watts is 52.6E6 watt-hours. The gasoline system provides 2631 watt-hr/kg. The fusion system provides 373,050 watt-hour/kg. For comparison, a NiCd battery provides 39 w-h/kg.
9. Cost for a year: Gasoline (@1.25/gal): $9125, or $0.17/kw-hr. Fusion costs $10, or $0.00019/kw-hr. The average cost to produce electricity in the US in 2001 was $0.05/kw-hr.

The advantages of the fusion reactor are in the fuel used to generate power. Very low volumes of fuel are required compared to a gasoline engine based generator. Also, the fusion fuel will not produce pollution and CO_2 as do fossil fuels. Further, the fuel will not run out in the foreseeable future, as will fossil fuels.

The advantage of the gasoline-based generator is that the gasoline engine (the heat producer) is smaller than the fusion heat producer by about a factor of 62% for small production systems. As the CESTFR gets larger, the reactor will get smaller relative to the motor generator set. Eventually, when large enough, it will be incorporated into the engine, meaning a 1-megawatt CESTR generator set will have mass about that of a 1-megawatt gasoline generator set.

There are other applications where the heat generated by the CESTFR can be used directly, such as in a gas turbine. In this case the heated air can be engineered to drive the turbine directly.

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