# Fusion Torch Can Create New Raw Materials

*The fusion torch can create new mineral resources from ordinary dirt and rock, and get rid of waste by reducing it to its constituent elements. Marjorie Mazel Hecht reports.*

How soon the world might run out of necessary resources and raw materials, from drinkable water to strategic minerals, should be no concern for panic, rationing, or calls for population control. We have the ability now to *create* the resources we need, using advanced technology. Conventional nuclear reactors can provide the energy to desalinate seawater, and high-temperature nuclear reactors can efficiently create hydrogen to replace petroleum fuel. The even higher temperatures available from thermonuclear fusion will provide working plasmas that can reduce garbage and waste down to its constituent elements, eliminating disposal problems; these high-temperature plasmas will also be able to "mine" strategic minerals directly from ordinary rock.

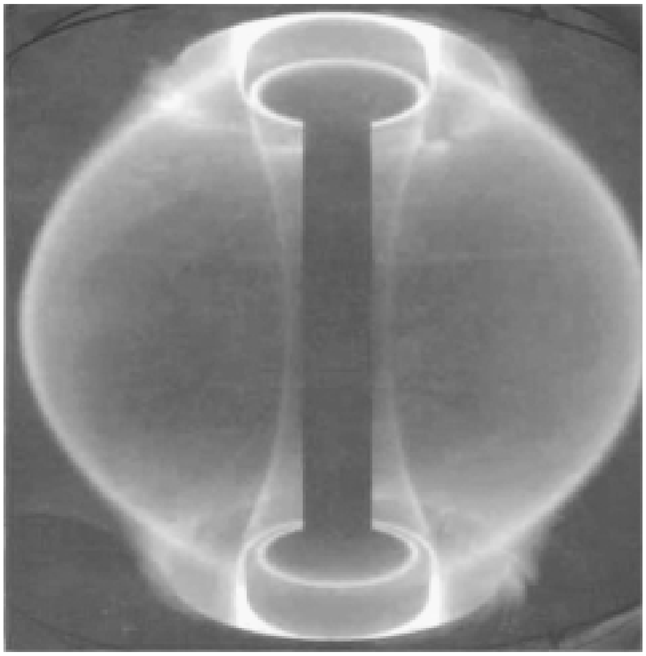
This new kind of fusion torch mining will dramatically change the relationship of man to the Earth's crust. To get an idea of what this means, think about the estimate that 1 cubic mile of ordinary rock can provide nearly 200 times the amount of annual U.S. aluminum production, 8 times the iron, 100 times the tin, and 6 times the zinc. Although it will still be necessary to find the richest possible ores for present uses, this new technology will allow us to efficiently exploit less rich ores. Furthermore, the fusion torch combined with new isotope separation technologies will ensure that we are able to make full use of all 3,000 isotopes. There are truly no limits to growth, if we allow the full development of scientific ideas and plans that date back to the 1960s, when science, and the world's population were forced off the high road of progress, onto the low-technology road.

## The Power of Plasmas

Fusion plasmas are hot, ionized gases, at temperatures of 50 to 200 million degrees, so hot that any material can be manipulated at its atomic level. (Ionization means that the electrons have been stripped from the atom, leaving it with an electrical charge.) Forty years ago, when the idea for a fusion torch was patented, scientific optimism prevailed, and the development of fusion reactors was assumed as a natural follow-on to nuclear fission. Many devices and processes for fusion were being investigated (tokamaks, stellarators, the Elmo Bumpy Torus, the z-pinch, just to name a few), and there was an excitement about the possibilities, similar to the enthusiasm about exploring the Solar System.

The development of fission and fusion was aborted, beginning in the 1970s, by an anti-science ideology (and its accompanying budget cuts) introduced into America to turn the population, and especially the younger generation, away from the idea of progress. Precisely because of the promise of both fission and fusion to transform the living standard of the entire world, and lift the Third World out of disease and poverty into prosperity, these technologies were attacked and almost buried in the same United States that developed them.

In 2006, as nuclear power begins a worldwide renaissance, it's time also to launch a "rebirth" of thermonuclear fusion in the general population. The small-minded detractors of both technologies, and the inch-by-inch pragmatists willing to wait another 50 years, need a rude and sustained shake-up: This country wasn't built by people who said, "It's impos-



U.K. Atomic Energy Authority

*A plasma discharge in the European spherical tokamak fusion device, MAST, in Culham, England. In a spherical tokamak, the plasma is more like a cored apple than a donut.*

sible," "It won't work because ________ (fill in the blank), "It costs too much," or "It will disturb Mother Nature." This article aims at beginning the shake-up of those who need it, and the beginning outline of education of those who want to know more.

## Thermonuclear Fusion

In fission, the breaking apart of the heaviest elements (like uranium) a tremendous amount of heat energy is released. As a fuel, uranium is 3 million times more energy dense than coal, and 2.2 million times more energy dense than oil. But fusion of hydrogen isotopes is orders of magnitude more energy dense, and more challenging to harness as a power source (**Table 1**).

When two atoms of the lightest element, hydrogen, are fused, the process produces helium (the second-lightest element) and "free" energy in the form of heat. For every two nuclei of hydrogen as fuel, there is one helium nucleus (called an alpha particle) produced and a specific amount of energy, which comes from the difference in mass between the input hydrogen and the output helium. (See **Figure 1.**)

Fusion is the process that goes on in the Sun and the stars, as the light elements collide at high speeds and high densities. The problem is how to replicate the process here on Earth. To fuse atoms in the laboratory requires very high, Sun-like temperatures—tens of millions of degrees Celsius—and a means of containing and controlling the reaction, sustaining it at a steady rate over a long period of time.

TABLE 1

### Energy Density for Various Sources

(Megawatts per Square Meter)

| | |
|---|---|
| Solar—biomass | .0000001 |
| Solar—Earth surface | .0002 |
| Solar—near-Earth orbit | .001 |
| Fossil | 10.0 |
| Fission | 50.0 to 200.0 |
| Fusion | trillions |

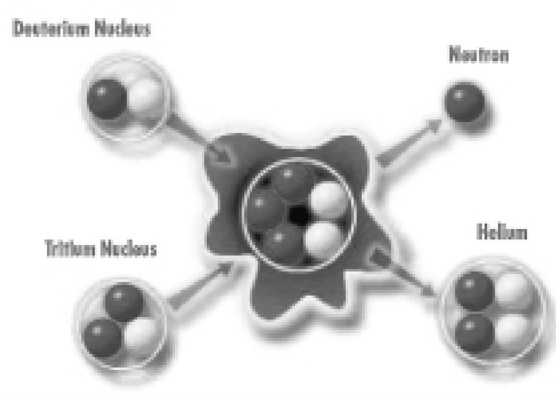
*The highly concentrated nature of nuclear and fossil energy is startling in comparison to the diffuse nature of solar energy on the Earth's surface. Even when collectors are placed in near-Earth orbit, the energy density is still 4 to 5 orders of magnitude below that of fossil fuel.*

In both the Sun and the laboratory, ultra-high temperatures strip the negatively charged electrons from the nuclei, resulting in a highly charged gas, called a plasma. Plasma, called the fourth state of matter, is a more familiar word now, because of television screen technology. Plasma screens have two thin layers of glass, with the gases argon, neon, and xenon trapped inside; the atoms of the gas are excited to the plasma state by electric pulses, emitting color.

Since the 1950s, scientists have explored different ways of heating and confining hydrogen nuclei to fuse atoms of the heavier hydrogen isotopes of deuterium (H-2) and tritium

FIGURE 1

### The Fusion Process

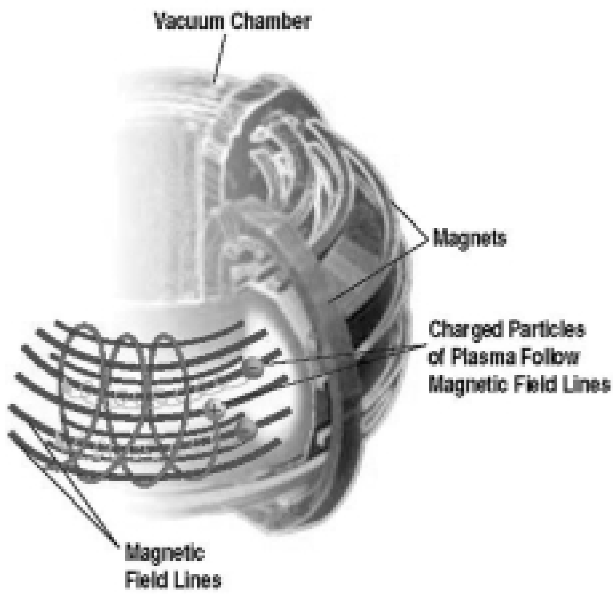



Source: "The Surprising Benefits of Creating a Star," U.S. Department of Energy, 2001.

*A fusion reaction takes place when two isotopes of hydrogen, deuterium and tritium, are combined to form a larger atom, releasing energy in the process. Fusion fuels the Sun and stars, but in the laboratory, atoms must be heated to at least 100 million degrees under sufficient pressure, to produce fusion. Other light elements can also be fused.*

FIGURE 2

## Magnetic Confinement Fusion

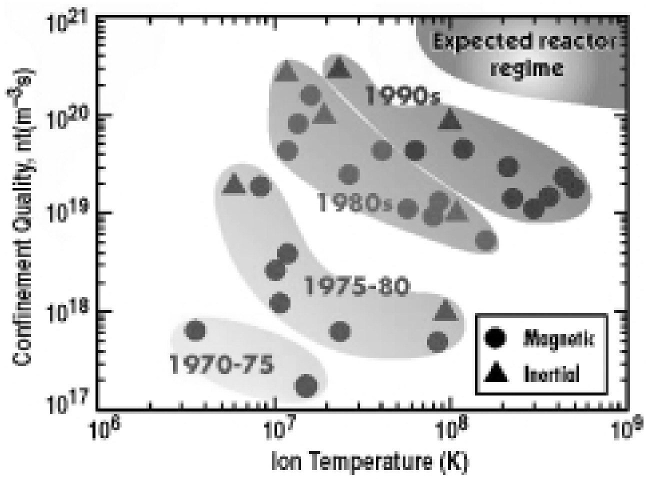



Source: "The Surprising Benefits of Creating a Star," U.S. Department of Energy, 2001.

*This diagram of a fusion tokamak shows the magnets, the magnetic field lines, and the charged particles of plasma that follow the magnetic field lines, spiralling around the tokamak. The magnetic fields "contain" the plasma.*

FIGURE 3

## Fusion Progress 1970-2000




*Even though the fusion program was forced out of engineering and into science research, there has been steady progress in magnetic and inertial fusion, decade by decade, in the quality of confinement of the plasma (measured in plasma density times time of confinement) as a function of plasma temperature (degrees K). The conditions for reactor-quality plasma are at the top right.*

(H-3). The ordinary hydrogen nucleus has one proton, deuterium has one proton plus one neutron, and tritium has one proton plus two neutrons. Deuterium is found naturally in seawater but tritium must be made by the decay of lithium.

The two basic methods to control fusion are known as magnetic confinement and inertial confinement.

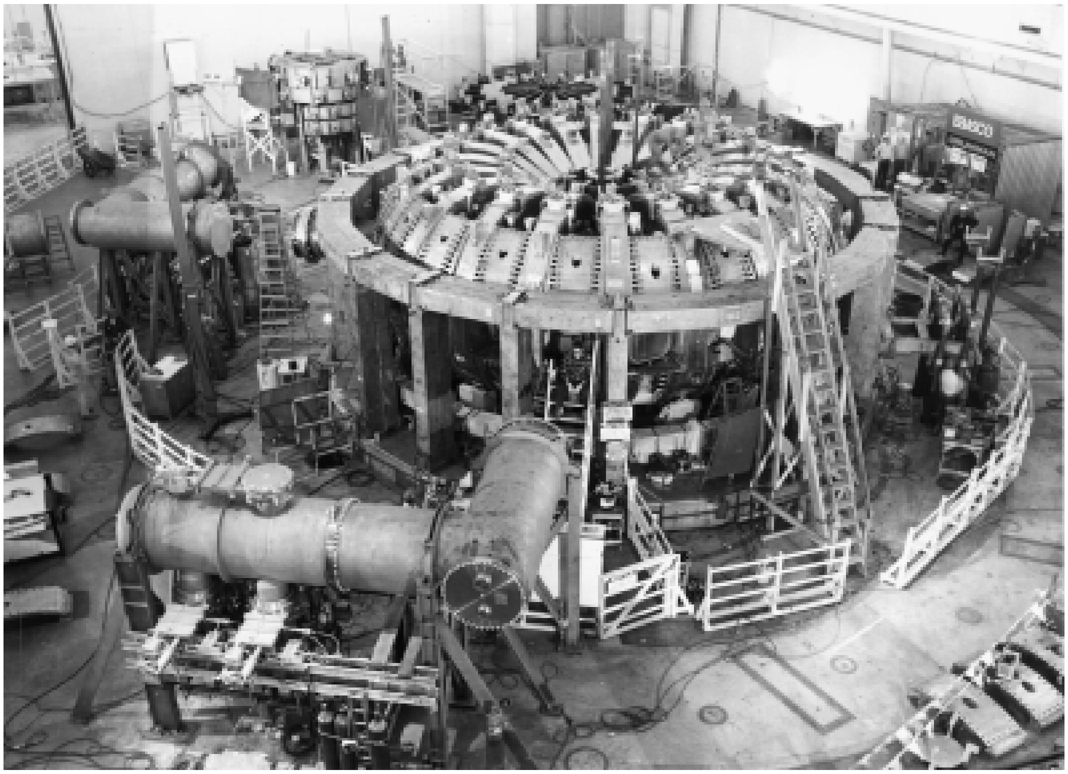
*Magnetic confinement.* In this method, magnetic fields are used to "hold" the fusion plasma in place. The most common magnetic reactor device is called a tokamak, from the Russian words for toroidal (donut-shaped) chamber. The fusion plasma is contained using a strong magnetic field created by the combination of toroidal and poloidal magnetic fields (the first refers to the long way round the torus, and the other, the short way). The resulting magnetic field forces the fusion particles to take spiral paths around the field lines (**Figure 2**). This prevents them from hitting the walls of the reactor vessel, which would cool the plasma and inhibit the reaction.

Just as in fission, where the speed and density of fissioning atoms, and the most favorable isotopes had to be carefully determined and engineered, to create the optimal conditions for a chain reaction, so in fusion, researchers had to figure out the most favorable hydrogen density and other conditions to produce fusion. Here is where the fun came in, designing different apparatuses to test hypotheses about sustaining and controlling a fusion plasma.

There are many tokamak research reactors around the world, including some small ones in the United States, and there was a succession of increasingly larger tokamaks at the Princeton Plasma Physics Laboratory. This increasing capability would have continued, if not for the budget cuts described below. Each successive reactor achieved higher temperatures and longer confinement times. Each reactor also made progress in solving the technical difficulties, such as heating, turbulence, and radiation (**Figure 3**).

The largest current device is an internationally sponsored tokamak, ITER (pronounced "eater"), to be built in Cadarache, France, with the aim of producing breakeven fusion power; that is, outputting more power than that required to create the fusion on a steady basis. The sponsors are the European Union, Japan, the Russian Federation, Korea, China, India, and the United States. The ITER's goal is to produce 500 megawatts of fusion power sustained for up to 500 seconds. ITER's predecessor, JET, the Joint European Torus) produced only 16 megawatts for less than a second.

ITER will produce net power as heat, but the heat will not be used to generate any electricity. Ned R. Sauthoff, project manager for the U.S. participation in ITER, estimates that ITER will be operating by 2016, and that commercial plants will follow by 2050. A commercial power plant would gener-



Princeton Plasma Physics Laboratory

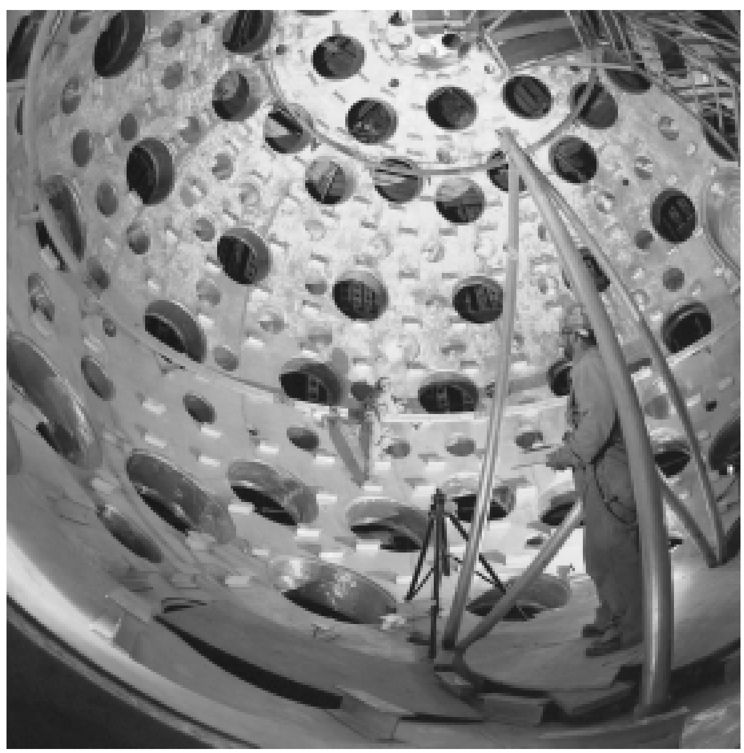
*In a recent interview, Ben Eastlund said that he had proposed small tokamaks as the plasma supply for his fusion torch. Here, the TFTR tokamak at the Princeton Plasma Physics Laboratory in December 1982. The follow-on research tokamaks planned in the Princeton program were not built.*

ate about 3,000 to 4,000 megawatts of thermal power.

*Inertial confinement.* In inertial confinement, also known as laser fusion, lasers or electron beams are focussed on a small pellet of fusion fuel, igniting it in a tiny controlled fusion explosion (**Figure 4**). In contrast, in the hydrogen bomb, fission is used to ignite fusion fuel in an *uncontrolled* fusion reaction. The term "inertial" refers to the fact that the atoms in the target have to use their own inertia not to fly apart before they can fuse.

The basic idea is to rapidly heat the surface of the target so that it is surrounded by a hot plasma. Then as the hot surface material "blows off" like a rocket, the fuel is compressed. The target fuel core becomes extremely dense, and then ignites when it reaches 100 million degrees Celsius. As it "burns," it produces many times more energy than the input beam energy.

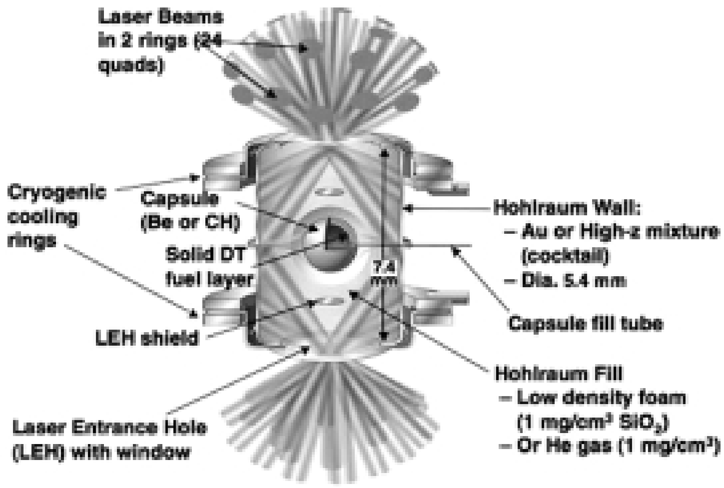
The United States has a large laser fusion facility at the Lawrence Livermore National Laboratory, the NIF or National Ignition Facility. Other inertial confinement laser programs are the OMEGA laser at the University of Rochester's Laboratory for Laser Energetics), the Nike at the Naval Research Laboratory, and the Trident at Los Alamos National Laboratory. There is also a Particle Beam Fusion Acceler-



LLNL/Jacqueline McBride and Bryan Quintard

*Inside the target chamber of the National Ignition Facility at Lawrence Livermore National Laboratory. The fusion fuel target is tiny, but the chamber is 30 feet in diameter and weighs 1 million pounds.*

FIGURE 4
## Inertial Confinement




Source: Lawrence Livermore National Laboratory.

*This schematic of the National Ignition Facility shows the array of laser beams focussed on the tiny pellet of fusion fuel (deuterium and tritium) encapsulated in beryllium and carbide. The laser beams compress and heat the fuel pellet in a billionth of a second, so that the deuterium and tritium fuse before the pellet flies apart. The term "inertial" refers to the fact that the atoms must have enough inertia to resist flying apart before they combine.*

ator and the Saturn pulsed-power facility at Sandia National Laboratories.

All the inertial confinement programs provide support for the National Nuclear Security Administration of the Department of Energy and other defense programs related to nuclear weapons, as well as civilian energy and basic scientific goals. The weapons aspect makes them a target for anti-nuclear groups, who want to shut down the weapons program and anything else that has to do with nuclear, including fusion energy. The NIF also has university and industry collaboration.

NIF is the largest laser in the world, the size of a football stadium, and very powerful. The laser system equals 1,000 times the entire U.S. electric-generating power. Each pulse is very short, just a few billionths of a second, directed at a tiny target, 1 millimeter—the size of a BB-gun pellet. The experiments involve directing this powerful beam for just a fraction of a second at the target, and then studying the results.

## What Happened to Fusion

The last 25 years of fusion research in the United States is a sad story; the fusion program became a victim of such severe budget cuts, that no engineering progress could be achieved, just research in scientific problem-solving. Yet, in 1980, fusion research had been progressing so well, with a wide variety of fusion devices, that both houses of Congress passed the Magnetic Fusion Energy Engineering Act of 1980, which mandated, in the spirit of the Apollo program, that the United States accelerate the current magnetic fusion program (1) to put on line an engineering device by the year 1990, and (2) to put on line a demonstration reactor by the turn of the century.

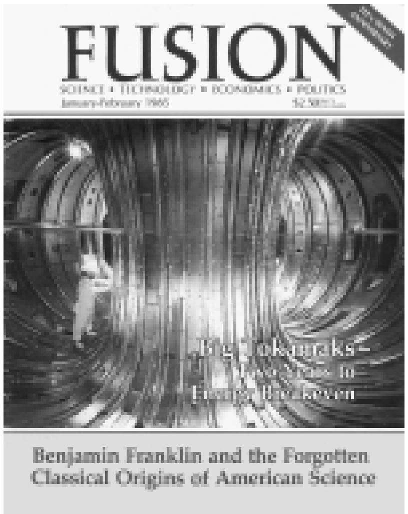
The Act, Public Law 96-386, was signed into law on Oct. 7, 1980, by President Carter. The Act's purpose was: "To provide for an accelerated program of research and development of magnetic fusion energy technologies leading to the construction and successful operation of a magnetic fusion demonstration plant in the United States before the end of the twentieth century to be carried out by the Department of Energy."

The Act specified how this was to be done, and the required funding: a doubling of the 1980 magnetic fusion budget in the next seven years, starting with a 25% funding increase in the fiscal years 1982 and 1983.

The Fusion Energy Foundation, launched by Lyndon LaRouche, Jr., in November 1974, was in the middle of the fight for fusion, and the Foundation's magazine, *Fusion,* which had a circulation of nearly 200,000, made "fusion" a household word in the years before the successful passage of the Fusion Act. It provided the public with an understanding of the science of fusion and of the experimental progress with different species of fusion devices.

But, the funds specified in the Fusion Act were never allocated under the Reagan Administration. The Act remained on the books, but the Department of Energy relegated fusion to be a "science research" program only, not the engineering program specified in the legislation. Like the Apollo program, fusion drew the wrath of those who said it would cost too much—with no regard for the boon to future generations of perfecting a high-temperature power source whose fuel was obtained from seawater, and which had no waste products. These critics—including, since 1989, many "cold fusion" researchers, whose research is also not funded—then complained that fusion research had gotten *X* amount of money for years, without producing commercial fusion, so why bother putting more money into a "sinkhole."

The overall problem is a profound ignorance of how a physical economy works, and, for a healthy economy, what percentage of public funds should be invested in scientific research to be a "driver" for the rest of the economy. Without such science drivers, the economy runs into a dead end. As the United States sank further into "services" instead of production, and chiseled and "privatized" the research programs of its national laboratories, universities, and other institutions, the nation largely lost the ability to discover new scientific principles, and educate new generations of students who




Fusion *magazine made "fusion energy" a household word in the late 1970s and early 1980s. Here, Rep. Mike McCormack, a Washington state Democrat, addresses a Fusion Energy Foundation conference in Washington, D.C. in May 1981. The Magnetic Fusion Energy Engineering Act, which became law in 1980, was called the McCormack bill, in honor of its tireless champion.*

could move the country forward.

Without a reversal of these anti-science, anti-prosperity policies, this country will collapse into Third World status, having to import technologies perfected elsewhere. We need a crash program to regain what we lost, and ensure that we implement the thrust of the 1980 Magnetic Fusion Energy Engineering Act in the next 25 years.

The scientific short-sightedness of cutting the fusion budget was magnified in 1999, when the United States decided not to fund its part of the international collaborative fusion effort, ITER, leaving the project to Europe, Russia, Japan, and other nations. (This decision was reversed in 2003, and the United States is now participating in ITER.) Where we stand today in fusion, is having a handful of U.S. research reactors, all inching along in national laboratories, universities, and at one private company (General Atomics), with a small core of experienced fusion scientists and a small number of younger students.

Creating a fusion reactor for a fusion economy is an example of a great project, planning for 50 years ahead, when most of the initial participants will no longer be alive. But what better inspiration for the younger generations, to work on perfecting a virtually unlimited energy source—instead of dung power.

## The Fusion Torch Viewed Historically

The history of man's development on Earth can be measured most accurately by the basic concept of physical economy developed by Lyndon LaRouche: the rate of change of relative potential population density. How can human society sustain an increasing number of people per square kilometer of settled land area. The key here is the mastery of increasingly more complex technologies that allow a population to thrive, beyond the limits of the natural conditions of climate and geography. To do this, individuals have to increasingly *create* new resources, particularly energy resources, and more and more energy-dense technologies, in order for the entire society to prosper. In this way, the former limits to growth of the society are overcome.

The increase in the energy-flux density of available technologies is directly related to population growth. At some point in human history, there was no ore, because there was no energy available to turn minerals into anything other than the dirt and rock we found them in (except for the use of crude tools to fashion other crude but useful objects). The introduction of fire and the elaboration of its uses changed that situation, providing a multi-fold increase in energy density for smelting, turning zinc and copper into bronze, for example. Thousands of years later, another "rock," uranium, became a powerful energy source.

With each advance in energy technology—wood, coal, oil, gas, uranium—there was a dramatic increase in human population, as man made use of increasingly energy dense technologies. (See Figure 1.) We indeed turned rocks, dirt, and other substances into energy resources. Ahead of us now lies fusion, created from a fuel of seawater, a trillion times more energy dense than its predecessors; and beyond that, who knows? Matter/anti-matter interactions? Or perhaps something else that will force more "laws of physics" into well-deserved retirement.

The fusion torch is no surprise, then, when looked at as a link in this chain of events.

In May 1969, two researchers with the U.S. Atomic Energy Commission, Bernard J. Eastlund and William C. Gough, published a booklet, *The Fusion Torch: Closing the Cycle from Use to Reuse,* which described two uses for the ultra-high temperature plasmas that were expected to be achieved with commercial fusion reactors. The first was a fusion torch that would use the high-temperature plamsa "to reduce *any* material to its basic elements for separation." The second was "the use of the fusion torch to transform the energy in the ultra-high temperature plasma into a radiation field, to permit process heating to be done *in the body* of a fluid." For example, heavy elements would be added to the plasma so that it emits X-rays or other radiation in large quantities to do work without the limits of a surface that would absorb some of the energy.

Their idea, conceived in 1968, captured the imagination of many, including the national press, which reported on the fusion torch with headlines like "Space-Age Science Would Atomize Pollutant Wastes" (*Washington Post,* Nov. 26, 1969) and "Drowning in Waste? Vaporize It by Fusion!" (*New York Times* March 15, 1970).



In the first application, the fusion reactor-produced plasma energy flux would be used for shock vaporization (the propagation of shock waves) and ionization of a solid, such as garbage or rock. Then, separation techniques would be used to "segregate the ionic species according to either atomic number or atomic mass." Eastlund and Gough note that there were several possible separation techniques, including electromagnetic, quenching of the plasma flow, selective recombination, or charge exchange.

In the second application, trace amounts of chosen elements would be injected into the fusion torch plasma, allowing the control of the frequency and intensity of the radiation emitted. For example, the plasma could be made to output radiation in the ultraviolet range. Because ultraviolet radiation can be absorbed in water to a depth of about 1 meter, the ultraviolet radiation could then be absorbed into the working fluid, to sterilize or desalinate water in bulk, process sewage, or for direct conversion to electricity (through fuel cells). This method eliminates the problem of having to transfer heat from a *surface* to the body of the fluid, which limits the process heating.

## Making the Plasma Work

Eastlund and Gough present detailed ideas and mathematical equations in their 1969 paper concerning the atomic composition of the plasma, its flow velocity, and energy losses. Region II in the torch diagram (**Figure 5a**) is designed as the area where any neutrons produced by the fusion source (Region I), especially with the deuterium-tritium cycle of fusion, are isolated by trapping them in a lithium blanket (**Figure 5b**). The resulting working plasma in Region III, like the plasma throughout the fusion torch, would have its density, temperature, and flow velocity controlled by methods that were already researched in 1969.

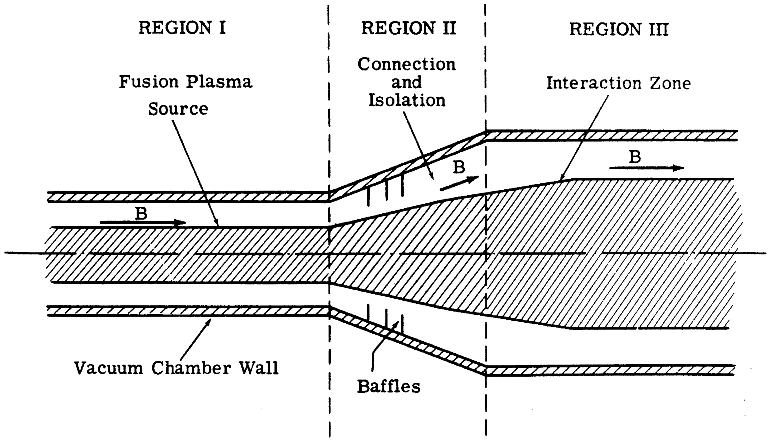
In their 1971 paper, Eastlund and Gough present a schematic for fusion torch recycling of solid waste, which they say would fit "quite naturally into the overall scheme" of then-planned solid waste treatment facilities (**Figure 6**). The solid wastes would be shredded, dried, and sorted, and then various combinations would be injected into the fusion torch plasma to be vaporized, dissociated, and ionized. The end products could then be separated out into specific elements for collection and recovery. The energy used to produce the plasma could also be recovered, in large part, because the system operates at such a high temperature.

The ionization of the solids occurs as the plasma energy is absorbed into the surface layer of the solid, producing a shock wave that vaporizes and ionizes it. This is possible only with an ultra-high temperature plasma, where the energy flux is greater than the shock speed in a solid and the energy needed to vaporize per unit volume. The resulting plasma that leaves Region III of the fusion torch would then be separated into constituent elements at lower temperatures.

Eastlund and Gough discuss several methods of separat-

FIGURE 5(a)

**Schematic of a Fusion Torch**

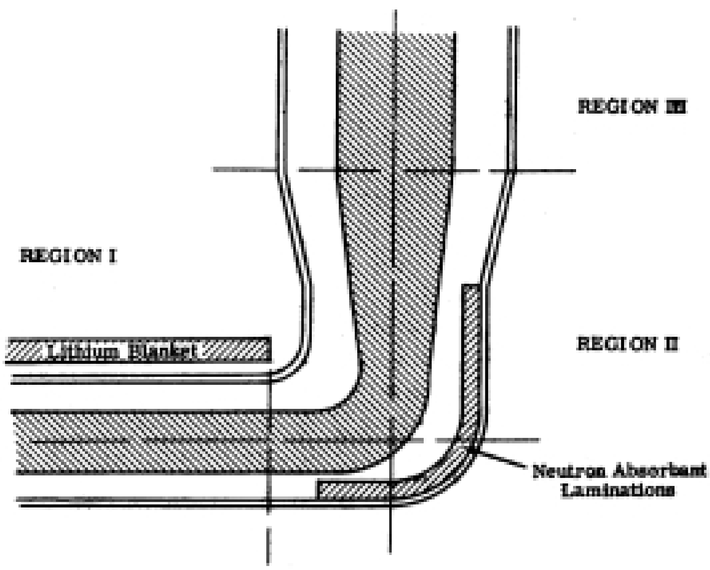



Source: Bernard J. Eastlund and William C. Gough, "The Fusion Torch: Closing the Cycle from Use to Reuse," Washington, D.C. : U.S. Atomic Energy Commission, May 15, 1969 (WASH-1132).

*In this suggested configuration for a fusion torch, the plasma is generated in the first region, and is transferred through the second region, into the interaction zone where the plasma processing takes place. Region II is conceived as using just a part of the plasma produced in the fusion device, which is siphoned off and fed into the torch by adjusting the shape and intensity of the magnetic field.*

FIGURE 5(b)

**Refining the Plasma for the Fusion Torch**




Source: Bernard J. Eastlund and William C. Gough, "The Fusion Torch: Closing the Cycle from Use to Reuse," Washington, D.C. : U.S. Atomic Energy Comission, May 15, 1969 (WASH-1132).

*A lithium blanket in Region I and neutron-absorbant laminations in Region II, remove any neutrons present before the working plasma gets to Region III of the fusion torch.*

ing the ionized solids into constituent elements, all of which could be handled in one recovery plant. Electromagnetic separation tops the list. In their 1969 paper, they note that the primary interest is in separating just a few elements with large mass differences. For example, reducing iron oxide ore ($FeO_2$) would require separation of iron (mass 56) from oxygen (mass 16). They note at the time that there had been advancement in plasma physics and beam handling, so that electromagnetic separation was more attractive as a technology.

Another separation technology noted, which Eastlund and Gough thought would have low capital cost and low energy requirements, is quenching, rapidly cooling the plasma flow, by injecting a cooler gas, flowing the plasma over a cold surface, or expanding the plasma flow. This would work with ore reduction, especially high grade ore with impurities; recovery of elements from eutectics (low melting point combinations), alloys, and low-grade metal scrap; and the elimination of plastic and paper waste products. This method of recyling could be used, Eastlund and Gough said, with "modified plasma technology" already available in 1969.

Selective recombination is another separation technique, where the temperature and density of the plasma would maintain conditions that would allow some of the elements in the plasma to recombine on the walls of the torch chamber, while others were "piped away." This method is based on the ionization characteristics of the species involved.

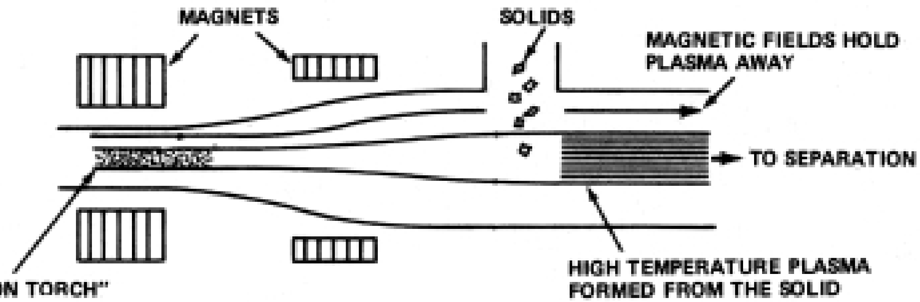
A fourth technique suggested in the 1969 paper is charge exchange. In this method, a beam of a gas would be sprayed at the flowing plasma stream from the fusion torch, and an atom or molecule in the injected gas would replace a selected ion in the plasma. The desired combination would be collected on the wall of the torch chamber, while the rest of the material would be magnetically piped away.

The method of separation would also depend on the state into which the solid was transformed by the fusion torch. Eastlund and Gough list four different stages: (1) conversion of the solid into a gaseous state, (2) the complete dissociation of the molecules, (3) raising the temperature of the gas to the point that some of the elements are ionized, and (4) raising the temperature of the gas to the point that all the elements are ionized.

The ability to transform the waste solids

FIGURE 6

**Schematic of Fusion Torch Processing of Solid Waste**




*In this suggested design for Region III of the fusion torch, the fusion plasma, controlled magnetically, flows over the injected waste solids, ionizing them, so that they can be separated out into their constituent elements.*

Source: Bernard J. Eastlund and William C. Gough, "Energy, Waste, and the Fusion Torch," Washington, D.C. : U.S. Atomic Energy Comission, April 27, 1971.

into the above states selectively, makes it possible to use a combination of methods to most inexpensively reduce solid waste into its constituent elements. For example, the major heavier elements in solid refuse (aluminum, copper, magnesium, tin, iron, lead, etc.) could be ionized at a temperature of 10,000 K, and separated out, while the lighter elements (carbon, oxygen, and hydrogen) could remain as neutral gases and handled chemically. Eastlund and Gough calculate that this partial ionization process would save 35,000 kw/h of energy.

Are there any problems in developing fusion and the ultra-high temperature plasma torch? Yes, of course there are. Plasmas are tricky to handle, a lot of energy is involved, new materials need to be developed. But these are the kinds of problems and challenges that can be solved—if one wants to solve them.

## Where Do We Stand Today?

Gough and Eastlund conclude their 1969 report:

> Ultra-high temperature plasmas are available *now,* although at a cost in energy. Little thought has gone into their potential use for industrial applications, nor has much imaginative thought gone into taking full advantage of the unique properties of fusion plasmas that will be available in future controlled thermonuclear energy sources. While not atttempting to minimize the large amount of research both on fusion itself and on fusion torch physics, it is entertaining to speculate on the vision this concept provides of the future—large cities, operated electrically by clean, safe fusion reactors that eliminate the city's waste products and generate the city's raw materials.
>
> The vision is there; its attainment does not appear to be blocked by nature. Its achievement will depend on the will and the desire of men to see that it is brought about.

So, where do we stand today? We don't have fusion yet, or the fusion torch. As Eastlund told the Fusion Energy Foundation back in 1975, the kind of research needed for developing the fusion torch was not going on. "What's required," he said, "is a commitment by a responsible funding agency to put some solid underpinning to the physics, chemistry, and technology" of fusion torch applications."

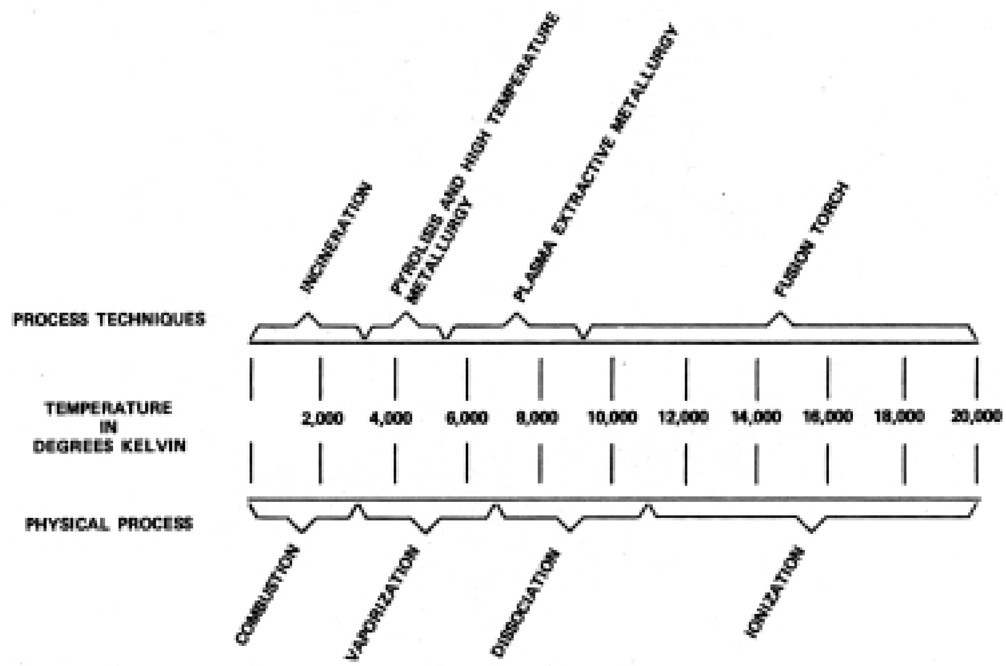
Thirty-five years later, the commitment to do this is still not there in the United States. But some of the technologies explored by Eastlund and Gough have been incorporated into lower temperature plasma torches that are now used in industry. Universities, the national laboratories, and many private companies have explored plasma processing, and make use of plasma torches. The plasmas are heated by microwaves or by passing a gas through an electric arc between two electrodes in a plasma generator. **Figure 7** shows the operating temperatures for the fusion torch and conventional methods of materials processing.

The Russians and others have used a low-temperature plasma torch process to produce steel from scrap metal. The East Germans and Soviets developed the process in the late 1960s, and commercialized it in the 1970s. At the time, their direct current argon plasma torch method reduced the cost of steel production by $400 per ton, compared to conventional high-temperature electric arc furnaces. Also, it cut the noise level from 140 decibels to only 40 decibels. The argon plasma torch produced temperatures of 15,000°C, compared to maximum temperatures of 3,600°C for conventional furnaces using electricity for energy.

The Japanese have developed the Plasma Type Incinerated Ash Fusion System, with a demonstration plant in Chiba City to recycle incinerator ash and reduce solid waste.

Today, Ben Eastlund holds three patents for plasma processing techniques that could perform the tasks outlined in his 1969 article. Specifically, Eastlund has more recently proposed that his Fusion Torch/Large Volume Plasma Processor, or LVPP, be applied to the recycling of nuclear spent

FIGURE 7
**Operating Temperatures for Incineration and Extractive Techniques**




*The fusion torch brings the temperatures available for processing thousands of degrees K above those for traditional methods of processing. With the fusion torch, ionization is possible, stripping the electrons from the atoms of whatever material is being processed.*

Source: Bernard J. Eastlund and William C. Gough, "Energy, Waste, and the Fusion Torch," Washington, D.C. : U.S. Atomic Energy Comission, April 27, 1971.

fuel from civilian nuclear plants and tank wastes left over from the Department of Energy weapons program. The LVPP would use an ultra-high temperature plasma to extract the radioactive components from bulk waste products using a "dry" process, as opposed to conventional technologies that use acids or molten metals, and a prototype could be in operation in two years. On his website (http://www.Eastlundscience.com), Eastlund writes:

> The Large Volume Plasma Processor can be used to separate the elements contained in the waste on an element-by-element basis. The non-radioactive elements can be released into the environment after ensuring there are no radioactive elements contained therein. The radioactive components would be recovered in a form suitable for conversion to industrial uses, severely reducing the volume of material slated for geological storage. Furthermore, because the 10,000,000 degree temperature of the LVPP can ionize any material, the uncharacterized nature of the material in the tanks does not present a problem.
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> The LVPP could significantly reduce the financial risk of proceeding with cleanup of the Hanford tanks. The "wet chemistry" approach requires the construction of large facilities that need to be financed up-front. Years will pass before their operation can be assured as a success. Any problems, such as a leak, or explosion of a minor system could delay implementation and cost millions in clean-up payments. The LVPP, a relatively small system, immediately begins separating radioactive materials. The material is injected as a slurry, ionizes in 300 millionths of a second, and is separated in less than 25 milliseconds. Separated material can be removed as often as needed, continuously for many elements, to assure that there is never a dangerous inventory in the system. When the tanks have been cleaned, the LVPP can then be easily removed from the site. In fact, the tanks themselves might be processed by the LVPP.

The fusion torch, in the form of the LVPP or in other forms, has the promise of supplying the world with new resources and getting rid of our garbage and waste with no pollution. As Eastlund suggests just above, the fusion torch can even turn the radioactive waste containers into usable materials! What are we waiting for? Any true environmentalist who cares about the world should happily jump on the fusion torch bandwagon for 21st Century technologies, instead of crawling into the doom, gloom, and cold of the Stone Age.