Clean up Eastern Europe's pollution by using MHD

While the Greens are trying to shut down industry, next-generation plasma technologies could get rid of pollution and fuel an economic boom. Marsha Freeman reports.

Western visitors to the newly liberated nations of Central and Eastern Europe invariably remark that the first thing they notice traveling East is the stifling air pollution. Forty years of lack of investment in new plant and equipment and in new technology in basic industries such as steel, have left these nations with many antiquated, pre-World War II factories. The inefficient coal-burning electric power, steel, and chemical plants, based on the incomplete combustion of fossil fuels, spew all varieties of solid and gaseous waste into the atmosphere.

On March 15, the U.S. Department of Energy (DOE) and the Minister of Environmental Protection of Poland, Bronislaw Kaminski, signed an agreement to install "clean coal technology" in a power plant in Krakow. Deputy Energy Secretary W. Henson Moore stated at the signing ceremony that this will create a "potential billion-dollar market for U.S. firms."

What the DOE means, however, by "clean coal technology" is the installation of stack gas scrubbers and other inefficient band-aid solutions to the problems of pollution. If the government of Poland and the other coal-dependent former East bloc nations spend their precious investment capital and foreign aid on this outmoded and wasteful "technology," they will forfeit the opportunity to leapfrog into the 21st-century plasma technologies, such as magnetohydrodynamics (MHD), which will not only end pollution, but also will raise productivity and revolutionize industrial production.

Before the East bloc nations became freed from the yoke of Communist governments, anti-nuclear self-styled "environmentalists" in the East were part of the dissident or opposition movements. When the old regimes were ousted this past winter, these modern-day malthusians lobbied for an *immediate* cleanup of the environment through what has been referred to as the "Pittsburgh solution," that is, the simple shutting down of the offending factories and power plants.

The striking result of this policy in the United States is not so much clear air, of course, as unemployment. In Pittsburgh, more than 100,000 people in the metal industry have been thrown out of work as a result. A recent survey found that out of 3,500 former steel and electrical workers in Pittsburgh, nearly 40% are unemployed. A quarter of those working had only part-time jobs, and no one was earning what he did previously. These former highly-skilled workers were not asked in the survey how much they like the cleaner air in their now-economically devastated towns and communities.

Since the beginning of this year, pressure by the Greens has led to the closing or contraction of factories in the east. In Czechoslovakia, plans for a large coking plant for steel production which was to be on the border with Poland have been scrapped. In Poland, a steel mill outside of Warsaw has been shut down, and another in Krakow has been instructed to cut production by one-third. In East Germany, an aluminum plant and a viscous rayon factory have been shut down for environmental reasons, and 500 workers are supposed to be transferred to another chemical plant. Radical environmentalist groups, such as the World Wildlife Fund/Conservation Foundation (WWF/CF), are meeting with Eastern government officials, advising them on how to shut down their economies.

Reportedly, the environment minister of Poland has a hit-list of 80 plants, factories, and mines, which will have to

Chris Lewis

The Clairton coal coking plant in Pittsburgh is still standing, but may be closed after the next round of "clean air" regulations from the EPA. The "Pittsburgh solution" of plant closings has been recommended by the environmentalists for Eastern Europe.

"shape up" or face the consequences. Rich Liroff of the WWF/CF group has stated that there are only "low-tech" solutions to the inefficient use of energy in Eastern Europe, and conservation should be encouraged through such measures as home insulation.

If the consumption of energy in these countries can be cut, Liroff explains, mines can just be shut down and so-called greenhouse gases cut. This is to be accomplished through the "free market." How would this work? Look at the case of Warsaw. According to news reports, air pollution has fallen 20% in Warsaw since Jan. 1, because the government has removed fuel subsidies and the "free market" has caused the price of gasoline to more than double!

There is no doubt that the International Monetary Fund "shock therapy" brand of "free market" austerity will lower air pollution. The question is, how many factories, power plants, housing units, and people will be left standing when they are done?

"Conservative" think-tanks such as the Heritage Foundation in the United States have become comrades-in-arms to the Greens, by trying to convince the fledgling Eastern democracies that the way to fight pollution is through private ownership. Non-government plants and factories will be more "accountable" to the general population than former dictators were, the argument goes, and can be sued for abuses, whereas the government could not be! Of course, private owners would, in reality, have no more answers for what to do with obsolete and polluting plants than the government does. As one Eastern spokesman put it, trying to retrofit 40-year-old steel mills with Western pollution control equipment would be like putting a gold watch on the wrist of a corpse.

It is certainly necessary to "clean up" these countries, which now have the opportunity to emerge as fully industrialized, Western-style nations. But they should leapfrog the 40 years of missed development, and become leaders in revolutionary, more productive industrial technologies.

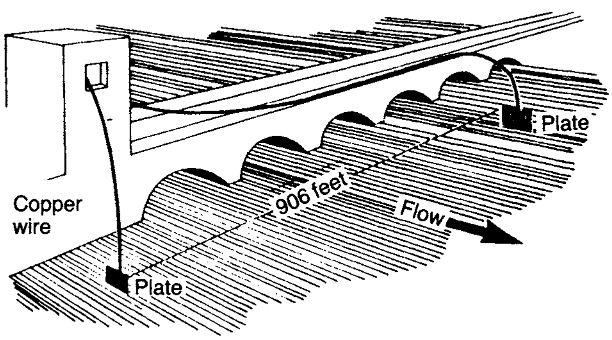
While it is the case that advanced-design modular nuclear reactors should become the electric-generating technology of choice, Eastern Europe will be burning coal for many years for both energy and industry. At the present time, East German energy is 80% coal based, and in Poland, 78% of domestic primary energy is coal based. Therefore, if shutting down polluting power plants is rejected, the alternative must be for us to develop new technology that burns coal more efficiently.

MHD direct conversion

One such technology is magnetohydrodynamics, or MHD, which allows the production of electricity from any

FIGURE 1
Faraday's 1832 experiment

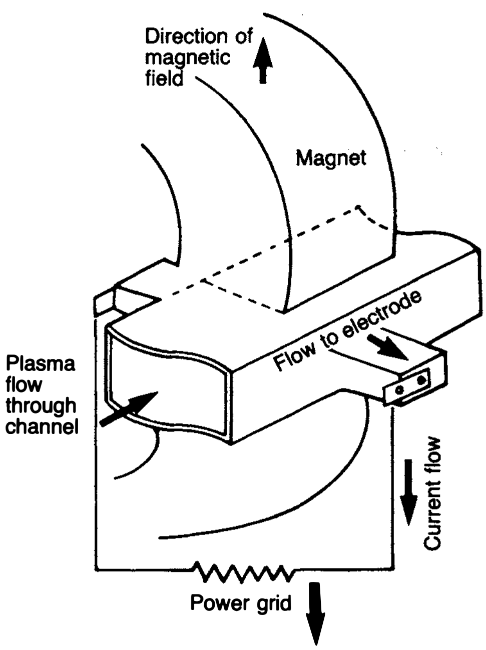
Waterloo Bridge



Source: *Fusion*, April 1980.

Michael Faraday performed the first experiment demonstrating the MHD direct conversion effect. The moving saline flow of the Thames River was the working fluid; the external magnetic field was that of the Earth; and the electrodes drawing off the Faraday current were metal plates submerged in the river.

FIGURE 2
Basic MHD concept



Source: *EIR*, Feb. 13, 1987.

If an electrical conductor, such as ionized gas, is moved through a magnetic field in a perpendicular direction, an electrical current is produced. Electrodes which are placed such that they are perpendicular to both the plasma flow and the direction of the magnetic field and attached to a load, directly draw off the electric current.

kind of fuel, at potentially twice the efficiency and without the pollution of conventional steam turbine systems. It is a plasma technology which not only produces power, but opens the door to the development of other, related, clean and efficient plasma processes for steel and metals production, and direct materials processing.

These technologies, which have been researched but never commercially developed in the United States, Western Europe, Japan, and the Soviet Union, can soon be introduced to greatly increase the productivity of obsolete "Communist" production, and end the attempted sabotage of these nations' future by the environmentalist malthusians.

Today's thermal power plants use the heat from the burning of fossil fuels to create steam, which turns turbines, transferring this rotational energy to a generator, which cuts across magnetic lines of force to produce electricity. At best, 34% of the energy in the fuel is turned into electric power. The fossil fuel burns incompletely, and the ash, sulfur, and other waste products of the fuel must be disposed of.

But over 150 years ago, Michael Faraday observed that an electrical current is produced when an ionized or electrically conducting material passed perpendicular to the lines of force of a magnetic field (see **Figure 1**). The only "moving part" is the plasma—the fluid made up of positively and negatively charged particles. In the case of Faraday's experiments, the electrically conducting fluid was the flowing water of the Thames River, and the external magnetic field surrounding the fluid was the natural magnetic field of the Earth (see **Figure 2**).

In principle, if the temperature is high enough, any material could be made into a plasma and used as the working fluid for MHD. Fossil fuels—coal, oil, or gas—can be burned at higher-than-normal temperatures, and the combustion product is then the plasma.

Direct MHD conversion can also be used with any nuclear fission system. In that case the radioactive nuclear fuel would not be used directly. The energy of the fission reaction would be used to heat an intermediate material to cause it to ionize. That working fluid, which could be an easily ionizable liquid or vaporized metal such as sodium, would then be taken through the MHD cycle.

In the case of more advanced nuclear fusion, a large amount of the energy produced can be directly in the form of charged particles. The plasma which is the product of thermonuclear fusion reactions can be directly channeled through an MHD device to produce electric power.

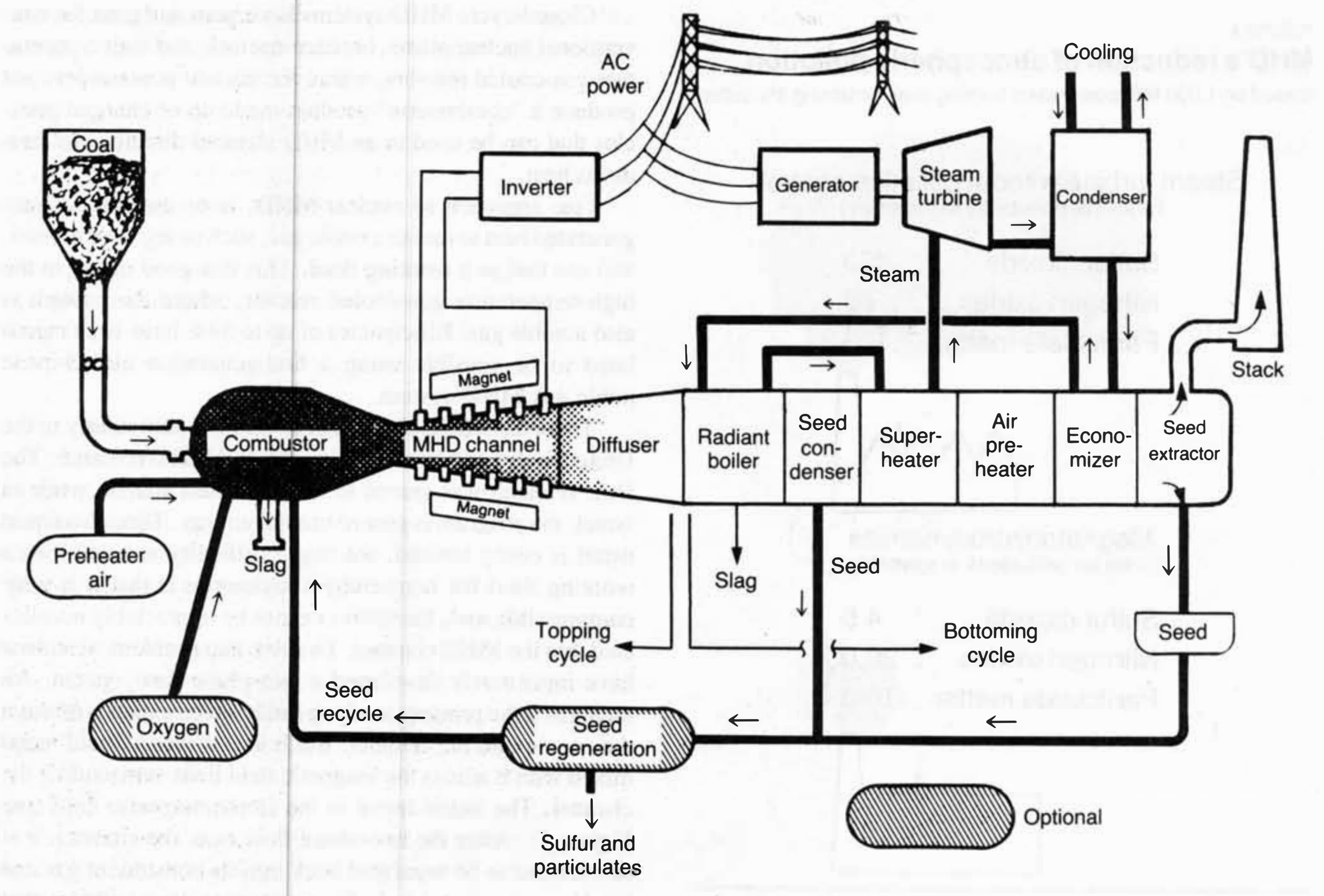
The basic design of an MHD system for fossil fuel application is seen in **Figure 3.** In this design, the coal is burned at between 4,000 and 5,000°F, which partially ionizes the coal gas. This plasma is seeded with a chemical to increase the level of ionization, and is then pushed through a nozzle which first compresses and then expands it, accelerating the gas to supersonic speeds. The plasma then travels through a channel, which must be made of a heat-resistant, non-

Fusion/Dr. V. Ovcharenko

New high-temperature materials are needed to line MHD channels. In coal-burning systems the hot gas is highly corrosive and improved ceramics are under development, which will be useful for many other applications.

FIGURE 3

Open-cycle MHD coal power plant



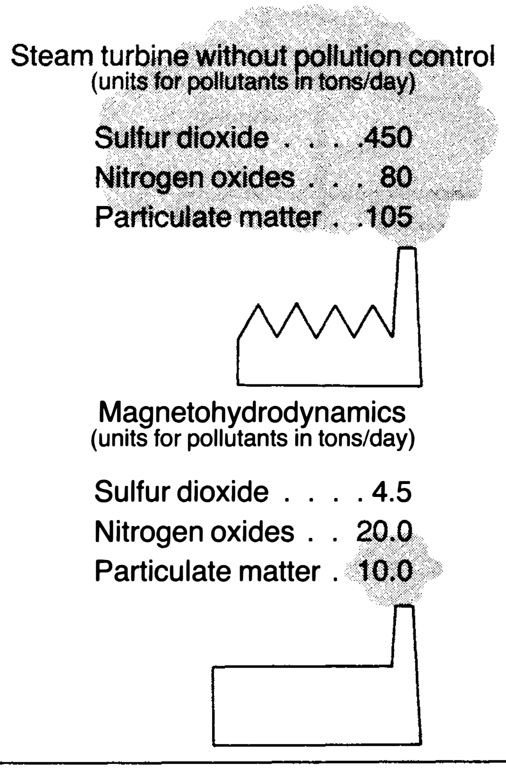
Source: AVCO Everett Research Laboratory.

In an open-cycle system, after the super-heated coal gas passes through the MHD channel in the topping cycle, the still-hot gas is used to produce steam for the steam turbine bottoming cycle. Chemical seed, such as potassium, which increases the coal gas conductivity and also eliminates sulfur from the coal, is reprocessed in the seed regenerator and recycled.

corroding ceramic material. The channel is surrounded by a superconducting magnet. Along each side of the channel is a series of electrodes, which are separated and insulated to prevent short circuits between them. If the electrodes are attached to a load, electrical current is directly drawn off from the channel.

How does MHD conversion eliminate pollution? First, combustion is more complete, and fewer carbon waste products are produced, because fossil fuel is burned at a higher temperature. Second, to increase the electrical conductivity of coal gas, potassium would be added as a seeding material. Experimenters have found that the potassium chemically bonds with any sulfur in the coal, reducing sulfur dioxide emissions by 99%. This eliminates the need for costly and inefficient stack gas scrubbers. To burn coal at high temperatures a new combustor must be designed. It has been found experimentally that, if the amount of air in the combustor is decreased and more oxygen is used, the nitrogen oxide emissions can also be reduced and meet environmental standards (see **Figure 4**).

FIGURE 4
MHD's reduction of atmospheric pollution
(based on 1,000 MW power plant burning coal containing 3% sulfur)



Source: Avco Everett Research Laboratory, Inc.

The figures for steam turbines are for output in the U.S. plants 15 years ago, before plants were retrofitted with pollution controls, and therefore approximate the equivalent technology in Eastern Europe today.

Another environmental advantage of MHD is that thermal waste is diminished. Even in a first-generation MHD system, less cooling water is required, because 60% of the thermal energy is converted to usable power compared to 40% for conventional plants.

MHD can be used in either an open-cycle or closed-cycle configuration. In the case of fossil fuels, the proposed design would place the MHD conversion system as a topping cycle on the power plant. This means that the higher-temperature heat is used first through the MHD generator.

The coal gas exiting the MHD channel has dropped about 2,000°F through the length of the channel, and this hot gas can then be cooled down and used in a conventional steam turbine cycle. This combined-cycle system is projected to potentially produce electricity at nearly 70% efficiency, or *double* today's conventional plants. This increase in efficiency means that each ton of coal used will produce twice as much power.

MHD for nuclear power plants

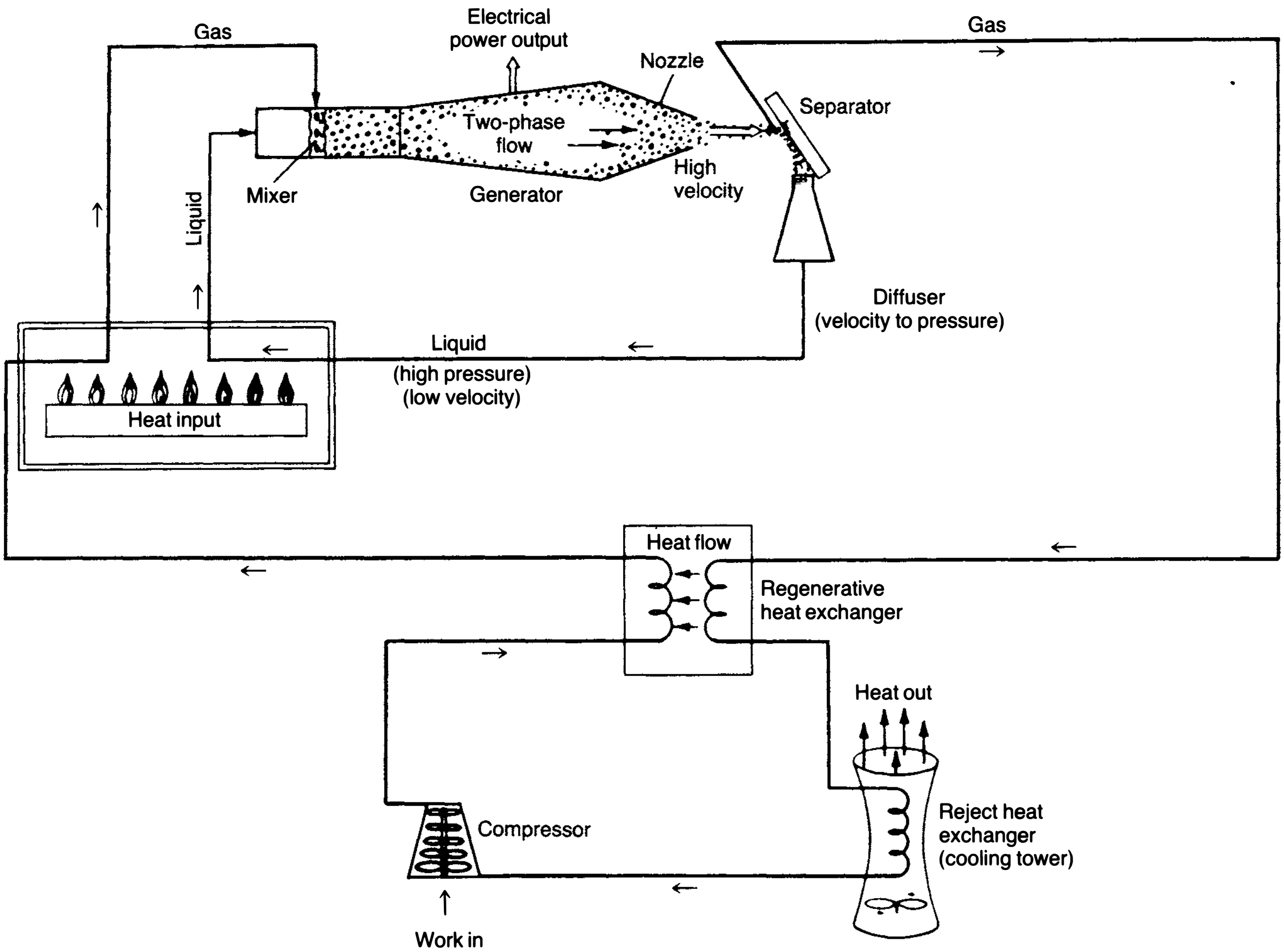
Closed-cycle MHD systems have been designed for conventional nuclear plants, breeder reactors, and high-temperature gas-cooled reactors, where the nuclear process does not produce a "combustion" product made up of charged particles that can be used in an MHD channel directly, but produces heat.

One approach to nuclear-MHD, is to use the nuclear-generated heat to ionize a noble gas, such as argon or helium, and use that as a working fluid. This is a good match to the high-temperature gas-cooled reactor, where the coolant is also a noble gas. Efficiencies of up to 54% have been calculated to be possible using a first-generation closed-cycle noble gas MHD system.

There have been significant programs, particularly in the United States and Israel, in liquid metal MHD research. The U.S. research was geared to a nuclear heat source, while in Israel, the program is geared to solar energy. Though a liquid metal is easily ionized, the major difficulty in using it as a working fluid for magnetohydrodynamics is that it is noncompressible and, therefore, cannot be appreciably accelerated into the MHD channel. To solve that problem, scientists have ingeniously developed a two-phase flow system. An inert gas is the primary working fluid, which expands through the nozzle into the channel. But it also drives a liquid metal mixed with it across the magnetic field lines surrounding the channel. The liquid metal is the electromagnetic fluid (see **Figure 5**). After the two-phase flow exits the channel, it is accelerated to be separated back into its constituent gas and liquid, and recirculated. Experimenters are confident that conversion efficiencies of 80% are possible.

In 1977 researchers at the Argonne National Laboratory in Illinois began experiments using the liquid-gas mixture as a foam. The foam is produced as a stable, homogeneous

FIGURE 5
Liquid-metal MHD for nuclear plants



Source: Argonne National Laboratory.

Rather than using the radioactive fission fuel as the working fluid in nuclear MHD systems, a liquid metal and inert gas can be mixed to produce the conducting medium which goes through the MHD generator. The gas and liquid are then reseparated, the excess heat in the gas vented, and the process repeated.

mixture with a high ratio of gas volume to total volume. It is created in the mixture and destroyed in the separator, with a lifetime of just tenths of a second, as it goes through the MHD channel.

MHD applications

All of these, and many more variations of MHD approaches, are important to pursue. Many will have specific applications, matched to particular energy sources. Magnetohydrodynamics technology has also been demonstrated in unusual applications, such as portable power in inaccessible terrains, where power lines are not available.

Soviet Academician E.P. Velikhov developed and tested a series of portable MHD generators in the 1960s and 1970s used in the mountains of the Soviet Union. The stand-alone power supply used solid rocket fuel and a copper magnetic coil to generate a pulse of electromagnetic energy. These Pamir and Urals generators were used as a sounding device to measure the electrical conductivity of the ground for predicting earthquakes, and locating concentrations of ores and raw materials.

This type of independent, stand-alone power supply could also be used for emergency power and for scientific experiments in remote locations.

One interesting proposal for applications of MHD is to treat what is left over from coal combustion, not as waste, but as a raw material feedstock for various industrial and agricultural chemicals. For example, nitrogen oxide produced from the burning of coal could be *increased,* and retrieved as fixed nitrogen for fertilizer production. If the air is increased 20%, the nitrogen oxides in the exhaust gas can be as high as 4,800 parts per million, which is high enough for recovery to be economical. A chemical plant located adjacent to an MHD power plant producing fertilizer could also process the sulfur from the coal for industrially useful sulfuric acid.

Studies have examined the direct linkage of MHD direct power and high-quality heat to specific industrial processes. The U.S. aluminum producer Reynolds Metals, for example, has been interested in such a system, because cheap hydroelectric resources in the Northwest are being exhausted. The cost of electricity is a most important factor, as it requires about 280 million BTUs (British thermal units) to convert a ton of bauxite ore to aluminum, compared with 27 million BTUs to produce a ton of steel. Reynolds determined that both the direct current from the MHD channel and the high-quality heat left over would meet the requirements for the Bayer process of converting bauxite to aluminum, but the federal government's MHD program never saw fit to fund research and development in the applications of MHD technology.

Magnetohydrodynamics and related techniques have been under consideration for spacecraft propulsion, on-board power generation, and plasma materials processing since the beginning of MHD research. Much of the early advanced research in liquid metal and high-temperature systems was begun in the late 1950s with an eye toward manned Solar System expeditions.

Technology spin-offs

Magnetohydrodynamics opens the door to the next-century plasma technologies that will be the basis for not only electricity production, but also materials processing, manufacturing, and space propulsion.

Creating a commercial MHD system, which can perform in a utility environment, requires the development of a series of new technologies, all of which will be useful for other applications. Commercial-scale MHD power plants, in the 1,000 MW range, will require superconducting magnets, for example.

If high-strength magnets were made out of conventional copper coils for MHD systems, the large amount of energy required to cool each magnet would make the entire system uneconomical. Superconductivity is an effect produced in certain materials at below room temperature, where no electrical loss and no waste heat is generated. A superconducting magnet, once energized, requires no additional energy input, as long as the magnet is kept below the critical superconducting temperature of the material. The magnet must be kept cold, but there is no waste heat to carry away.

Superconducting magnets will be needed if magnetically confined fusion devices are developed. High-power, energy-efficient magnets can also be used for the separation of materials, and for second-generation magnetically levitated trains. Any nation developing magnetohydrodynamics, therefore, will gain important expertise in this crucial future technology.

The first superconducting MHD magnet was built in Japan, and used on the ETL Mark V generator. In 1977, the Argonne National Laboratory built the largest such magnet, weighing 40 tons, which had a field strength of 5 Tesla. It was shipped to Moscow that year, where it was used on the Soviets' U-25 gas-fired MHD test generator, which delivered power to the city electric grid.

New materials will be required for the high-temperature components of the MHD system, especially those exposed to corrosive coal gas. These include the coal combustor and the channel. Such new ceramics will have applications in other coal-based and chemical processes.

The overall advancement of relatively low-temperature plasma technology will revolutionize many metal processes. In East Germany, plasma steel-making has been under development since 1969. At that time an experimental 3-ton capacity furnace was in operation, using a direct current argon arc plasma torch. The plasma torch produces a temperature up to 15,000°C, compared to the 3,600°C maximum temperature in a conventional electric furnace.

Using scrap as the raw material for high-quality alloy metals, the higher plasma temperature allows the recovery of almost 100% of the materials in the scrap. It also decreases iron losses, and has a higher melting efficiency, as well as lower heat and dust exposure and noise level for the operators. Each torch used for the furnace consumes between 12 and 15 MW of power.

In 1977 East German experts and specialists from the Soviet Academy of Sciences in Novosibirsk built a 30-ton furnace which has produced more than 100 grades of high-quality steel alloys, including heat-resistant, corrosion-resistant, and special-alloy tool steels.

Plasma steel-making technology must now be brought quickly into commercial use to replace the obsolete and inefficient equipment in the East today. Many prototype devices have already proven that steel-making that uses coking coal and chemical processing can be superseded by applying higher-quality thermal and radiant energy to metals manufacturing.

An example of a spin-off from even a modest scale of magnetohydrodynamics research, is a plasma-based coal ignition device which was developed from the MHD experiments in Australia. The University of Sydney researchers state that this device will largely eliminate the current need to consume millions of gallons of oil used in starting up big coal-fired boilers in power stations.

Every technology milestone which will be passed in developing magnetohydrodynamic systems will spin off into industry, and help enhance the overall scientific capabilities of the new democracies in the East.

Retrofitting existing plants

Magnetohydrodynamics technology has been under development in the U.S. since the 1950s. In 1959, the Avco Everett Research Laboratory near Boston put the world's first power-generating MHD device into experimental operation, and it has been ready to begin commercial development for at least two decades. But MHD research in the U.S. has always been conceptualized as a "coal" technology, and therefore, the funding has risen and fallen along with the fortunes of coal burning as a favored energy source. During the Reagan years, MHD, along with the nuclear fast breeder reactor and many other technologies, was classified as a "near-term" technology. In Republican lingo, this meant that the "private sector" was supposed to come up with the money to commercially demonstrate the technologies' feasibility. Under this rhetoric, neither the breeder, nor nuclear fuel reprocessing, nor MHD, has advanced very far.

Since the 1970s, consortia of electric utilities and industrial MHD component contractors have advocated retrofitting an existing coal-burning power plant with an MHD topping cycle. This would require adding a high-temperature combustor and other equipment, plus the MHD channel and magnet, to the front-end of a plant.

After the coal gas was taken through the MHD generator, it would then proceed through the steam turbine conversion cycle already in operation at the power plant. It has been estimated that such a retrofit could be accomplished in about three years, if a top-flight technical-industrial team were assembled to do it. Using the expertise that exists in Europe from the relatively small MHD efforts in Poland, the Netherlands, and Italy, and perhaps the Soviet Union, U.S. experts could be deployed to finally bring this cruical technology to commercial demonstration.

The proposal has been to choose a coal-burning electric plant of approximately 50 MW, and place an MHD topping cycle alongside. In addition to burning the coal cleanly and eliminating pollution, an additional estimated 15-20 MW of power would be extracted from the same amount of coal currently being used by the plant.

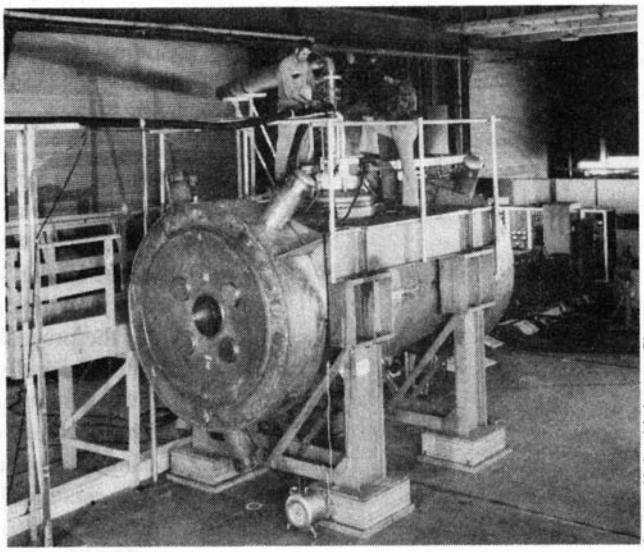
Therefore, the MHD topping cycle could potentially increase the amount of electricity available from existing power plants, while cleaning up the atmosphere. By comparison, retrofitting existing plants with today's technology of stack gas scrubbers, not only requires spending perhaps $100 million, but it also actually *reduces* the amount of power available from the plant. The scrubbers themselves require electricity drawn from the plant in order to operate, and therefore, this low-technology pollution control equipment is a net drain of power. But more importantly, the scrubbers require frequent maintenance, and lead to an increased number of times the facility must be shut down. This lowers the overall plant availability and reliability.

The Electric Power Research Institute has estimated that between 1966 and 1976 steam-cycle coal plant availability was reduced by about 6% due to scrubbers in the United States. The institute estimated in 1980 that each 1% decrease in plant availability leads to a loss of $1 million in purchased replacement power costs, or for the use of older, less efficient operating units to replace the lost power.

Any proposal either to simply close down power plants, factories, and mines which pollute, or to waste billions of dollars in retrofitting old facilities with inefficient pollution control equipment should be seen as what it is—a program to *decrease* the industrial productivity, basic infrastructure, and possibility for future growth of the Eastern nations, as it has done in the West.

Similarly, proposals that the "free market" will somehow take care of these pollution problems are simply sabotage. The government of any nation has the responsibility to provide the infrastructure, which most definitely includes energy, as an *enabling* prerequisite for economic growth.

The research and development in advanced energy and transport technology in the United States over the past 20 years, since the takedown of the space program and the collapse of infrastructure investment, has been sitting on the shelf, unused. Now scientists and engineers in U.S. companies, national laboratories, and universities who have developed these breakthroughs, can join with their European counterparts to change the face of the new democratic nations in Europe. Then, perhaps, the United States will be able to bring back for commercial deployment the technologies it has failed to bring to fruition in the past two decades.



Argonne National Laboratory Photo

The largest superconducting magnet for MHD was built in 1977 at Argonne National Laboratory, and shipped to the Soviet Union. It weighs 40 tons, generates a 5 Tesla magnetic field, and is kept at about 7°F above absolute zero.