Electrical suppliers use a variety of fuel sources to generate electricity. The combination of energy sources used is referred to as the “generation mix.” Our nation’s current generation mix is illustrated in the chart at right.

Using a varied generation mix protects electricity producers and their customers from contingencies such as supply shortages, fuel price fluctuations, and changes in regulatory practices. The generation mix also is key to affordable and reliable electricity for our nation. In planning the type of facility to build for electricity generation, companies must consider the cost and availability of fuel sources.

The generation mix has shifted dramatically over the past 20 years. Changes in legislative and regulatory practices, often prompted by national energy crises, have produced many of these shifts. Access to fuel sources on public lands, tax policies, technology improvements, and environmental requirements also have shaped the cost and availability of fuels for electricity generation.

This timeline provides examples of the many forces that have influenced our nation’s energy policies since 1990. The past fifty years have seen recurring events and numerous policy re-directions. History clearly demonstrates the need for a comprehensive, consistent, and coordinated energy policy in the U.S. — an energy policy that preserves the electric generation mix. Policymakers are called upon to develop policies that foresee, rather than react to, trends.
The first practical nuclear reactor is put into service for a submarine. It is only a matter of time before nuclear energy is approved for electricity generation.

The Atomic Energy Act allows private ownership of nuclear reactors, paving the way for nuclear power plants to be built.

The Price Anderson Act resets limits to plant liability for damage to the public, and thereby promotes nuclear development.

The first gas turbines are placed into service as stationary power sources by U.S. utilities, opening the door to another fuel source for the nation's energy supply.

Jersey Central Power and Light Company announces its commitment for Oyster Creek nuclear power plant, the first time a nuclear plant is ordered as an economic alternative to a fossil fuel-fired plant. This action opens the door to a vast resource for electricity generation.

A series of limited federal air pollution control laws are passed, introducing regulatory controls aimed at utility plants.

The Environmental Protection Agency is created, forming the first federal government entity dedicated entirely to regulating and enforcing environmental laws.

The Clean Air Act is enacted, setting more stringent air pollution standards. It establishes new primary and secondary standards for ambient air quality, sets new limits on emissions from stationary and mobile sources to be enforced by both state and federal governments, and increases funds for air pollution research.

The price of oil soars as an Arab oil embargo begins, precipitating enactment of a variety of federal laws on energy security and efficiency. The embargo also results in increased demand for alternate energy sources, particularly nuclear energy.

The Emergency Petroleum Allocation Act imposes controls on crude oil and petroleum products.

Utilities order 41 nuclear power plants, a one-year record and a move encouraged by the U.S. government. Few of the plants are actually built.

Thirteen nuclear projects are cancelled due to increased costs and decreased electricity demand. Many state agencies that regulate electricity rates do not favor the building of these plants.
1978 The Public Utility Regulatory Policies Act (PURPA) is enacted, requiring utilities to buy power from qualifying non-utility generating facilities that use renewable energy sources or cogeneration. PURPA also facilitates the increased use of natural gas and encourages development of renewables.

1978 The Natural Gas Policy Act decontrols the price of most gas drilled after 1977 and leaves controls on "old gas" found before then. Prices controls on the old gas and all remaining gas were phased out by 1985 by the Natural Gas Wellhead Decontrol Act of 1989.

1978 The Energy Tax Act encourages conversion of boilers to coal, as well as investment in cogeneration equipment and solar, wind, geothermal, and other renewable energy technologies.

1978 The Powerplant and Industrial Fuel Use Act (repealed in 1987) prohibits new utility plants and industrial boilers from burning oil or gas and requires existing plants to phase out use of those fuels by 1990. (Gas phaseout was dropped in 1981.)

1979 A major accident occurs at Unit 2 of the Three Mile Island nuclear plant near Harrisburg, Pennsylvania. No new nuclear plants are ordered or built after this accident.

1979 Oil prices jump, this time due to an Iranian revolution, resulting in pressure to reduce oil use for power generation.

1980 The first U.S. wind farm is built in New Hampshire.

1980 The U.S. Synthetic Fuels Corporation Act is created to encourage development and production of synthetic fuels (repealed in 1986).

1982 The Nuclear Waste Policy Act directs DOE to build a geological repository for high-level nuclear waste. The ban on reprocessing nuclear fuel is lifted.

1986 The Electric Consumers Protection Act contains the first significant amendments to the hydro-licensing provisions of the Federal Power Act, a 1935 law giving the Federal Energy Regulatory Commission (FERC) broad authority over interstate transmission and sale of wholesale electricity.

1990 Clean Air Act amendments mandate additional pollution controls that set limits on the amount of a pollutant in the air anywhere in the U.S. All states must develop state implementation plans (SIPs) to explain how they will achieve the limits set forth in the Clean Air Act.

1990–1991 Iraq invades Kuwait, an oil-rich nation, an action that results in higher oil prices. Operation Desert Storm is launched by the U.S. and the U.N. to force Iraq's withdrawal from Kuwait.

1992 The Energy Policy Act is enacted to address a broad array of energy-related issues.

1993 Commercial production of variable-speed wind turbines begins in the U.S. By 2000, wind power is established as a reliable source of renewable energy. Worldwide, it is one of the fastest growing sources of electricity production (on a percentage basis).

1994 DOE unveils its "million solar roofs" initiative in a federally funded attempt to encourage renewable energy use in every day applications.

1998 President Clinton signs the Kyoto Protocol, which would obligate the U.S. to a 7 percent greenhouse gas emissions reduction target below 1990 levels. If the U.S. Senate votes to ratify the Protocol, the U.S. generation mix is projected to be altered significantly.

1999 The DOE unveils "Wind Powering America," an initiative to support the growth and development of wind power in the U.S.

1999 The EPA sues seven shareholder-owned, coal-based utilities and the Tennessee Valley Authority, alleging violations of the New Source Review Program under the Clean Air Act and putting further pressure on coal-based generators.

1999 Edwards Dam in Maine is breached (torn down), marking an effort to reduce the number of dams used to generate electricity. The relicensing of hydroelectric facilities is one mechanism being utilized to reduce the use of hydropower. Between 1999 and 2010, 228 hydropower projects face relicensing.

2000 The Nuclear Regulatory Commission approves the first renewals, for 20-year periods, of nuclear power plant operating licenses. Calvert Cliffs in Maryland becomes the first to be relicensed.

2000 A federal appeals court upholds EPA's NOx SIP call rule in 19 of the 22 states covered by the regulation, maintaining pressure on coal-based generators to further decrease nitrogen oxide (NOx) emissions from coal-based power plants.

2001 Natural gas prices continue to reach historic highs, contributing to spikes in electricity and home heating costs.
New Power For The Next Century

A Harvest of Technology

GAS TURBINE MODULAR HELIUM REACTOR

DOE002-0593

Obtained and made public by the Natural Resources Defense Council, March/April 2002
Steam still generates most of the world’s electricity. We burn coal, gas and oil, and use nuclear power to turn water into steam to drive turbines which produce electricity. Even larger quantities of gas and imported oil are being consumed for other energy requirements including transportation. Burning fossil fuels can be very expensive and taxing to the environment. Oil accounts for over half of our entire balance of payments deficit. . . more than a billion dollars a week in foreign oil imports . . . up the chimney, out the tailpipe and into our atmosphere.

**BACKGROUND**

There is a cleaner, more economical, and much safer way to generate electricity. The Gas Turbine - Modular Helium Reactor (GT-MHR) is a new turbine generating system powered by a passively-safe nuclear reactor. It eliminates the need to make steam to produce electricity, and frees us from the pollution and waste of fossil-fuel generating plants. It could also help to reduce our billion dollar a week deficit for foreign oil.

**THE FUTURE**

By capitalizing on late 20th century technologies, the GT-MHR achieves high efficiency with a compact operating system and elegant simplicity. The gas turbine power cycle is far superior to the century-old steam plant technology employed in all other nuclear plant designs. The super-safe GT-MHR power plant includes one or more modular units in underground silos, each containing a reactor vessel and a power production vessel.

**WHY IT WORKS**

Because helium is naturally inert and single-phase, the helium-cooled reactor can operate at much higher temperatures than today’s conventional nuclear plants. The higher the turbine’s operating temperature, the more efficient the plant becomes . . . mandated by the laws of thermodynamics.

To this is added the efficiency of the helium directly driving the turbine, instead of having to go through a large heat exchanger to produce steam.

**DESIGN SIMPLICITY**

The combination of the MHR and the gas turbine represents the ultimate in simplicity, safety and economy. The reactor coolant directly drives the turbine which turns the generator. This allows costly and failure prone steam generating equipment to be eliminated.

- *No corrosion-caused leaks*
- *No corrosion-caused reduction in operating life*
- *No stress corrosion-caused structural failures*
The GT-MHR combines a meltdown-proof reactor and advanced gas turbine technology in a power plant with a quantum improvement in thermal efficiency... approaching 50%. This efficiency makes possible much lower power costs, without the environmental degradation and resource depletion of burning fossil fuels.

EFFICIENCY FROM THERMODYNAMICS

Conventional, low-temperature nuclear plants operate at about 32% thermal efficiency. GT-MHR power plants can achieve thermal efficiencies of close to 50% now, and even higher efficiencies in the future.

* 50% more electrical power from the same number of fissions.
* Dramatically lower high-level radioactive waste per unit of energy – today's reactors produce 50% more high-level waste than will the GT-MHR.
* Much less thermal discharge to the environment. Plants can use air cooling.
THE SIMPLICITY OF THE GAS TURBINE AND THE HELIUM REACTOR PROVIDE THE NEXT GREAT STEP IN NUCLEAR POWER

PLANT DESCRIPTION

The entire GT-MHR power plant is essentially contained in two interconnected pressure vessels enclosed within a below-ground concrete containment structure. The larger vessel contains the reactor system and is based on the steam-cycle MHR which has been under development as part of the U.S. Department of Energy’s Modular High Temperature Gas-cooled Reactor program.

The second, smaller vessel contains the entire power conversion system. The turbo-machine consists of a generator, turbine and two compressor sections mounted on a single shaft rotating on magnetic bearings. The active magnetic bearings control shaft stability while eliminating the need for lubricants within the primary system. The vessel also contains three compact heat exchangers. The most important of these is a 95% effective plate-fin recuperator, which recovers turbine exhaust heat and boosts plant efficiency from 34% to 48%.

As an added benefit, the GT-MHR also has the potential to consume weapons-grade plutonium as fuel to provide electrical energy.

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Obtained and made public by the Natural Resources Defense Council, March/April 2002
HIGH EFFICIENCY AND PLANT SIMPLICITY PRODUCE
LOW-COST ELECTRICITY AND MINIMIZE WASTE

ECONOMICS

- Dramatic system simplification combined with high efficiency results in impressively low power costs, even competing with those of natural gas-fired, combined-cycle systems.

- Fewer systems and fewer parts significantly reduce the complexities of conventional reactor systems.

- Modularized, factory-controlled, serial production ensures industrial-type economy based on established learning curves, rather than elusive economies of scale.

- Simple systems based on passive and inherent safety characteristics and slow transient responses mean simpler licensing and reduced staffing needs.

CONSERVATION

The GT-MHR technology can help reduce fossil-fuel usage four ways:

- Nuclear-generated electricity saves fossil fuels.

- High temperature characteristics make the MHR ideal for supplying high-grade thermal energy for oil and gas-intensive industrial processes.

- Waste heat is at the ideal temperature for use in district heating.

- Inexpensive electricity can be used to charge electric vehicles, further saving gas and oil. Ultimately, the MHR's high temperature capability will make hydrogen and methanol economically attractive for transportation uses.

THE ENVIRONMENT

- The GT-MHR is free of the emissions associated with burning fossil fuels.

- Radioactive emissions from helium-cooled reactor plants are lower than those from comparably sized coal-fired plants.

- The MHR spent fuel characteristics result in substantially reduced proliferation risks.

- Worker radiation doses are only a fraction of those from today's nuclear power plants.

- MHR thermal discharge to the environment is low, due to the system's high efficiency.

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DOE002-0597

Obtained and made public by the Natural Resources Defense Council, March/April 2002
THE ROBUST, CERAMIC FUEL RETAINS ITS INTEGRITY EVEN UNDER THE MOST SEVERE ACCIDENT CONDITIONS AND SIMPLIFIES THE SAFETY EQUATION

A SIMPLER, MORE RATIONAL WAY TO THINK ABOUT NUCLEAR SAFETY: FOUR LEVELS OF SAFETY*

Level 0:
No hazardous materials or confined energy sources.

Level 1:
No need for active systems in event of subsystem failure.
Immune to major structural failure and operator error.

Level 2:
No need for active systems in event of subsystem failure.
No immunity to major structural failure or operator error.

Level 3:
Positive response required to subsystem malfunction or operator error.
Defense in depth. No immunity to major structural failure.

The MHR is the only reactor that meets the criterion of Level 1 safety. Its design is derived from natural properties of materials and optimum choice of reactor size, geometry and power density. It can withstand the total loss of coolant without the possibility of a meltdown — going beyond simply saying "it is safe enough."

The Chernobyl and Three Mile Island reactors fall in the Level 3 category.

The Chernobyl power runaway was initiated by human error which resulted in loss of coolant, which led to structural failure.

The Three Mile Island core melt accident was caused by human error which resulted in loss of coolant. Core melt caused radioactivity release from the reactor vessel, but containment effectively confined radioactive release.

*Definition developed by Professor Lawrence Liddel, Massachusetts Institute of Technology.

The MHR is the only...
WHAT A LARGE NEGATIVE TEMPERATURE COEFFICIENT MEANS TO SAFETY

The picture has captured a power pulse in a TRIGA research reactor where the power increased 4,000 times over its normal operating range. This intentional power increase lasted only about one hundredth of a second because the reactor has a very large negative temperature coefficient which naturally shuts the reactor down. . . guaranteed by the laws of nature.

Like other U.S. power reactors, the GT-MHR has a negative temperature coefficient.

By contrast, Chernobyl had a positive reactivity coefficient; its temperature increase acted to intensify the fission reaction, thus causing a runaway.

SAFETY: THE EFFECTS OF DECAY HEAT

Decay heat, resulting from the decay of fission products, is a phenomenon in all reactors. The heating does not stop when the power is shut off, so having a negative temperature coefficient is good but not enough.

The decay heat at Three Mile Island caused the reactor fuel to melt, even after the fission reaction had essentially stopped, because of the loss of cooling water.

The Modular Helium Reactor's decay heat will not cause a meltdown even if the coolant is lost. The reactor's low power density and geometry assure that decay heat will be dissipated passively by conduction and radiation without ever reaching a temperature that can threaten the integrity of the ceramically-coated fuel particles . . . even under the most severe accident conditions.

*reactor that meets the criterion of Level 1 safety.*

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DOE002-0599

Obtained and made public by the Natural Resources Defense Council, March/April 2002
THE TURBOMACHINERY AND HEAT EXCHANGER TECHNOLOGIES REQUIRED
FOR THE GT-MHR HAVE ALREADY BEEN DEVELOPED BY INDUSTRY

AIRCRAFT INDUSTRY EXPERIENCE

The MHR gas turbine uses the same technology as the modern jet engine. However, in the case of the MHR, its design requirements are less demanding. Temperatures, stresses and blade tip speeds are all far below those proven in millions of hours of aircraft engine operation. Although most of the components represent current state-of-the-art technology, additional design work is needed to integrate them into the most economical and reliable package. Supercomputers will aid in analyzing the dynamics of the gas turbine power-producing module before the prototype hardware is built. This design approach is very similar to that which went into the Boeing 747-400..., which had to work the first time.

Even more intriguing, the gas turbine uses the same technology which powers the 747... the modern jet engine. Just as it replaced the reciprocating engine for modern world-spanning travel, so will the gas turbine replace the steam turbine to generate electricity.

RECUPEROTATOR EXPERIENCE

New plate-fin recuperators are highly efficient and compact heat exchangers. The GT-MHR recuperators will draw on extensive experience from the fossil-fuel power industry, including the construction of sixty such units for large gas turbine plants.

LARGE HELIUM TURBINE
OVER 30 YEARS OF EXPERIENCE PROVIDE AN EXTENSIVE DATA BASE

England - Dragon - 1964 to 1976 — This helium-cooled test reactor provided early successful demonstration of the high temperature gas-cooled reactor.

Germany - AVR - 1966 to 1988 — This prototype helium reactor operated successfully for over 20 years and provided demonstration of 1740°F gas outlet temperature and key safety features, including safe shutdown with total loss of coolant circulation and without control rod insertion.

U.S. - Peach Bottom - 1963 to 1974 — This prototype helium reactor achieved a remarkable 96% availability during the electricity production phase.

U.S. - Fort St. Vrain - 1979 to 1989 — This reactor used water-lubricated circulator bearings which resulted in frequent water ingress into the reactor system and caused significant down time. In spite of a poor operating record, the Fort St. Vrain control fuel and reactor core worked extremely well. Because of the non-corrosive nature of helium, workers were exposed to radiation doses only about 1% that of average water reactors. Fort St. Vrain generated about 5 billion kWh.

Germany - Oberhausen 2 - 1975 to 1987 — This 50 MW electric turbine plant represented the evolutionary step from fossil-fuelled gas turbines with air as the working fluid towards the realization of nuclear powered helium gas turbines. Helium was used as the working fluid in a closed-cycle process for electricity and heat production. The plant incorporated heat exchangers (recuperator, precoolers, intercoolers) of comparable size to those required for a 600 MW thermal GT-MHR.

Germany - THTR - 1985 to 1988 — This helium-cooled nuclear power plant generated about 3 billion kWh. Political resistance in the post-Chernobyl era precipitated early shutdown.

Russia — Various successful demonstrations of fuel fabrication and fuel irradiation performance.

Japan — A high temperature helium-cooled test reactor is now under construction.
INDUSTRY EXPERTS BELIEVE THE TECHNOLOGY REQUIRED
HAS ALREADY BEEN DEVELOPED

Now...a timely convergence of four state-of-the-art technologies offers quantum improvements in power generation efficiency and cost.

1. The helium-cooled reactor in modules of up to 600 thermal megawatts matches the size of the newest gas turbines, while maintaining the inherent safety characteristics demonstrated in the steam-cycle helium-cooled reactor.

"A unique characteristic of the helium-cooled reactor is its high gas temperature which enables efficient electricity generation directly from a gas turbine generator in the reactor system. This eliminates the need for complex, costly and inefficient steam cycle equipment and results in the most efficient and economic reactor ever. The meltdown-proof modular helium reactor takes full advantage of over 30 years and billions of dollars of gas reactor design and development."

MARK FORBES, SENIOR VICE PRESIDENT (HELIUM REACTORS), GENERAL ATOMICS

2. Gas turbines using fossil fuels achieve high efficiencies in aircraft and in electric power generating stations. Higher operating temperatures and continually improving reliability have produced high efficiency and low power cost. This technology is directly translatable to a nuclear heat source with helium as the coolant.

3. Magnetic bearings are proving superior in diverse applications, including natural gas pipeline pumping stations. Magnetic bearings are essentially frictionless and provide longer equipment life.

"The GT-MHR turbomachinery is a logical application of our successful jet engine and power turbine technology. Sizes are similar, and stresses, temperatures and pressures are either less demanding or comparable to those in our latest civil transport engines. Helium is an excellent working fluid. Being inert, helium eliminates concern over oxidation and corrosion. In properties provide subsonic flow fields throughout the machine and eliminate the complexities of transonic and supersonic flows in the blading.

The GT-MHR magnetic bearings are a modest extension of existing in-service technology. They are essentially frictionless, and provide automatic and adjustable dynamic dampening and on-line monitoring resulting in improved performance and reliability. Of particular importance is the elimination of oil-lubricated bearings and the potential ingress of oil into the working fluid.

All things considered, we think the GT-MHR is a highly rational, practicable and economic approach to the next generation of nuclear power plants."

T.A. DOMHUR, GENERAL MANAGER, ADVANCED TECHNOLOGY OPERATIONS, GENERAL ELECTRIC

4. Compact plate-fin recuperators developed for fossil-fired applications are capable of achieving 95% effectiveness.

"The recuperators for the GT-MHR are about the same size as units we have made for the fossil fuel power industry. In fact, we have made some 2½ million units using this type of construction, sixty of which have been for large gas turbine plants. These sixty units utilize approximately 1,000 individual brazed modules. GT-MHR temperatures are less demanding than units now in operation, and efficiencies are within the range of units previously delivered. Pressures are higher, but we do not see that as a problem. The non-corrosive helium environment is very beneficial."

DR. J. A. FREDERICK, DIRECTOR, RESEARCH & TECHNOLOGY, ALLIED SIGNAL AEROSPACE

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DOE002-0602

Obtained and made public by the Natural Resources Defense Council, March/April 2002
Nuclear Reactors Everyone Will Love

By PAUL E. GRAY

The American nuclear industry is its own worst enemy. By trying to push ahead with vast, costly projects that have been stalled by political opposition, it exacerbates the irrational public fears that have blocked the development of nuclear power in the U.S. Instead, utilities should be exploring a new approach: modular nuclear reactors that are much smaller, designed to fit within a 300-foot square, and whose safety systems can withstand the maximum temperatures possible under the worst of circumstances. Their design limits the power density of the reactor core as is the actual size of the core, and exploits natural processes to remove heat and avoid fuel damage in the event of a loss of coolant.

Such "passively safe" reactors can be designed to suffer the simultaneous failure of all control and cooling systems without danger to the public. And their safety can be demonstrated by an actual test: a West German modular reactor has passed such tests three times.

It is possible to design and build reactors that could survive the failure of components without fuel damage and without releasing radioactivity.

One of the most advanced of these modular reactors is under study at the Massachusetts Institute of Technology. It is based on the West German reactor that has demonstrated its safety, but adds several technologies in which the U.S. still has a competitive advantage. For example, the hot gas that leaves the reactor is used directly to spin a turbine (based on aerodynamic designs), which, in turn, drives a small, very high speed generator (based on power electronic technology). This combination results in a power-generating system that is substantially smaller and more efficient than current LWR systems, which are based on steam turbines and coal-fired generators.

By virtue of its inherent or passive safety features, this small, gas-cooled reactor eliminates the complex, active safety systems needed by current LWRs. The gas turbine eliminates the complex, hard-to-maintain, steam generators common both to nuclear plants and to fossil-fired power plants. The result is a power plant that produces electricity not only at lower cost than nuclear reactors (an easy target), but that is competitive with the projected cost of next-generation "clean" coal-fired plants. Power from such coal generators, the Department of Energy calculated in 1986, would cost an average of 5.5 cents per kilowatt hour. Power from modular reactors can be brought to market for 4.5 cents per kilowatt hour.

These savings can be realized because the new plants will be made to a single, preengineered design in central factories. Construction costs are estimated to be less than $1,900 per kilowatt of electricity. Costs per kw for the Seabrook reactor in New Hampshire and the Shoreham project in Long Island were more like $5,000 to $6,000, primarily because of long delays and extensive redesign during construction.

Operating costs of traditional nuclear plants are also much higher than those of modular plants, because the older type require very large staffs—700 people per plant—to oversee their involved safety systems. Modular reactors could offer much more safety with staffs only half as big.

These new plants will not only be cheaper to build, but the added bonus of high efficiency means there will be less heat to throw away. The plants will be easier to site because they cause less damage to the local environment. And, best of all, they will not do harm to the atmosphere.

These new reactors do not eliminate the waste disposal problem, but their ceramic encapsulated fuel does simplify it. A fuel that can survive unscathed in a reactor...
US Needs Fresh Approach to Nuclear Energy

By Edward Teller

The nuclear-power industry in the United States is currently in a hiatus. The primary reason for this is rooted in the industry itself. The nuclear industry has had the technical capability to make reactors that cannot melt down. But it has not done so.

Why has the nuclear industry not pushed more vigorously in the direction of the low power density, low-pollution, high-price, high-temperature requirements and the need for premature replacement of major systems, such as steam generators? Perhaps because of the lack of public and institutional support, and the huge existing investment in first-generation reactor technology. There has been concern that the cost of meltdown-proof safety characteristics could not be justified.

These factors have made the industry and the government reluctant to pursue quantum improvements in reactor designs. As a result, the world is struggling with acceptance of 30-year-old technology and, at the same time, proceeding along a dangerous path: overreliance on Middle East oil and current expensive and reflective nuclear systems.

Like all energy sources throughout history, first-generation nuclear reactors have had problems. The most obvious are those of Three Mile Island and Chernobyl. There are also the problems of costs and schedule caused by systems that are too big, too complicated, and too expensive. High operating costs, aggravated by spiraling regulatory requirements and the need for premature replacement of major systems, such as steam generators, have undermined public confidence and nuclear power's competitiveness. Finally, there are concerns about radioactive wastes with half-lives of thousands of years and nuclear proliferation.

In the face of this history and many justifiable concerns, some people have suggested simply abandoning nuclear power. I believe it would be shortsighted and foolish to do so.

With the best second-generation reactor design we have the ability to address virtually all of the concerns about nuclear power. In meltdown-proof reactors, the power density is low and the reactor size is such that there is not enough heat available to fail — even during an accident involving complete loss of coolant.

Sitting the reactors underground enhances security and containment features. These features also effectively eliminate the risk to the public from potential sabotage, terrorist activity, or even overt military attack. Modularizing the reactors and building them in factories with factory cost and quality-control measures make their cost and schedules predictable and minimal.

The leading work on one such reactor design, halium reactor technology, is currently being done by General Atomic of San Diego. The first work on the technology began in Russia in 1949 and substantial advances were made in Germany through the '60s and '70s. Improvements of this kind should help the public acceptance of nuclear reactors. Indeed, they are needed to offset the consumption of millions of barrels of imported oil and billions of cubic feet of natural gas.

First-generation reactors have had problems. The best second-generation designs can address virtually all of the concerns about nuclear power.

With the plutonium, it is insufficient because it only gets the plutonium out of sight. It does not destroy it. We should not be happy with any plan in Russia that leaves plutonium where it can be dug up and reconstituted into bombs. Likewise, the Russians should not be satisfied with a plan that does not destroy US plutonium.

And no one should be satisfied with any plan that does not take advantage of the huge energy potential of the plutonium, which can be captured even as the plutonium is destroyed for all time. This destruction should not rely on constant reprocessing. It should be destroyed as totally as possible in one cycle. This is the most decisive way of dealing with surplus plutonium. If it is not dealt with in such a manner, this material can fall into the wrong hands.

Growing world energy requirements, particularly in the third world, must also be dealt with. Yet the third world would be relegated to consuming huge amounts of irreplaceable fossil fuels, ripping down its forests, or fighting for resources that are fundamental to civilized progress.

In my opinion the best alternative, the key to accomplishing these essential synergistic objectives, is completing the development of a truly modern, inherently safe reactor. I believe the public would look differently at reactors that could not melt down, as compared to present reactors, which cannot be without their share of accidents.

I believe the public would prefer reactors that are sited underground and are less subject to terrorists and seismic events. I believe the public would like to see reactors for the future that are built substantially in factories with factory cost and quality control. Such reactors would be more economical than and can ultimately replace present reactors, which use 50 percent more nuclear fuel resources, create 50 percent more waste, and exhaust 100 percent more thermal energy to the environment.

The nuclear-power industry has made great contributions worldwide to reduced reliance on Middle East oil and reduced toxic emissions to the environment. The public must be brought to appreciate this and recognize the importance of energy to productivity and improved living standards.

Even the Club of Rome now believes the world is headed for serious energy problems because of its reliance on fossil fuels. I believe we must rally our intellectual and technical resources and deliver the best nuclear power possible to ease this problem.

The nuclear industry's current fixation on reactors that represent the technical status quo and the Department of Energy's lack of support of research and development of inherently safe meltdown-free reactors is unworthy of the great American tradition of creating a better future through progress in technology.

Edward Teller is a senior research fellow at the Hoover Institution in Stanford, Calif.

January 31, 1994
Fueling Electricity Growth for a Growing Economy

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National Economic Research Associates

Prepared for Edison Electric Institute

January 2001

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DOE002-0605

Obtained and made public by the Natural Resources Defense Council, March/April 2002
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Fueling Electricity Growth for a Growing Economy

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www.eei.org

January 2001

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DOE002-0607

Obtained and made public by the Natural Resources Defense Council, March/April 2002
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Published by:
Edison Electric Institute
701 Pennsylvania Avenue, N.W.
Washington, D.C. 20004-2696
Phone: 202-508-5000
Web site: www.eei.org
Publications orders: 1-800-EEI-5453

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Obtained and made public by the Natural Resources Defense Council, March/April 2002
Fueling Electricity Growth for a Growing Economy

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DOE002-0614

Obtained and made public by the Natural Resources Defense Council, March/April 2002