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The Cheney Energy Plan: Technically Unsound and Unsustainable

BY ARJUN MAKHIJANI

In May 2001, a task force led by United States Vice-president Dick Cheney issued a report entitled *National Energy Policy: Report of the National Energy Policy Development Group*. An alternative title is provided inside: *Reliable, Affordable, Environmentally Sound Energy for America's Future*. The report is often called the Cheney Plan for short. It is on the Internet at http://www.whitehouse.gov/energy/. It has unleashed a flood of debate on energy policy questions. This debate has been needed for some time for a number of reasons:

- U.S. emissions of carbon dioxide, the principal greenhouse gas, are at record highs and rising, in contrast to those of the European Union and, in recent years, even China.
- The rising world demand for oil and growing U.S. oil imports are occurring in the context of a renewed political-military crisis in the Middle East, both as regards Israel-Palestine and Iraq. There is also an emerging competition between the United States, Russia, and possibly China over the oil and gas resources of the Caspian-Central Asian region (including Iran).[1] The U.S. imports about 55 percent of its oil requirements. At about 11 million barrels a day imports, it is, by far, the world's largest oil importer.
- Utility deregulation has produced chaotic conditions, including electricity prices in California, that were literally unthinkable at the start of the year 2000. The highest reported price

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MARK FREDERICKSON/CLEAN WATER ACTION ALLIANCE OF MINNESOTA

A wind farm in Minnesota. See page 9 for information on wind energy potential in the United States.

Rokkasho: A Troubled Nuclear Fuel Cycle Complex

BY MASAKO SAWAI[1]

Following the sodium leak and fire at Monju fast breeder reactor in December 1995[2], Japan switched the focus of its nuclear fuel cycle policy from fast breeder reactor development to MOX (mixed oxides of plutonium and uranium) fuel use at light water reactors. The MOX plan is commonly called the plu-thermal program in Japan. While fast breeder reactor (FBR) development has been hindered mostly by technical problems, the plu-thermal program has been met with great difficulty due to strong local opposition. As such, there are many people, even among the nuclear promoters, who back a "once through" approach.[3] However, neither the utilities, the Japanese government, nor the country's Atomic Energy Commission have plans to end their promotion of the plu-thermal program.

In fact, as part of the plu-thermal program, several facilities

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was $3,880 per megawatt-hour. That is almost 40 times the peak price of about $100 per megawatt-hour considered appropriate as the upper limit for peak electricity power charges prior to deregulation. Even at the extremely high price of natural gas at $10 per million Btu (British thermal units), which prevailed briefly last winter (it is just over $3 at the time of this writing, July 2001, and was $2 in early 2000), a reasonable maximum price of peaking power would be about $200 per megawatt-hour. A good deal of peaking power can be generated for much less.

While the Cheney Plan devotes a substantial proportion of its pages to renewable energy sources, efficiency, equity, and environment, the recommended actions in these areas are minor, and place all of these issues at the margins of energy policy. Reduction of emissions of carbon dioxide is not a part of the plan, which mentions voluntary measures by corporations in this regard. The *National Energy Policy* does not mention the Kyoto Protocol, the international treaty to reduce greenhouse gas emissions,[2] which the United States has signed but which the Bush administration has rejected. The United States is responsible for about 25 percent of the world's greenhouse gases. (See the chart on the following page for a comparison of U.S. greenhouse gas emissions to those of other countries.)

The central focus of the plan (to be found in Chapter 5) is increasing energy supply using coal, oil, gas, and nuclear energy. Complementing that supply focus, in the related chapters 7 and 8, are infrastructure developments and foreign policy measures. The following are some of the practical highlights of the *National Energy Policy:*

- *Oil and natural gas*: The proposed policy would (i) open up federal lands to drilling for oil and gas, notably by reducing "restrictions" currently placed on such drilling; (ii) open a part of the Alaska National Wildlife Refuge (ANWR) for oil and gas drilling (the U.S. Geological Survey estimates oil reserves there to be between 5 and 15 billion barrels of oil); (iii) encourage drilling in offshore Arctic areas off Alaska; (iv) consider measures for reducing "risk associated with production [of oil and gas] in frontier areas," and "incentives" such as reduction of royalty payments to the government from new offshore oil and gas production; (v) promote "enhanced oil and gas recovery from existing wells through new technology."
- *Coal*: The proposed policy would provide $2 billion for research on clean coal technologies and "provide regulatory certainty" that would make it easier to invest in coal burning for electricity generation. This appears to be an implicit reference to potential regulations on carbon dioxide emissions that have been a source of concern to the coal industry.
- *Nuclear power*: The proposed policy would "support the expansion of nuclear energy in the United States as a major component of our national energy policy." This support would include (i) easier relicensing of existing nuclear power plants beyond their design lifetimes, (ii) encouragement of new nuclear power plants at existing nuclear power plant sites, possibly without any new

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6935 Laurel Avenue, Suite 204
Takoma Park, MD 20912, USA
Phone: (301) 270-5500
FAX: (301) 270-3029
E-mail: ieer@ieer.org
Web address: www.ieer.org

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Editor: Lisa Ledwidge

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environmental impact statement process, (iii) encouragement of research in a new form of reprocessing called pyroprocessing, in order to promote development of "advanced nuclear fuel cycles and next generation technologies for nuclear energy" (p. 5-17). This is an implicit reference to the Integral Fast Reactor, which is a sodium-cooled breeder reactor with a pyroprocessing plant attached to it. The plan also advocates foreign collaboration on commercial nuclear fuel reprocessing, with countries such as France. The nuclear energy part of Chapter 5 also states that a new reactor type called the Pebble Bed Modular Reactor has "inherent safety features" (p. 5-16), but does not mention any of its safety vulnerabilities. (See Dear Arjun column on page 13 for a discussion of this reactor.)

- *Electric power plants*: The plan advocates that the United States should build between 1,300 and 1,900 new electric power plants by the year 2020 based on projected demand. (The standard power plant size assumed appears to be 300 megawatts.)
- *Infrastructure*: New natural gas and electricity transmission lines would be encouraged by granting rights of way on federal lands and by new "legislation to grant rights-of-way for electricity transmission lines, with the goal of creating a national transmission grid." This would create federal power to acquire land for interstate commerce on a basis similar to current law for natural gas pipelines (pp. 7-7 and 7-8).

One overall provision would tilt the entire federal decision-making process towards energy supply. In the supply measures portion of the summary, the plan recommends that the president "[i]ssue an executive order directing all federal agencies to include in any regulatory action that could significantly and adversely affect energy supplies a detailed statement on the energy impact of the proposed action" (p. xiv). For example, if a new national park is to be created, then its energy impact will have to be examined. There is no corresponding provision on the energy demand, or efficiency, side of the equation.

The plan falls far short as regards renewables, efficiency, distributed grids, and decentralized combined generation of heat and electricity (called cogeneration, which is often far more efficient than producing heat and electricity separately), even though these measures could increase energy efficiency by the criterion of the second law of thermodynamics. (For a description of the second law of thermodynamics, see "Dear Arjun" in *Science for Democratic Action* vol. 6 no. 3, March 1998.) For instance, while the plan goes into detail about reducing regulatory and institutional blocks for oil, gas, and nuclear energy, it does not make a single recommendation in this regard for distributed grids. It completely ignores an excellent study produced by the National Renewable Energy Laboratory of the Department of Energy, published in July 2000,[3] which provides extensive documentation of such regulatory and institutional barriers to cogeneration, renewable

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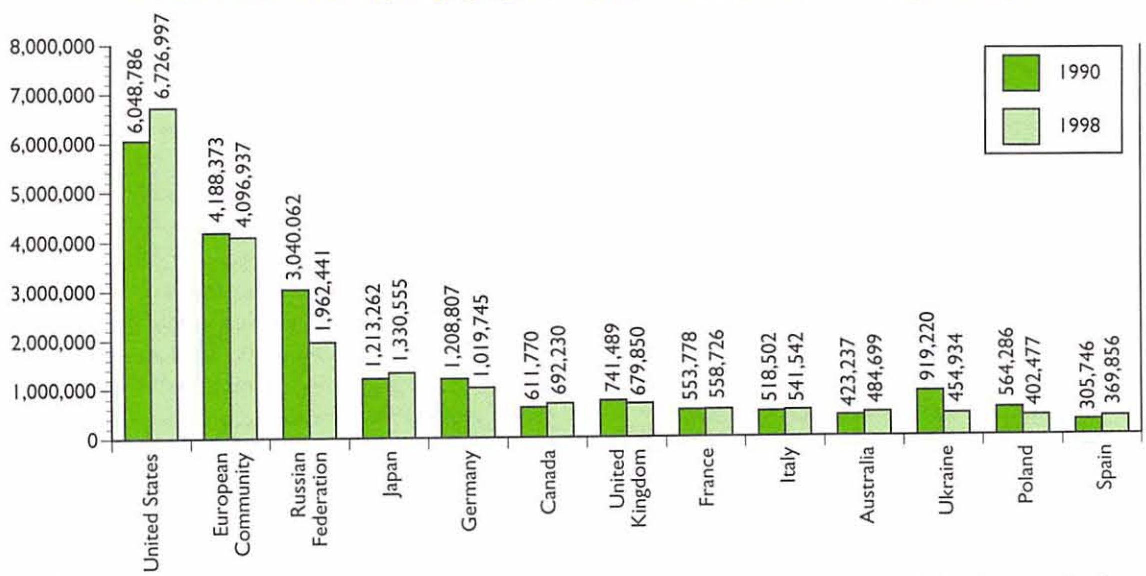
Total Aggregate Greenhouse Gas Emissions in CO_2 Equivalent, 1990 and 1998 (in gigagrams, or millions of kilograms)



Source: United Nations Framework Convention on Climate Change, *National Communications from Parties Included in Annex I to the Convention: Greenhouse Gas Inventory Data from 1990 to 1998,* FCCC/SBI/2000/INF.13 (The Hague, Netherlands: United Nations, 11 October 2000), accessed via http://www.unfccc.int/resource/ghg/tempemis2.html on 3 August 2001.

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energy generation, and other decentralized power plants that would fit into distributed grids. The resistance of major power companies to such projects, expressed in the form of unreasonable charges for backup power supply for instance, continues to be a major problem, as it has been for decades.

The Cheney Plan would provide tax credits and subsidies for certain efficiency improvements and renewable energy sources. It would:

- Enact new legislation to provide a tax credit for cogeneration.
- Continue the 1.7 cents per kilowatt-hour subsidy for wind-generated electricity.
- Provide a tax credit for hybrid cars and fuel cell cars, both of which are more efficient than standard gasoline vehicles. Hybrid cars, which use gasoline as a fuel, run part of the time on batteries charged by energy recovered, for instance, during braking.
- Allocate $1.2 billion of the money that the U.S. government would get from leasing ANWR to oil companies toward research and development funds for renewables. This money would not be available if ANWR is not leased.
- Provide some modest tax breaks and credits in other areas, such as solar energy.
- Continue certain information programs to encourage greater energy efficiency and use of renewable energy sources.

The plan also recommends that the Secretary of Transportation recommend whether and what mileage standards for vehicles (known as Corporate Average Fuel Efficiency, or CAFE, standards) might be established after taking into account a new study by the National Academy of Sciences. The study, released on July 31, 2001, suggested a number of measures to increase efficiency standards but made no firm recommendations.[4]

The CAFE standard for passenger cars is currently 27.5 miles per gallon (mpg) and has not been tightened since model year 1985[5], even though gasoline fueled cars using hybrid technology that get 60 mpg are now commercially available. Diesel hybrids can reach up to 100 mpg with current technology. The CAFE standard for light trucks (a category that includes sport utility vehicles, cargo vans, minivans, and pickups) has increased only gradually since the mid-1980s and is now only 20.7 miles per gallon.

Overall evaluation of the plan

The most notable accomplishment of the plan is that it has made energy into a central topic of national discussion at a time when such debate is urgently needed. The topic has been sorely neglected on a bipartisan basis for the last two decades. But the substance of the plan is technically unsound and unsustainable. It neglects the fact that the energy system consists of complex interactions between the aspects of supply, distribution, conversion (from fuel to electricity), and utilization system. It would considerably increase carbon dioxide emissions, when large decreases are needed.

Specifically, the plan takes no account of the fact that the efficiency of energy use in the United States is still very low, despite some improvement over the past 25 years. By measures related to the second law of thermodynamics, the efficiency of many parts of the energy system, such as lighting and heating, and cars and sport utility vehicles (if just the human loads are taken into account), is in the one to ten percent range.

Some criteria by which to evaluate the Cheney Plan or any other energy plan are shown in the box. It is difficult to match the last three criteria, as a group, to the first three. For instance, nuclear energy creates large quantities of plutonium and relies on reactors that can have catastrophic accidents that would pollute the land for uncounted generations. As another example, the present global energy system emits more than 6 billion metric tons of carbon (in the form of carbon dioxide to the atmosphere), but the natural absorption capacity is about half that. Both these systems fail the sustainability test.

Currently, the world's reliance on the Persian Gulf region has created a vulnerability to shocks and is also

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SUSTAINABLE ENERGY SYSTEM CRITERIA

The following criteria, if met simultaneously, could result in an environmentally sustainable and economically viable energy system for the United States.

1. It must be reliable.
2. Its cost should be reasonable.
3. It should not produce routine severe pollution.
4. It should be possible to almost wholly confine the environmental and security costs of the energy system to the generations benefiting from it. In other words the system should be amenable to cost internalization.
5. Its core functions should be resilient to supply, transportation, transmission, and economic shocks.
6. It should not add matter or energy flows to natural systems to an extent that is comparable to pre-existing natural levels, or large-scale fluctuations in those levels.

From: Arjun Makhijani and Scott Saleska, *Nuclear Power Deception* (New York: Apex Press, 1999), Chapter 9.

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unsustainable. The region has been a major flash point for global conflict for over half a century and remains so. The addition of the Caspian region to this mix, which is also part of U.S. oil policy, will not alleviate the problem, but rather may increase nuclear dangers, due to the added potential for U.S.-Russian confrontation.

Recently, the U.S. energy system, which had historically met the first two criteria – reliability and reasonable cost – seems increasingly unable to do so, as witness the wild swings in natural gas prices and the extremely unreasonable electricity prices that most Californians have had to pay over the past year.

The Cheney Plan will not solve these major problems. For instance, creating a national electricity grid to facilitate the transmission of electricity by large-scale generators will not necessarily address reliability problems and may aggravate them. Low reliability arising from a lack of reserve capacity was the main reason for the power problems in California. Deregulation created a situation in which power producers had no responsibility to maintain reserve capacity, and the regulators had no resources to do so either.

A completely unfettered electricity generation sector that has no responsibility for transmission or for reserve capacity would increase costs and be prone to unanticipated breakdowns. It would also increase transmission losses and will likely be less energy efficient. Reliability requires that large-scale private (and public) power producers have a responsibility for providing or paying for the maintenance of reserve capacity and for channeling power along efficient, relatively predictable routes. A free-for-all in generation on a large scale, across the continental United States, is a recipe for continued economic and technical problems. The Cheney Plan does not propose to impose any rules of good behavior on large-scale generators. Therefore, it is unlikely to create a reliable system that will have reasonable and predictable costs. Transmission capacity and location, reserve capacity, and the consuming system need to be coordinated with generation in order to get a reliable system overall.

It would be far better to mix small-scale plants that are close to the consumer or are on the consumer's premises and interconnect them to regional grids, which also have large-scale plants on them. Such systems are called distributed grids. These can be connected to regional grid systems, which already exist and only need modest improvement, as for instance between southern and northern California. Such a system of regional hybrid grids can be joined with regional renewable energy sources on a large scale. It would be far more reliable and environmentally sound than creating a national grid.

The Cheney plan opens up the questions of resuming reprocessing, establishing plutonium-fuelled reactors, and building new reactors in the United States after a hiatus of a quarter of a century. Reprocessing and plutonium—fuelled reactors would throw overboard, without serious national debate, non-proliferation policy that has been sustained on a bipartisan basis through five presidents.

Moreover, nuclear energy is a poor choice for the future for reasons that have been discussed at length in IEER publications and prior newsletters. For instance, in *Science for Democratic Action* vol. 6 no. 3 (March 1998), IEER published a comparison between nuclear power and natural gas as ways of reducing greenhouse gases by replacing coal-fired power plants. This comparison shows that moderate natural gas prices and an adequate natural gas supply are important in the transition period to a long-term sustainable energy system based only on renewable energy sources. Hence considerable increases in the efficiency of natural gas are essential. It is also likely that some added production of natural gas will be required. This can come from (i) a reduction of natural gas flaring abroad and imports of liquid natural gas, (ii) added domestic production from wells not associated with petroleum, and (iii) added imports from Canada and Mexico.

The Cheney Plan would greatly increase oil drilling, but it would not effectively address oil supply vulnerabilities. Even if all potential new reserves that are now economical at about 15 dollars a barrel of oil are added to USA reserves, U.S. oil reserves would remain well under 50 billion barrels. (Current proven reserves are 21 billion barrels and ANWR may add as much as 10 billion to this total; some estimates are considerably lower.)

Middle Eastern proven oil reserves are well over 600 billion barrels. Even more important, the cost of oil production is very different in different parts of the world and a central part of the inflexibility of the current systems. It costs only about one dollar per barrel (42 gallons) to get oil out of the ground in Saudi Arabia, compared to between 10 and 15 dollars per barrel in many other regions (including the United States). The flexibility of this system to economic shocks cannot be increased by increasing supplies of relatively high cost domestic oil, since downward price shocks can occur through simple increases in production in low cost areas. However, opening up ANWR will likely achieve one goal – up to as much as $100 billion in total profit for oil companies.[6]

Nor will energy security increase measurably. U.S. oil consumption is currently about 7.5 billion barrels per year (20 million barrels a day). If demand continues to increase at somewhat over one percent per year, the United States will be importing about three-fourths of its oil in twenty years, even if ANWR is opened up and

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supplies as much as one million barrels a day. This will put a strain on the global oil supply systems economically, politically, and militarily. It will also increase carbon dioxide emissions. This is not only unsustainable, it is a recipe for conflict. In other words, this policy would mean that the many conflicts that are, in fact, already going on in the Middle East-Persian Gulf-Caspian-Central Asian region would likely worsen.[7]

As noted above, technology to increase efficiency to between 60 and 100 miles per gallon for cars is available today. Annual consumption of gasoline can be reduced to less than four million barrels per day, over the next forty years compared to the present 8.5 million barrels per day, if progressively stringent standards are set on a schedule compatible with capabilities of manufacturers to install new technologies. This possible reduction takes into account a doubling of car-miles.

Mandating CAFE standards for cars and light trucks together is preferable to taxing gasoline and diesel, since fuel represents a relatively small part of the overall cost of operating a car (though the most visible on a day-to-day basis). Taxing gasoline is also regressive because it most affects middle income and poor people adversely. For these reasons, it is more efficient and equitable to achieve efficiency by requiring manufacturers adopt efficient technology.

Historical experience shows that car makers seem to remember safety when the issue of mileage standards is raised and seem to remember mileage when the issue of reducing emissions of noxious gases, like nitrogen oxides or hydrocarbons, is raised. In practice they have needed government action to set standards for all three — emissions (other than carbon dioxide), mileage, and safety. All three can and should be simultaneously mandated by the government. Setting achievable standards well in advance also encourages research and development on new technologies, such as new strong materials to reduce the weight of cars and increase safety at the same time.[8]

CAFE standards are needed to force manufacturers to use the best available technology for whatever cars or light trucks they make and sell in the same manner that laws were needed for seat belts and airbags. Standards should be set simultaneously for efficiency and safety since the track record of manufacturers shows that they are reluctant to incorporate either without government pressure. They seem to worry about safety most when the issue of efficiency standards is raised. Their current resistance to mileage standards is a case in point.

Reasonable costs for environmentally sound technologies requires that the cost of many new technologies be reduced. The traditional approach in the United States and in some other countries has been to provide subsidies and tax breaks to alternative energy sources. This approach is also favored in the Cheney Plan. However, tax breaks and subsidies are a poor way to achieve a sustained increase in renewable energy sources and highly efficient technologies, since they tend to lock in higher cost technologies and provide insufficient incentive for investment in technology development. Further, tax breaks are too uncertain and politically vulnerable, which is a source of uncertainty for investors.

IEER therefore recommends that instead of tax breaks and subsidies for new renewable energy development and efficient technologies, the government's resources should be directed to the establishment of appropriate procurement policies.[9] If the government provides a steady market for wind generated electricity, solar electricity, cars meeting efficiency standards, and distributed generation in federal buildings with interconnection obtained at reasonable prices, then the overall nature of the marketplace will be affected positively. Open bid each year for such commodities would also encourage private sector research and development investments to reduce costs. The federal government can also provide grants to states and local governments designated for such purposes, as it does for a variety of other purposes, for instance sewage treatment plant construction and educational programs.

1 Michael Klare, *Resource Wars: The New Landscape of Global Conflict* (New York: Metropolitan Books, 2001).

2 See *Science for Democratic Action* vol. 6 no. 3 (March 1998) pp. 8-10 for a discussion of the provisions of the Kyoto Protocol. See also the article by Kevin Gurney in that issue for a discussion of the greenhouse gas problem. The issue can be accessed on-line at http://www.ieer.org/ensec/no-5/index.html.

3 R. Brent Alderfer, M. Monika Eldridge, and Thomas J. Starrs, *Making Connections: Case Studies of Interconnection Barriers and their Impact on Distributed Power Projects*, NREL SR-200-28053 (Golden, Colorado: National Renewable Energy Laboratory, May 2000, as revised in July 2000).

4 Committee on the Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards, *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards* (Washington D.C.: National Academy Press, 2001).

5 U.S. Department of Transportation, Bureau of Transportation Statistics, *National Transportation Statistics 2000*, BTS01-01 (Washington, D.C.: U.S. Government Printing Office, April 2001), table 4-23, accessed via http://www.bts.gov/ntda/nts/NTS99/data/Chapter4/4-23.html on 1 August 2001.

6 This assumes a $10 per barrel profit for a maximum recoverable reserve of approximately 10 billion barrels (see http://geology.cr.usgs.gov/pub/fact-sheets/fs-0028-01).

7 Klare, 2001, op. cit.

8 For information on efficient cars, safety, and latest technical developments see, for instance, the web site of the Rocky Mountain Institute, www.rmi.org.

9 However, subsidies for existing renewable energy and energy efficiency installations, which was factored into the design of the projects, should be continued to prevent these projects from being shut.

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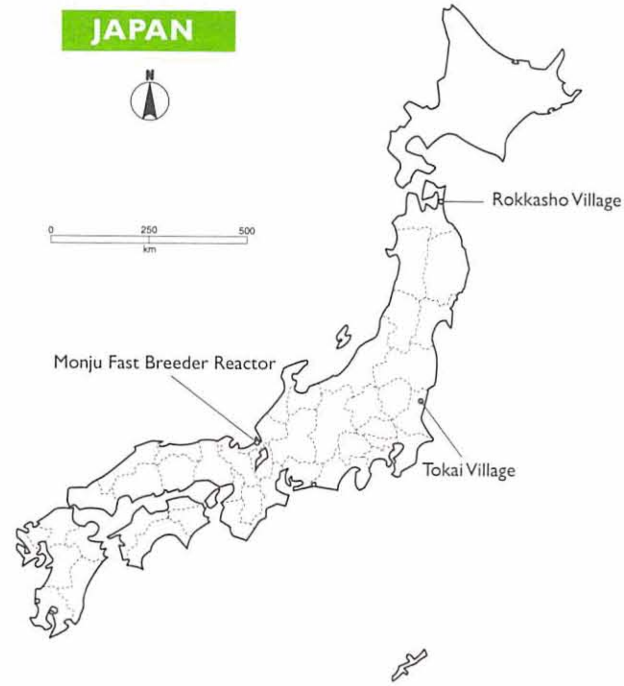
are planned or already in operation. The Tokai Reprocessing Plant began full operation on 20 November 2000 after being shut down for over three-and-a-half years following the fire and explosion at the facility's bituminization plant in March 1997.[4] In December 2000, the operator of Monju, shut down since the 1995 incident, asked Fukui Prefecture and Tsuruga City to agree that it should apply to the Ministry of Economy, Trade and Industry for the safety review of its remodeling plans for Monju. The construction of Rokkasho Reprocessing Plant, to be completed by July 2005, continues at an accelerated pace.

The Rokkasho Reprocessing Plant

The Rokkasho Reprocessing Plant is being constructed in Rokkasho Village, Aomori Prefecture, by Japan Nuclear Fuel Ltd., and financed by major Japanese electric power companies and the nuclear industry[5], for the purpose of processing spent fuel from Japanese light water reactors. About 35 large and small concrete buildings will be built on about 3.8 million square meters of land. Each building will consist of four underground floors and four floors above ground, and thus half of the plant is being built underground. The total distance of pipes which connect the facilities will amount to about 1,500 km. As of the end of March 2001, 64% of the plant's construction had been initiated. Because of the subcontracting system particular to the Japanese construction industry, there are about 1,000 companies involved in the construction, and about 7,000 construction workers working around the clock.

Though the plant is still under construction, the spent fuel storage pool has already been completed. The maximum storage capacity of the pool totals 3,000 metric tons of uranium, or tU (1,500tU each for boiling water reactor and pressurized water reactor spent fuel). The transportation and storage of spent fuel at the pool began in December 1999. About 1,600tU of spent fuel is expected to be stored at the pool by the time of the completion of the plant.

Rokkasho Reprocessing Plant will use the PUREX method, which dissolves spent fuel in nitric acid and separates uranium, plutonium and high-level waste. The plant's annual capacity is 800tU, with a daily maximum capacity of 4.8tU, and will annually separate about 5 metric tons of fissile plutonium. Maximum burn up of the spent fuel to be reprocessed at this plant is 55,000 megawatt days thermal per metric ton of uranium (MWdth/tU). The average burn up of spent fuel reprocessed within a day will be under 45,000MWdth/tU. The spent fuel will be cooled for more than a year before it arrives at the plant, and must be cooled for more than four years before it is sheared.



Plant's process

As with the Tokai Reprocessing Plant, operated by the Japan Nuclear Cycle Development Institute (JNC), the main process of the Rokkasho Reprocessing Plant is based on technology imported from France and is modeled after the French company COGEMA's UP-3 Plant located in La Hague, France. Other parts are based on technology adopted from various countries.

As shown in Figure 1 on page 10, the plant consists of the following processes: receiving, storage, chopping (shearing), dissolving, separation, refining (purification), denitration, storage of product uranium and plutonium, and solidification (vitrification) of high-level radioactive waste. In most cases there is one building for each process. Technology for main processes like chopping, dissolving, separation, and refining is provided by COGEMA's subsidiary SGN.

The plant is a mosaic of technologies from overseas and domestic companies. Technology for high-level liquid waste treatment and acid recovery is provided by British Nuclear Fuels, plc (BNFL), iodine removal technology by Germany's KEWA, uranium-plutonium denitration technology by JNC, Mitubishi Materials, and Toshiba, high-level liquid waste vitrification technology by JNC and Ishikawajima-Harima Heavy Industries, and spent fuel storage pool technology by Hitachi, Toshiba and Mitsubishi.

The basic blueprint for the main processes adopted from SGN was prepared by SGN itself, but blueprints for the processes with technology from other overseas companies and domestic companies were prepared by

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The Baker's Dozen

IEER Energy Policy Recommendations

1. Adopt sustainable energy system criteria, including the goals of phasing out nuclear power plants as their licensed lifetimes end, unless safety dictates a faster shutdown of specific plants, and reducing U.S. carbon dioxide emissions by 50 percent over the next forty years.

2. Request the National Academy of Sciences to establish a standing committee on the second law of thermodynamics that would evaluate the energy system annually and recommend what fundamental research needs to be done to develop new energy-related technologies with far greater efficiency. For instance, this committee would recommend what materials research is needed to improve the efficiency of heat exchangers under conditions of small temperature differences. (For a description of the second law of thermodynamics, see "Dear Arjun" in *Science for Democratic Action* vol. 6 no. 3, March 1998.)

3. Mandate stringent fuel efficiency standards increasing progressively to the equivalent of 100 miles per gallon for a CAFE standard that includes all passenger vehicles (including light trucks) by 2040. Stringent safety standards should be simultaneously mandated.

4. Establish stringent efficiency standards for appliances.

5. Dedicate about $5 billion per year for federal purchases of renewable energy, efficient vehicles, and advanced energy conversion technologies (such as fuel cells) for federal use and resale and provide a similar sum annually to states and local governments for the same purposes.

6. Re-establish federal and state regulation of generation requiring reasonable rules for small power generators to connect to the grid. Severe financial penalties should be assessed for failure to comply and especially for any deliberate subversion of the regulations, since the damage to society from continued institutional resistance to the establishment of a distributed electricity grid would be great. The roadblocks to distributed grids, identified in the July 2000 report by the National Renewable Energy Laboratory (full cite in endnote 3 on page 6), should be expeditiously removed by a combination of local, state and federal government action and vigilant enforcement.

7. All major residential and commercial real-estate developers as well as major industrial projects should be required to assess the energy impact of their projects and to consider developing their own local generation systems that would be connected to the grid.

8. The Bush administration should ask the National Renewable Energy Laboratory to do a detailed study of how large-scale wind resources can be brought to play a major role in the electricity system in the next 20 years and in the overall energy system (via hydrogen production) in the two decades after that. (See next page for IEER's description of wind energy potential.) This study should also address the potential of offshore wind energy in the United States.

9. Ask the National Renewable Energy Laboratory to design a pilot program for hydrogen generation and use that would enable a realistic evaluation of the methods by which a transition to a hydrogen economy based on renewable energy sources can be made.

10. The U.S. government should re-affirm its policy of no reprocessing of spent nuclear fuel and adopt a policy of phasing out nuclear power plants at the end of their licensed lifetimes, unless safety dictates a faster shutdown of specific plants.

11. Establish a task force that would study the potential need for natural gas to be a fuel that would enable the United States and the world to transition to a sustainable energy system by 2050. This task force would look at places where natural gas not associated with oil may be produced in an environmentally safe way and how such gas would best be used to reduce carbon dioxide emissions and phase out nuclear power at the same time. (See *Science for Democratic Action* vol. 6 no. 3, March 1998).

12. The United States should take the lead in urging major oil companies to completely end the flaring of natural gas in oil-exporting developing countries such as Nigeria within the next three years. Instead of being wasted by flaring, this resource should be used domestically in those countries and possibly also exported for the purpose of reducing greenhouse gas emissions.

13. All local, state and federal jurisdictions should require utilities to establish just-in-time electricity efficiency plans. (See Arjun Makhijani and Scott Saleska, *Nuclear Power Deception* (New York: Apex Press, 1999), chapter 9.)

Large-scale Wind Energy Development in the United States

The Cheney Plan[1] goes into great detail about oil and gas, as well as electricity transmission infrastructure that would make it easier for large companies to generate anywhere and sell anyplace. However, it provides no quantitative analysis of the enormous wind energy potential of the United States. The top twelve states in terms of wind energy potential after land use exclusions, such as national parks or areas with dense populations, is shown in the table. The wind potential of many other states is considerable, but is lower than the ones listed below due to a combination of factors such as wind speed, population density, and/or other land use restrictions.

Only about one-and-a-half percent of the potential wind resources in these top twelve states would, over 40 years, be equivalent to the entire oil reserves of the Alaska National Wildlife Refuge (assuming they are as much as 10 billion barrels). Of course, the wind energy potential would still be available after that, while the oil reserves would be exhausted.

A development of the wind energy potential on a significant scale would require the development of transmission infrastructure to feed wind generated electricity into high voltage transmission lines and the infrastructure of some new transmission line corridors in some states. The most expedient approaches in the short term may be to connect Wyoming, Montana, and New Mexico westward, and the Midwestern states with high wind potential to the east.

For more information on wind energy, see IEER's 1999 report, *Wind Power Versus Plutonium: An Examination of Wind Energy Potential and a Comparison of Offshore Wind Energy to Plutonium Use in Japan*. A summary of this report can be found in *Science for Democratic Action* vol. 8 no. 1 (November 1999).

1. Also known as *National Energy Policy: Report of the National Energy Policy Development Group* (May 2001). The report is available on-line at http://www.whitehouse.gov/enerrgy.

Wind Energy Potential, Top Twelve States

(land use exclusions accounted for)

State	Annual electricity generation potential, billion kWhe	Percent of total U.S. electricity generation, 1999[a]
North Dakota	1,210	32.8
Texas	1,190	32.2
Kansas	1,070	29.0
South Dakota	1,030	27.9
Montana	1,020	27.6
Nebraska	868	23.5
Wyoming	747	20.2
Oklahoma	725	19.6
Minnesota	657	17.8
Iowa	551	14.9
Colorado	481	13.0
New Mexico	435	11.8
TOTAL, TOP TWELVE	**9,984**	**271**
Total ERCOT (Texas)	~1,000[b]	
Total Western Interconnect (up to approximately the Montana-New Mexico North-South line)	~2,700[b]	
Total Eastern Interconnect (rest of the lower 48 states)	~6,000[b]	

Source: *An Assessment of the Available Windy Land Area and Wind Energy Potential in the Contiguous United States*, Pacific Northwest Laboratory, 1991, as cited in American Wind Energy Association, "The Most Frequently Asked Questions About Wind Energy," accessed via http://www.awea.org.

Notes in table:

a. Electricity generation in 1999= 3,690 billion kWhe (kilowatt-hour electric)

b. The totals for the interconnected regions are approximate since the regions do not correspond exactly to state borders. ERCOT (Electric Reliability Council of Texas) includes most of Texas, but excludes a part of the Texas panhandle. Transmission is currently coordinated within the Interconnect regions. Wind energy totals include only the wind potential for the listed states. Actual totals would be higher if the potential of the states not listed is included. Offshore wind potential would boost totals in all three regions.

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Japanese companies. Due to Japan's earthquake prone nature, it was necessary to also add anti-seismic designs to the blueprint. Thus Japanese companies made the necessary alterations and additions to the blueprints for aseismic purposes, and were also in charge of detailed designing, manufacturing and installing of aseismic equipment. This complex and confused process resulted in mis-transcribing of designs, and a number of missing or faulty parts have been discovered as the construction progresses (described below).

The plant differs from the reprocessing plants in France and England in that it will produce mixed 50% plutonium and 50% uranium oxide (MOX) as the end product, whereas French and British plants yield uranium oxide and plutonium oxide separately. As a non-proliferation measure, Japan is forbidden under the U.S.-Japan Nuclear Agreement[6] to extract plutonium from uranium supplied by the U.S. Most of Japan's spent fuel includes uranium from the U.S.

COGEMA, BNFL and technological cooperation

Partial test operations using water and vapor began in April 2001 at completed parts of the Rokkasho Reprocessing Plant to identify cracks, holes and problems with welding and connections of pipes. Tests and test operations using uranyl nitrate solution and subsequently spent fuel dissolved in nitrate solution will continue until the planned completion of the plant in 2005. For example, the confirmation tests for the chopping and dissolving treatment building alone involves literally millions of check items to confirm whether that part of the plant is precisely built according to the blueprint.

The inexperience of Japan Nuclear Fuel Ltd. (JNFL) and the fact that the plant's technology has been adopted from various companies pose serious concerns about the construction and operational safety of the plant. On 26 February 2000, it was reported by the *Daily Tohoku* and the *To-o Nippo Newspaper* that a storage tank for low-level radioactive liquid waste and two temporary storage tanks for high-level radioactive concentrated liquid waste brought into the plant were lacking important parts due to Hitachi staff's mis-transcribing the blueprint.[7] For example, the aseismic support for the inside of the high-level concentrated liquid waste storage tanks were inversely installed. Such defects are a result of the confusion between SGN and Japanese companies following the drastic alterations that were made to the original blueprint in order to lower cost after construction began in 1993. JNFL's incompetence regarding quality control is clear, and it is highly possible that there are various problems with other parts of the plant and equipment.[8]

In 1987, JNFL signed the Technology Transformation Agreement with the French company SGN, and the General Framework Agreement with U.K.'s BNFL. JNFL has requested COGEMA to send about 50 and BNFL to send a couple technical assistants during the test operations until the plant's completion. Since last year, COGEMA technicians and their families have begun to arrive in Rokkasho, and a "French Village" is being constructed in the vicinity of Rokkasho Village where houses are being built especially for the French technicians.

Together with technology transfer, plant operator training is proving to be a serious task. JNFL expected

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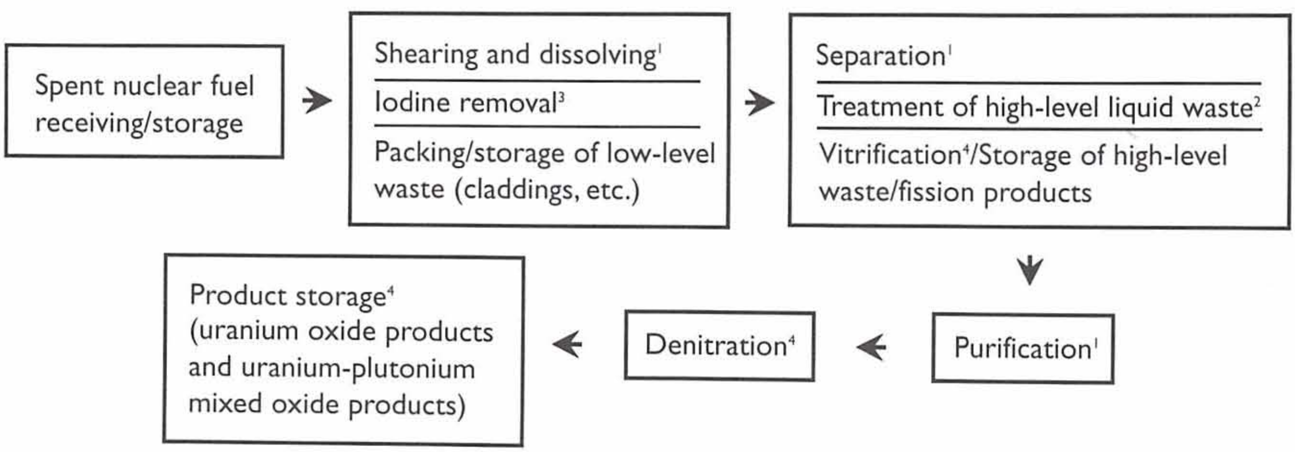
FIGURE 1: ROKKASHO REPROCESSING PLANT PROCESS AND SOURCE OF TECHNOLOGIES



Technology from:
1. SGN (COGEMA's subsidiary)
2. BNFL
3. KEWA
4. JNC

Source: Japan Nuclear Fuel Ltd.

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to accomplish technology transfer by having Japanese workers trained at facilities of COGEMA and BNFL in addition to JNFL's mock reprocessing facility, JNC's Tokai Reprocessing Plant and test facilities of the domestic nuclear industry. Training at domestic facilities is limited since it is conducted at mock or test facilities or at the Tokai plant which does not use the technology with which the Rokkasho plant will be equipped. JNFL is negotiating with COGEMA to get its operators trained at COGEMA's UP-3 plant, but the negotiations have been met with difficulty. As a condition for such an arrangement, COGEMA is requesting training fees of about 100 million yen[9] per trainee, in addition to new contracts for the reprocessing of Japanese spent fuel. The two have not finalized this plan.

The world's most expensive plutonium

According to the original licensing application, submitted in 1989, the Rokkasho plant was to be completed in December 1997, but the completion date has been postponed four times. When construction began in 1993, the completion date was set at January 2000 and the total construction cost was estimated at 760 billion yen. In 1996, due to construction delays, the projected completion date was moved to January 2003, and the construction cost re-estimated at 1.88 trillion yen . Then in 1999, the completion was projected to be July 2005, and estimated construction costs soared to 2.14 trillion yen (about US$20 billion) — three times the original estimate. The construction cost is expected to rise further by the time of the plant's completion.

JNFL has not released an estimate of the plant's projected reprocessing cost which takes into account this rise in construction cost. It is estimated by the Japanese Agency for Natural Resources and Energy that reprocessing at Rokkasho will cost around 351 million yen per metric ton of spent fuel[10], which would be about one and a half times the reprocessing costs of BNFL and COGEMA.[11] There are other estimates with higher cost projections, the highest being 500 million yen per metric ton of spent fuel.[12] Because of Germany's decision not to continue reprocessing, COGEMA and BNFL might be forced to lower their reprocessing costs and thus force Rokkasho's expensive reprocessing cost to be even more non-competitive. [Editor's note: This MOX fuel will be at least 20 times more expensive than LEU (low enriched uranium) fuel. French MOX fuel is about 5 times more expensive than LEU fuel.]

According to its financial report for fiscal year 1999 (April 1999 to March 2000), released in June 2000, JNFL was 500 million yen in the red after taxes. This financial report included the utilities' annual allotment payment of 12.5 billion yen for the construction of the Rokkasho Reprocessing Plant, but this allotment is not covering the rising construction cost. JNFL is going further into debt by continuing the construction of the reprocessing plant, and it is very likely that Rokkasho-manufactured plutonium will be the world's most expensive.

The proposed MOX plant and its problems

While the construction of Rokkasho Reprocessing Plant progresses, concerns are intensifying over the possibility that the plutonium separated at the plant will become excess. To amend this situation, Japan's Federation of Electric Power Companies and JNFL decided to build Japan's first commercial MOX plant.

Plans call for the MOX fuel fabrication plant to be constructed in the vicinity of the Rokkasho Reprocessing Plant. The two plants would be connected to each other with an underground trench through which MOX powder will be transferred. This large-scale plant is projected to have an annual processing capacity of 130 metric tons of heavy metal (t-HM), and to begin operation in 2008 or 2009. Like plants in Belgium and France, the MIMAS method[13] was chosen as the manufacturing process. The total construction cost is estimated at 120 billion yen.

The plutonium enrichment level of the MOX fuel manufactured at the proposed plant would range from 5 to 10%. The plant would use the 50:50 uranium/plutonium MOX powder manufactured at the Rokkasho Reprocessing Plant as raw material. The mix would be diluted by adding depleted uranium stored at the Rokkasho Enrichment Plant. Fuel pellets would then be manufactured and fuel rods prepared.

Because plutonium is involved with MOX fuel manufacturing, neutron emissions increase by about 10,000 times and gamma-ray emissions increase by about 20 times compared to the manufacturing process of uranium fuel. Thus, strict safety control is necessary, especially to set up measures for shielding and trapping of radioactive materials, heat management, and criticality control. The 1999 criticality accident at JCO's Tokai plant, which claimed two lives, exposed local resident to neutrons and forced residents within a 350 meter radius of the plant to evacuate, is still fresh in the minds of the Japanese public.

In addition since this raw MOX will include retrieved uranium, unlike MOX plants in England and France, the protection of workers and the public from strong gamma-rays from daughter nuclides of uranium-232 and uranium-236 will pose a considerable challenge. The Rokkasho MOX fuel fabrication plant is burdened with the necessity to have fortified shielding structures and stricter control over worker exposure than other MOX plants.

As if tagging behind the industry's plans, the

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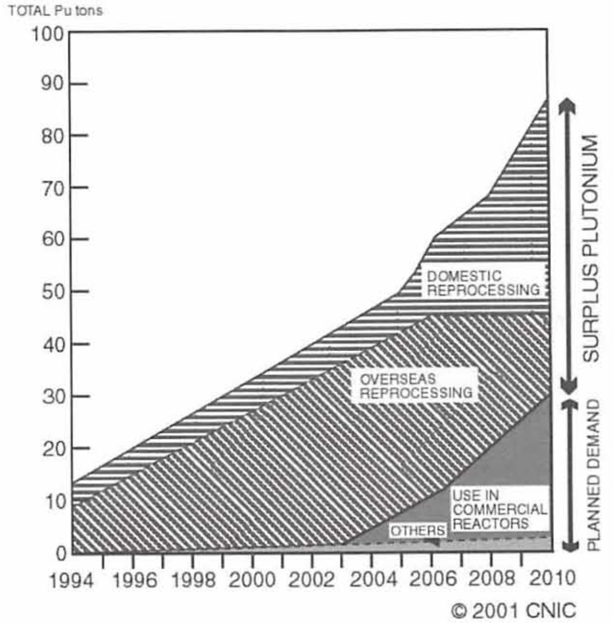
Nuclear Safety Commission (or NSC, Japan's counterpart to the U.S. Nuclear Regulatory Commission) is hastily preparing safety review standards for the licensing of the commercial MOX plant in order to set standards by the end of this year. Moreover, discussions on the review standards include talk of possibly using plutonium oxide as raw material in addition to 50:50 MOX. Should this become a reality, it may be that Japanese-owned plutonium extracted and stored overseas would be returned, since under the U.S.-Japan Nuclear Agreement, Japan cannot extract pure plutonium in the country from most of its spent fuel. The use of plutonium oxide at a large-scale plant in Japan poses serious safety and proliferation risks and is not something to be taken lightly. Citizens must keep a watchful eye on the NSC as it prepares the safety review standards.

Meanwhile, plans to use MOX fuel in Japan are reaching a dead end. As of May 2001, none of the MOX fuel transported since Fall 1999 from Europe to Japan has been used due to BNFL data falsification scandals and strong local opposition.[14] Utilities had planned to begin irradiating MOX at light water reactors in Fall 1999. At the moment, none of the country's reactors have fixed dates for the loading of MOX fuel. Even if the plans had progressed according to original targets, the projected demand for plutonium until 2010 would be 30 metric tons, in comparison to the projected supply which is 55 metric tons — a serious surplus of plutonium. (See Figure 2.)

There is strong criticism inside and outside Japan over the country's plans for domestic reprocessing and MOX manufacturing. The 1999 JCO criticality accident, MOX fuel data falsification scandal, and other scandals involving concealment and manipulation of information concerning the 1995 Monju breeder reactor incident and the 1997 Tokai incident have made the Japanese public increasingly skeptical of nuclear technology and the nuclear industry. The government's blind promotion of plutonium use, despite such skepticism and local opposition, will meet further delays and difficulties.

FIGURE 2: HISTORIC AND PROJECTED JAPANESE PLUTONIUM INVENTORIES, IN METRIC TONS



1 Masako Sawai is a staff member of the Citizens' Nuclear Information Center (CNIC) who specializes in the nuclear fuel cycle. She wrote this article in May, 2001. Gaia Hoerner of CNIC translated the article from Japanese and helped edit it.

2 For background information on the 1995 Monju breeder reactor incident, see CNIC's bimonthly newsletter *Nuke Info Tokyo* Nos. 51 and 53-56.

3 In the "once through" approach, the policy of the U.S. and Canada, spent nuclear fuel is not reprocessed. The nuclear fuel cycle approach includes reprocessing (the extraction of uranium and plutonium from spent nuclear fuel in order to create new nuclear fuel). France, England, and Japan have a nuclear fuel cycle policy.

4 For background information on the 1997 Tokai Reprocessing Plant incident, see *Nuke Info Tokyo* Nos. 58, 59 and 63.

5 Including Toshiba, Hitachi and other companies.

6 Full title is *Agreement for Cooperation between the Government of Japan and the Government of the United States of America Concerning Peaceful Uses of Nuclear Energy* (1988).

7 Japan's former Science and Technology Agency conducted an investigation into this matter and released "Report on the Investigation of the Failure to Equip Parts at JNFL's Reprocessing Facility" in March 2000.

8 According to the *To-o Nippo Newspaper* and the *Daily Tohoku*, on 19 November 2000 all cooling circulation pumps temporarily failed at the spent fuel storage pool of the Rokkasho Reprocessing Plant. In the 14 April 2001 issue of the *Daily Tohoku*, it was reported that spent fuel was accepted into the plant's storage pool after being postponed one day by the governor of Aomori Prefecture due to a number of problems discovered with the ventilation system of the spent fuel storage building. The 20 May 2001 issues of the *To-o Nippo Newspaper* and the *Daily Tohoku* reported that cracks were found in the concrete of some of the completed parts of the plant's buildings.

9 In the last decade, the exchange rate averaged 114 yen per U.S. dollar.

10 Written answer of the Japanese Prime Minister, dated 16 May 2000, to a question submitted by Sumiko Shimizu, a member of the House of Councilors.

11 JAERI-Research 2001-014: JAERI, *An analysis on the economics of plutonium cycle*, Japan Atomic Energy Research Institute (JAERI), 2001.

12 *Asahi Newspaper* Evening Edition, 13 September 1999 issue.

13 MIMAS (MIcronized MASter blend) method: A method where MOX fuel is manufactured by blending plutonium and uranium by ball milling. This method was developed by Belgonucleaire and has been used at COGEMA's MELOX plant as well. Because the blending involves two separate steps, it creates problems with the homogeneity of plutonium, causing the formation of plutonium spots. Under certain conditions, plutonium spots in the vicinity of fuel claddings can cause them to rupture.

14 The MOX fuel inventory consists of 60 assemblies or 15.2 metric tons of boiling water reactor fuel and 8 assemblies or 3.7 metric tons of pressurized water reactor fuel.

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DEAR ARJUN

Dear Arjun:

What are these PBMRs I keep hearing about? It sounds like a peanut butter candy bar, but I know it has something to do with items commonly found in nature, like pebbles and Bushes. Can you help?

Baffled in Bethesda

Dear Baffled:

PBMRs are not candy bars, but you are partly right. They do contain peanut butter. PBMR is an adult treat: it is Peanut Butter Marbled with Rum.

One night some representatives of the nuclear establishment ate too much of the marbling in the PBMR. As a result, they got quite happy, started playing with the acronym, and landed on something really wonderful: a nuclear reactor. They initially thought of calling it the Pebble Bush Modular Reactor, because the fuel elements are like round fruits on a bush. But that was before the last election, or whatever. So now PBMR stands for Pebble Bed Modular Reactor. The Indian version of this will be the PBNMR, or Pebble Bed of Nails Modular Reactor (just kidding). My advice to you, Baffled, is to just call it The Pebble Bed, and try to remember that this is not about a camping vacation along a dry stream in the Rockies.

One permutation of the letters PBMR is MPBR. This is how it is called by the joint research team composed of the Massachusetts Institute of Technology (MIT) and the Department of Energy's Idaho National Engineering and Environmental Laboratory (INEEL). DOE has designated the latter as the lead lab for the government's efforts in the field of commercial reactor research and development.

The PBMR, like most new reactor ideas, is a reincarnation of an old reactor idea. (All the reactors you've ever heard about and then some were dreamed up in the 1940s and 1950s.) In this case the old idea is the "high temperature gas reactor" or HTGR, that then was proposed in a modular version, known, of course, as the MHTGR. If you purchase a copy of IEER's book, *The Nuclear Power Deception*, you will find an analysis of the MHTGR in it, including safety issues. But, dear Baffled, if you are broke, I'll send you a free copy. Or you can just look at the entire section on HTGRs of that book on our web site, at http://www.ieer.org/reports/npd7.html. You can also learn some pretty nifty nuclear physics and nuclear reactor basics on IEER's web site (visit our On-Line Class-room at http://www.ieer.org/clssroom/index.html), in case you want to go into the reactor business these days, seeing as how it's so hot and politically approved and all. (But that doesn't guarantee you'll make any money.) The PBMR is a variant of the HTGR.

HTGRs are cooled by helium gas, which is inert. They use graphite as a moderator (instead of water, which is the moderator in most existing nuclear reactors). Graphite is also used in Chernobyl-type (RBMK[1]) reactors, which are water-cooled, and in British Advanced Gas Reactors, which are cooled by carbon dioxide. Some graphite-moderated reactors use slightly enriched uranium fuel; others use natural uranium. Descriptions of various reactor types can be found on IEER's web site at http://www.ieer.org/reports/npd-tbl.html.

One large-scale, 330-megawatt-electrical, HTGR has been built in the United States – the Fort St. Vrain reactor in Colorado. It was a commercial failure and was closed in 1989. It routinely faced operating problems and had a forced outage rate of over 60 percent. Its lifetime capacity factor was only 14.5 percent. Baseload power plants, like nuclear power plants, are normally designed to have capacity factors of 75 percent or more. Cost calculations by PBMR advocates use a 90 percent capacity factor (see for instance, presentation by Andy Kadak at http://www.min.uc.edu/nuclear/kadak/sld051.htm).

The PBMR is a variant of the HTGR

The designers of PBMRs claim to have learned lessons from experience. In the PBMR, the hot helium drives a turbine directly, reducing the chances for water-graphite contact. There is a secondary water loop, however. The water is used to cool the helium gas before it is sent back to the reactor. The water usage would be lower than in light water reactors, since the projected efficiency of the PBMR is higher. For the South African promotional site on the PBMR, see http://www.pbmr.co.za/.

PBMRs would have uranium dioxide fuel coated with silicon carbide and pyrocarbon. The fuel would be fabricated into tiny particles, like grains of fine sand, called microspheres. In a PBMR, a larger size container, 60 millimeters (a little less than two-and-a-half inches) in diameter, is filled with these fuel grains. These fuel balls continuously flow through the reactor, and are

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mixed with balls made of graphite, which is used as a moderator. There would be 360,000 fuel balls, or pebbles, per reactor core, each containing 11,000 microspheres of fuel, for a total of about 4 billion microspheres per 110 megawatt reactor. There would be neutron absorbing balls and six control rods, according to the proposed design. About one-third of the pebbles would be discharged from the reactor every year. These figures apply to a design being considered by MIT and INEEL.

British Nuclear Fuels, owned by the British government, along with other corporate partners, as well as the national South African utility, ESKOM, are in the process of designing a 110 megawatt-electrical PBMR to be built in South Africa. It would be a demonstration plant the consortium hopes will become the basis of a large export industry. Such a plant would have a power output equal to about one-tenth that of a large, light water reactor that is now common. Hence the term "modular."

ESKOM and British Nuclear Fuels and other companies are designing a demonstration PBMR to be built in South Africa

The PBMR seems the latest nuclear industry attempt to sell new, improved, "inherently safe" reactors. This is an inherently misleading term. No commercial PBMR has actually been built and operated. A small German pilot reactor operated for 21 years and operated at 70 per capacity factor, according to the promoters of the PBMR (http://www.pbmr.co.za/2_about_the_pbmr/2_8background_to_the_pbmr.htm). The experience with HTGRs is decidedly mixed. The one large HTGR in the United States, the Fort St. Vrain reactor, had quite a lot of problems and was prematurely shut. PBMRs were proposed in the 1990s as possible reactors to use for waste transmutation. (See *Science for Democratic Action* vol. 8 no. 3, May 2000, for a description of IEER's transmutation study.)

No commercial PBMR has actually been built and operated

An analysis of the safety issues related to such use of PBMRs is provided in a 1996 study on transmutation by the National Research Council of the National Academy of Sciences. That safety analysis does not directly apply since the operating conditions and fuels would be different than the proposed PBMR. However, it is noteworthy that the study concluded "At this stage of its conceptual development, there is little information about the safety features of the PBR [Pebble Bed Reactor], its dominant risk factors, or its environmental impact." The study further stated that "It is not clear how the core [of the PBR] would react to any event that may interrupt the flow of helium coolant."[2]

The proportion of components designated as "safety-related" in the proposed PBMR, and therefore subject to more stringent inspections, would be just about 15 to 20 percent, compared to between 40 and 50 percent for light water reactors. The smaller number of inspections may make the plant cheaper to operate, but it may also render it more vulnerable to accidents. The Three-Mile Island accident started with a "non-safety" component, a valve in the condensate system inadvertently closed. It was the thirteenth time in a year that a non-safety component in that system had caused a reactor trip. Since it was a "non-safety" component, it was not inspected. Had it been a safety component, it would have been.

While the design of PBMRs would avoid fuel meltdown type accidents, a loss of the coolant could still produce serious radiological consequences. PBMRs will contain graphite, which could catch fire if air enters the core after a loss of the helium coolant. Further, a loss of coolant accident that involved a breach in the separation between the helium and water circuits poses a risk of steam-graphite reactions, which generate carbon monoxide and hydrogen, which would give rise to a fire hazard.

In sum, PBMRs have their own safety vulnerabilities, specific to their design, and should not be called "inherently safe." Note that the PBMR proponents still want the government to insure their reactors under the Price Anderson Act. Quite a show of confidence in its inherent safety, wouldn't you say Baffled?

If the reactor is built without a secondary containment, as has been proposed, this could result in a large release of radioactivity. If it is any consolation, the amount of radioactivity in the reactor core per unit of power produced is lower than with other reactor designs, because the fuel pebbles flow continually out of the reactor and are put into storage while new fuel pebbles are fed at the top. This reduces the inventory of short-lived radionuclides, such as xenon-133 and iodine-131, that might be released in the event of a severe accident. It is very questionable that a modular reactor of 110 megawatts could be made economical if a secondary containment were required, as it should be. It is important to remember that the secondary containment was the single feature that prevented the Three-Mile Island accident from releasing vast amounts of radioactivity that would have made it more comparable in scale to Chernobyl.

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DEAR ARJUN

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MHTGRs are more vulnerable to terrorist attack than light water reactors (see *Nuclear Power Deception*). It is unclear if this vulnerability of MHTGRs would also apply to the PBMR since a detailed design is not available.

PBMRs would use fuel enriched to a considerably higher level than present-day power reactors. Figures in the range of 8 to 20 percent have been proposed, with the former being the currently favored number. While such 8 percent enriched uranium cannot be used for making nuclear weapons, it would take far less work to make weapons grade uranium from PBMR fuel than from light-water reactor fuel (less than 5 percent enrichment).

PBMRs have their own safety vulnerabilities, specific to their design, and should not be called "inherently safe"

About 20,000 PBMRs would be needed over the next four decades or so to make a contribution to global electricity supply that would have a significant impact on carbon dioxide emissions. Allowing a decade for reactor development (a very short time, considering none have been built), that would be *almost two reactors per day* being brought on line for thirty years after that. Quality control for so many reactors and their regulation would be essentially impossible. Further, were a design problem found in the PBMR a decade or two after the hectic construction phase began, it would become economically prohibitive to fix it.

Fuel production for 20,000 units would have to be about 25 trillion microspheres per year. How the quality control would be implemented for such a huge supply of a relatively novel fuel would be a crucial issue for the PBMR. In this context, it is worth noting that one of the corporations leading the charge for the PBMR is BNFL, the British government-owned company that has admitted that some of the plutonium oxide-uranium oxide (MOX) fuel that it sent to Japan had fabricated quality control data.

Finally, there are a number of questions associated with PBMR waste. While PBMRs would reduce the amount of waste volume per unit of power production, there would still be an enormous of amount of radioactive waste that would result, posing the familiar problem of what to do with long-lived radioactive waste. Further, the interaction of the carbon and silicon carbide-coated fuel of the PBMR with the repository environment has not been studied in any detail.

Despite the vast number of the problems relating to the waste being generated by the current crop of power reactors, the Bush administration and the nuclear industry seem set to encourage new reactor orders without a significant social debate about where the waste would be put. Yucca Mountain, even if it were to be licensed, is prohibited by law from accepting more than 70,000 metric tons of spent fuel and is unlikely to be able to accommodate vast new amounts of nuclear waste even if it were to be licensed.

In sum, Dear Baffled, I conclude that PBMR = MBRP, for which the non-mathematical explanation is: If we go ahead with the Pebble Bed Modular Reactor, society May Be in a Real Pickle.

Yrs. etc.

Arjun, a.k.a. Dr. Egghead

IEER would like to thank Dave Lochbaum of the Union of Concerned Scientists for his review of a draft of this article and for the many useful suggestions he made. Dear Arjun retains responsibility for the contents of this missive, however.

1 Russian acronym for Reactor Bolshoi Moschnosti Kanalynyi "Channelized Large Power Reactor."

2 Commission on Geosciences, Environment, and Resources of the National Research Council of the National Academy of Sciences, *Nuclear Wastes: Technologies for Separations and Transmutation, Committee on Separations Technology and Transmutation Systems*, (Washington, DC: National Academy Press, 1996), p. 292.

ERRATA

The corresponding issue of *Energy & Security*, IEER's international newsletter, should have been identified as *Energy & Security* No. 17, not 16 as it was listed in the last issue of *Science for Democratic Action* (vol. 9 no. 3, May 2001).

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RECENT DEVELOPMENTS REGARDING MOX IN JAPAN

Plans for all three Japanese nuclear power plants that were scheduled for the loading of MOX fuel have been postponed. First, the 1999 BNFL data falsification scandal resulted in the postponement of MOX fuel loading into the Takahama plant, located in Fukui Prefecture. Second, in February 2001, the Fukushima Governor postponed the loading of MOX fuel at Fukushima 1-3 in Fukushima Prefecture, and in May established a committee to comprehensively review the Prefecture's energy policy. Third, in a referendum held on 27 May 2001 in Kariwa Village, located in Niigata Prefecture, a majority voted against the use of MOX fuel. Subsequently, Tokyo Electric accepted the village mayor's request to postpone the loading of MOX fuel at the Kashiwazaki-Kariwa plant, originally scheduled to take place this summer.

Following the postponements on MOX use by Fukushima and Niigata Prefectures, the head of the Ministry of Economy, Trade and Industry (METI) visited the perplexed Governor of the Aomori Prefecture in June 2001 to assure him that domestic reprocessing and MOX use will be pursued as national policy. However, the visit was planned mostly because of the government's and utilities' desire to secure Rokkasho Reprocessing Plant as a storage facility for domestic spent fuel.

The postponement of MOX fuel use due to strong local opposition has dealt a serious blow to the government and the utilities. However, instead of directly addressing public opinion, the government and industry have chosen to reorganize their efforts in order to further promote MOX use and the nuclear fuel cycle. The METI, Federation of Electric Power Companies, and major electric companies like Tokyo Electric and Kansai Electric are establishing a number of organizations to promote better local subsidies and other incentive programs.

On 6 June 2001, the Japan Nuclear Cycle Development Institute applied to the government for the safety review of its remodeling plans for the Monju fast breeder reactor, which it operates. The plant, shut down since the 1995 sodium leak and fire, will be remodeled and restarted when the remodeling plans pass the safety review.

On 21 June 2001, the Kariwa Village Assembly adopted a resolution calling on the Japanese government to respect the result of the referendum held on MOX use on 27 May. The Japanese government is not expected to respond.

On 28 June 2001, METI's Advisory Committee for Natural Resources and Energy, released a report on Japan's future energy policy. It recommends the construction of 10 to13 new nuclear power plants — a drastic revision of the previous report on energy policy released in 1998 which recommended building 20 new plants.

The Institute for Energy and Environmental Research
6935 Laurel Avenue, Suite 204
Takoma Park, MD 20912 USA

Address correction requested.

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