# PEDDLING PLUTONIUM

## Nuclear Energy Plan Would Make the World More Dangerous

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## Summary

President Bush's Global Nuclear Energy Partnership (GNEP) plan is certainly bold. But boldness should never be mistaken for wisdom, or even as evidence of rationality. The president wants U.S. taxpayers to foot a $100 billion plus bill to develop, over the course of the next several decades, a global nuclear enterprise to extract plutonium and uranium from spent fuel and recycle it as fresh fuel, first in current light-water reactors, and then later in a new generation of liquid-metal cooled fast burner reactors. The arguments against this plan can be summarized as follows.

- **GNEP is an extravagant, unaffordable excursion into nuclear state-socialism on a global scale.** Implementing *just the initial demonstration phase* of the GNEP will cost taxpayers $30 billion to $40 billion over the next 15 years without generating a single kilowatt of commercially available electric power. Funding requests for plutonium recycle related programs total more than $1 billion dollars in fiscal year 2007. The entire scheme represents a bizarre departure for a president and party professing abhorrence of excessive federal spending and reverence for the workings of the free market.
- **Spent-fuel reprocessing and plutonium-fueled fast reactors are well-proven commercial disasters.** The United States, Europe and Japan spent tens of billions of dollars in the 1970s and 1980s trying to develop plutonium fast breeder reactors (like the proposed GNEP "advanced burner reactors," but with uranium "blankets" added to "breed" more plutonium than is consumed in the reactor). These fast reactors proved to be uneconomical, highly unreliable, and prone to fires due to leaking liquid sodium coolant, which burns spontaneously when it comes in contact with air or water.
- **There is no technical silver bullet available that will appreciably diminish the risks of widespread plutonium use in the civil sector**. Contrary to the assertions of GNEP proponents, the proposed nuclear fuel cycle will increase the proliferation risks relative to the fuel cycle used in the United States, in which the spent fuel is never reprocessed and the plutonium is never re-used commercially. GNEP proponents maintain that a new reprocessing technique, called UREX-plus, offers increased "proliferation resistance" However, the technique produces a mixture of plutonium and minor transuranic elements with a total radiation dose-rate far below the International Atomic Energy Agency's (IAEA) threshold for "self-protection" (i.e. a level of radioactivity making even short exposures to the material very hazardous to human health). Moreover, the critical mass of the UREX-plus mixed product is *intermediate between weapon-grade plutonium and highly-enriched uranium, and therefore can be used in nuclear weapons*.
- **Current international safeguards cannot monitor and measure the flow of nuclear material in reprocessing and enrichment plants with the continuity and accuracy required to promptly detect diversion from peaceful uses.** Current techniques applied to these nuclear "bulk-handling" facilities are insufficient to meet the IAEA's standard for "timely warning" of a lost, stolen or diverted bomb-quantity of nuclear material. Moreover, the IAEA's thresholds for defining such "significant quantities" are four to eight times higher than the technically correct minimum values, suggesting that it is virtually impossible for the agency to determine that nuclear material is missing from such a facility within the time period required to convert it into a weapon.
- **By rashly launching the GNEP, President Bush is jumping the gun by a century or more**. Given the inherent complexities, massive costs, environmental hazards, and security risks involved in plutonium recycling, programs like GNEP should be attempted only when, and if, there is an overwhelming economic and urgent climate-change case for doing so. That is not the case today, when alternative nuclear and new alternative energy technologies are available at dramatically lower cost. Given the rapid technical and economic progress of renewable energy technologies, distributed cogeneration and biofuels, and continuing improvements in the efficiency and cost of uranium enrichment services for conventional nuclear fuels, the sun may *never* rise on the "plutonium economy."

In sum, an energy technology that creates millions of gallons of highly radioactive mixed wastes requiring expensive treatment and disposal, can hardly be called "clean." A plutonium fuel-cycle plagued by radiation leaks, sodium fires, and periodic alarms about missing plutonium in its material balance accounts, can hardly be called "safe." And a "global partnership" that further develops, disseminates, and trains tens of thousands of people in the complex chemical techniques for separating long-lived weapon-usable materials, like plutonium, from self-protecting, intensely radioactive fission byproducts such as cesium and strontium, can hardly be called "proliferation-resistant."

No doubt, the plutonium lobby will persist in ignoring these risks and proffering its relentless forecasts of a golden era of technological progress and declining costs, somewhere just over the rainbow. This kind of salesmanship has been going on for more than 50 years.

The plutonium pork barrel is back again, but it's more cosmopolitan this time around. French, Russian and Japanese government agencies and corporations (in the state-socialist plutonium economy, bureaucrats and businessmen are often one and the same) are now part of the mix. And if news reports are to be believed, President Bush has just promised Indian officials that they, too, can join the GNEP, soaking up whatever the "partnership" has to offer in the way of novel reprocessing and fast-reactor technology, so they can put it to good use in their parallel civil *and military* breeder-reactor programs.

One can only hope that most members of Congress will have the good sense to stay out of the barrel this time around. For those who don't, just remember, this pork barrel is packed with funny numbers and phony technical promises, making the political footing a bit slippery. Legislators could wind up wasting billions of taxpayer dollars in the likely event the GNEP scheme proves infeasible, but *even more money* should the scheme "succeed" in becoming the massive, money-losing government enterprise that peddling plutonium on a global scale requires.

## PEDDLING PLUTONIUM: In-Depth Analysis

### What is Reprocessing, Plutonium Recycling, and Transmutation?

The Bush administration claims its new nuclear energy initiative would diminish America's "addiction to oil" by altering the PUREX (plutonium-uranium extraction) chemical process – originally devised in the 1950s to obtain plutonium for bombs – to avoid separating plutonium in its pure form, thereby allegedly enabling a new "proliferation resistant" mode for "recycling" spent nuclear fuel rather than storing it as waste for many thousands of years. GNEP proponents believe this advance promises to usher in a new global era of "clean" affordable nuclear power and dramatically reduced requirements for nuclear waste storage.

After a series of failed U.S. government efforts to commercialize PUREX spent-fuel reprocessing in the 1960s and 1970s, the Carter administration abandoned reprocessing in 1977 and sought to discourage the international spread of the technology because of its obvious proliferation implications. President Ronald Reagan reinstated the U.S. willingness to cooperate with selected foreign reprocessing programs, and briefly sought a revival of the U.S. civil program, but the exorbitant costs and associated security and environmental risks of reprocessing remained so daunting that no U.S. commercial entity proved willing to enter the business, and in 1982 Congress killed the commercial demonstration plutonium breeder reactor that was the keystone of the project.

The United Kingdom, France, Japan, Russia and India continue to maintain government-financed-and-managed programs for "commercial" reprocessing that rely on the old PUREX process, but only a small fraction of the world's inventory of spent fuel from civilian reactors has been reprocessed in these plants.

In the commercially dominant "once-through" nuclear fuel cycle, uranium fuel rods, typically enriched to about 4.5 percent in the uranium isotope U-235, undergo a controlled fission chain reaction that produces heat for generating steam that in turn propels turbine generators. The fuel rods are replaced every 18 to 24 months, and the spent fuel from some 103 operable US reactors – about 2,000 metric tons annually – is put temporarily into spent fuel cooling pools at the reactor sites.

The federal government is legally obligated and overdue in taking title to this fuel and moving it to a permanent underground repository – the designated U.S. site is Yucca Mountain, near Las Vegas, Nevada – where its radioactivity is supposed to be safely contained for hundreds of thousands of years.

The conventional PUREX reprocessing technology begins by dissolving the spent fuel rods in a bath of nitric acid, and then proceeds, by means of a staged series of chemical processes, to create three separate product streams, comprised of uranium, plutonium, and high-level radioactive waste. The high-level waste stream is comprised of "fission products" (the lighter radioactive materials produced in the fuel as a consequence of fission and radioactive decay) and "transuranics," the heavy radioactive elements beyond uranium in the periodic table that, like plutonium, are produced primarily by the absorption of neutrons by uranium and transuranics.

Unlike PUREX, the UREX-plus technique is designed to leave the plutonium product mixed together with the other transuranics, which comprise less than 20 percent of the new mixed-product stream. The intent is to make the resulting product unsuitable for weapons and more difficult to handle for anyone trying to build a bomb, but as described below, the process fails to achieve these objectives. What would be mixed with the plutonium has become a moving target. Original it was to be only neptunium, but that proved to be no more self-protecting than plutonium. Then it was proposed to also mix in the americium and curium elements, but that mix was still far below the minimum level set by the IAEA as sufficient for the mix to be deemed "self protecting." Now it is also proposed to include europium, and possibly other elements of the "lanthanides" series. The separated uranium, in the form of an oxide, would be set aside for later recombination with the plutonium-transuranic mixture

and fabrication into new fuel elements. The chemical stream containing the shorter-lived fission products would undergo further treatment and then be encased in glass logs or blocks ("vitrified") and allowed to cool for decades-to-centuries before permanent burial in an underground repository. It has also been proposed to separate out the strontium and cesium fission products and bury them separately or store them on the earth's surface for hundreds of years.

When placed in conventional power reactors of current design, plutonium and other long-lived radioactive elements are not efficiently "transmuted" into shorter-lived or stable elements, thereby not realizing the full alleged nuclear waste reduction benefit from reprocessing. More efficient transmutation requires an entirely new generation of extremely costly *advanced burner reactors*, likewise called for in the president's scheme, which are updated versions of the unworkable Clinch River Liquid Metal Fast Breeder Reactor that Congress terminated in 1983. A version of the new transuranic-uranium fuel—possibly metallic—would be used in such "fast reactors," which are usually designed with a more densely packed – and therefore generally less safe – core than a conventional light-water reactor. In fast reactors the heat-producing fission chain reaction relies, like a nuclear weapon's, on "fast neutrons" that have not been slowed down, as in a conventional thermal reactor, by interactions with a "moderator," typically water. When exposed to this "fast spectrum" of more energetic neutrons, a fraction of the long-lived transuranics break down into shorter-lived or stable elements.

The spent fuel from the fast reactor would then be reprocessed as a metal using a second, less-developed and more costly technology known as "pyro-processing," which partitions the fuel by dissolving it in molten salt and running an electric current through it. The metallic state of the material brings the technology involved this process one step closer to nuclear weapons.

By steadily "transmuting" the long-lived radioactive elements into shorter-lived ones, multiple recyclings would in theory steadily reduce the amount of long-lived radioactive material requiring very long-term isolation, and hence the size and number of future underground repositories requiring (unpopular) siting in someone's back yard. A major drawback, however, would be a sharp increase in the volume of radioactive wastes from reprocessing requiring shorter-term forms of disposal. Disposal of these wastes are less carefully regulated, and still pose significant environmental threats to water and soils, but on a timescale of decades, rather than centuries or millennia.

## What is the GNEP?

In the Department of Energy's (DOE) fiscal year 2007 budget, the president is requesting a $250-million down payment on what a swiftly coalescing plutonium lobby[1] hopes to parlay into a multi-$100-billion Global Nuclear Energy Partnership (GNEP) funded by U.S. taxpayers. Under GNEP, the United States and its international partners ostensibly would develop and build new advanced *spent-fuel reprocessing plants* to separate plutonium, uranium and selected long-lived radioactive isotopes from the short-lived highly radioactive isotopes in spent nuclear fuel, so that the former can be recycled into fresh fuel.

[1] The new plutonium lobby includes, but is not limited to, the following major institutional and political players: Areva Corp., France's mostly government-owned reprocessing and nuclear fuel services enterprise; Spencer Abraham, former secretary of energy and now non-executive chairman of Areva, Inc., the company's U.S. subsidiary; DOE's Office of Nuclear Energy, Science, and Technology (NE), Idaho National Laboratory, and Argonne National Laboratory in Illinois; Washington Group International, corporate parent of the Washington Savannah River Company (WRSC), which manages DOE's Savannah River Site, where much of the plutonium in the U.S. nuclear weapons stockpile was produced and separated: Bechtel Corp., co-manager of Los Alamos National Laboratory (with the University of California) and major subcontractor at the DOE's Savannah River Site (SRS); Sen. Lindsey Graham, (R-S.C.), a member of the Armed Services Subcommittee that oversees the DOE's operations at the SRS; Sens. Pete Domenici (R-N.M.) and Larry Craig (R-Idaho), chairman and member, respectively, of the Senate Energy and Water Appropriations Subcommittee; Alex Flint, a former Domenici appropriations staffer now representing the Nuclear Energy Institute; and Clay Sell, a former Domenici committee staffer and architect of GNEP now serving as deputy secretary of energy.

Taking this next step requires a multi-billion-dollar *mixed oxide (MOX) fuel fabrication plant* to blend the uranium and plutonium into fresh fuel elements for current generation reactors, in which the plutonium replaces highly-enriched uranium (HEU) as the principle fissioning element in the fuel. (The federal government is just beginning to construct one of these plants, nominally for the initial purpose of "disposing" of 34 tons of excess U.S. weapons plutonium over a planned seven-year period, at the Savannah River Site in South Carolina at a planned cost of some $3.7 billion). Construction of a Russian MOX fabrication plant has been stalled for more than a decade because no one wants to pay for it. Russia and the United States have 68 tons of military plutonium that both countries would gladly give away for civil reactor fuel, but nobody wants it because it is cheaper to buy low-enriched uranium and fabricate it into fuel than it is to fabricate plutonium fuel.

To blunt the proliferation and security risk arguments that sank plutonium recycling during the Ford and Carter administrations, the Bush administration is proposing that the so-called "advanced nuclear countries" – the five declared nuclear weapons states (the United States, Russia, China, France and the United Kingdom) – plus Japan and possibly India, South Korea and a few additional European Union countries, should together constitute a kind of nuclear oligopoly, "leasing" enriched-uranium and plutonium fuels– and even *entire transportable modular fast reactors*– to the "developing" world. The spent fuel would then be returned to one of the "advanced" countries for reprocessing and remanufacture into fresh plutonium fuels for re-leasing, in a never-ending international cycle of ostensibly "clean," "safe" and "economical" nuclear power. It's a grand– some might even say grandiose– neo-colonialist vision for electric power generation in a carbon-constrained, but energy-hungry world.

The intensely radioactive but relatively short-lived strontium and cesium wastes from reprocessing would be encased in glass logs and stored on the surface in the reprocessing country until they had cooled for several hundred years, and then entombed by a future society in (as yet nonexistent) permanent underground repositories. As noted, plutonium and other long-lived radioactive "transuranic" elements formed during the fission process ostensibly would be "burned-up" (i.e. transmuted into stable and/or shorter-lived radioactive elements) in a new generation of yet-to-be developed liquid-metal-cooled "fast reactors," so-called because, like a nuclear weapon, they utilize a "fast spectrum" of neutrons that have not been slowed by a "moderator," such as graphite, or the water in now widely deployed light water reactors.

The Bush administration's overall vision of a U.S.-led Global Nuclear Energy Partnership – predicated on an exorbitant, taxpayer-funded revival of U.S. spent-fuel reprocessing and plutonium-fueled fast reactors – is seriously flawed. The GNEP is at once fiscally irresponsible, strategically misguided, and technically implausible on any reasonable timescale, for the specific reasons set forth below.

## A New Long-term Addiction to Plutonium Won't Reduce Our Current Addiction to Oil

Whether or not one puts any stock in the long-term GNEP vision for U.S. and global energy security, the president's attempt to link it to America's current heavy dependence on petroleum-derived fuels is twice removed from present day realities. In the first instance, the linkage cannot withstand scrutiny because nuclear energy and petroleum are used in sectors of the economy that barely overlap. With the exception of the U.S. Navy's nuclear powered warships, nuclear energy in the United States is used exclusively for electricity generation in the public utility sector, accounting for about 20 percent of current generating capacity, while only 3 percent of U.S. oil consumption is used for this purpose.

The bulk of U.S. oil consumption (68 percent) occurs in the transportation sector, very little of this sector involves electrified modes of transport (i.e. urban mass transit, intercity high-speed rail, electric or hybrid-electric vehicles), and the administration and the majority in Congress have remained mostly hostile to public policies that could promote substitution of electrified for petroleum-based modes of transport, thereby potentially giving nuclear-generated electricity a market opening into the transportation sector.

Even if nuclear-generated electricity could surmount this first hurdle, it would still have to compete in the energy marketplace with other, presently cheaper sources of electricity. Even assuming more enlightened government policies penalizing carbon-emitting sources, history suggests that President Bush's plutonium fuel-cycle proposal has the proverbial snowball's chance of generating *cost-competitive* electricity, or even *any* commercially available electricity, for decades.

### GNEP is an Unaffordable Experiment in Nuclear State-Socialism on a Global Scale

Implementing *just the initial demonstration phase* of the GNEP would cost taxpayers tens of billions of dollars over the next 15 years, without generating a single kilowatt of commercially available electric power. The entire scheme represents a bizarre departure for a president and party that profess to abhor excessive federal spending and revere the workings of the free market.

By 2011, the administration's vision demands taxpayer-funded, government-run development and construction of a pilot *engineering-scale demonstration*, costing at least $1 billion, to guide design of a subsequent full-scale commercial spent-fuel reprocessing plant that will employ the new UREX-plus chemical separations process.

By 2014, the DOE hopes to start-up a *mixed-oxide (MOX*) *plutonium fuel plant* that will cost at least $3.6 billion, followed in 2015 by a plutonium-fueled prototype for an *advanced burner reactor (ABR)* likely to cost $4 billion or more. This will be followed by the opening of a billion-dollar plus *advanced fuel cycle facility* in 2016, and, if all goes well, by completion of a *commercial scale UREX-plus reprocessing plant* around 2020 costing at least $10 billion to $15 billion. By way of comparison, the U.S. government had poured $8 billion into developing and fabricating components for the Clinch River Breeder Reactor before it was cancelled in 1983, prior to site construction. Japan's Rokkasho commercial-scale reprocessing plant has required more than $20 billion and 15 years to construct, and is only now undergoing its first test runs with plutonium-laden spent fuel.

The government also will spend at least another $1.6 billion through 2015 just on maintaining the existing plutonium fuel-cycle research infrastructure at the Idaho National Laboratory (INL), the recently reborn "lead laboratory" for implementing the president's plutonium fuel-cycle initiative. Annual costs for operating each of the above named government-owned facilities will add many billions more to the tab.

### Spent-Fuel Reprocessing & Plutonium-Fueled Fast Reactors are Commercial Disasters

Worldwide, not a single spent-fuel reprocessing and plutonium recycle program has been commercially successful. On the contrary, heavily dependent on overt and hidden government subsidies and ownership, these programs represent one of the last vestiges of Soviet-style state socialism in an increasingly globalized free-market economy.

To achieve GNEP's claimed reduction in the volume of future nuclear waste requiring long-term isolation in a permanent underground repository, every fourth or fifth reactor in the world would have to be a fast-reactor capable of "transmuting" longer-lived radioisotopes. To also transmute the plutonium and actinides in the existing backlog of spent fuel, every third of fourth reactor would have to be a fast reactor. In fact, to deliver on its forecast benefit, if this program had any credibility the next 100 or more new commercial reactors worldwide would have to be fast reactors. In the United States alone, this adds an $80 billion to 100 billion requirement for 20 to 25 fast reactors just to transmute the fuel discharged from existing U.S. power reactors. Globally, this would add hundreds of billions to a trillion dollars to the cost of nuclear-generated electricity.

The United States, Europe and Japan spent tens of billions of dollars in the 1970s and 1980s trying to develop plutonium fast "breeder" reactors. The proposed GNEP advanced "burner" reactor is essentially the same as the fast "breeder" reactor, but without the breeder's addition of a uranium "blanket" to breed more plutonium than is "burned" in the reactor. These fast reactors proved to be grossly uneconomical, highly unreliable, and prone to fires from leaks of their highly corrosive liquid sodium coolant. The

historical record suggests that the GNEP fuel-cycle would prove at best to be uneconomical and in need of continuing taxpayer subsidies, and at worst it would prove unreliable and even dangerous to workers and surrounding communities.

GNEP also has all the earmarks of becoming an inefficient, global state-socialist-sinkhole for tens of billions in capital sucked from the accounts of developing nations and international banks, with continuing reliance on hidden subsidies from the U.S. taxpayer. These are funds that developing nations could put to better use creating genuine energy autonomy by developing indigenous renewable sources and implementing efficiency standards and technologies.

Every last cent to develop and deploy a U.S. commercial reprocessing program—on top of the $80 billion already spent to develop and subsidize the current generation of nuclear plants—would likely be borne by U.S. taxpayers. This open spigot for civil plutonium clearly would diminish federal resources available for tax and other incentives aimed at accelerating the adoption of safer, cleaner, renewable and other low-carbon technologies that have a *near-term* and much better chance of becoming self-sustaining in the marketplace, and thereby fostering *commercially viable, exportable* U.S. products. One thing is certain. No purely commercial enterprise anywhere in the world will be building, much less exporting at a profit, liquid metal fast reactors anytime soon. Not in this decade, and not in the next. But the president, it seems, wants to foist this loser of a business plan on the U.S. taxpayer.

Even allowing for the possible long-term emergence of a technically viable reprocessing/transmutation enterprise, which seems unlikely, the currently proposed GNEP represents *nothing but federal payouts for at least the next 20 years*. Negative cash flows from the enterprise are likely to persist for decades after that, possibly indefinitely. The chance that revenues from the envisioned nuclear fuel-leasing to developing countries would be sufficient to amortize the massive capital investment on some reasonable time-scale, and provide a reasonable inflation-adjusted return to the federal treasury, is nil.

## GNEP Would Multiply Targets for Terrorists and Require Heavy Investments in Security

GNEP is hardly the right foundation on which to build a U.S. international energy policy to reduce global warming emissions and promote growth in the developing world. The United States originally developed chemical reprocessing technology to extract plutonium for nuclear weapons. Spent-fuel reprocessing (what the administration now seeks to rebrand as ecologically minded "recycling") *is an inherently dangerous activity* because it separates nuclear weapons-usable plutonium from the highly radioactive waste surrounding it in spent fuel (a feature nonproliferation experts dub "self-protection" for the plutonium within the spent fuel rod). The plutonium is stored until it can be fabricated into fresh fuel, creating stockpiles of separated plutonium and uranium that can be mislaid, poorly accounted for, stolen by black marketeers with help from insiders, assaulted by terrorists, or diverted by another nation state, agency, or sub-national group to a secret weapons program.

Notwithstanding the administration assertions, the supposedly "proliferation resistant" UREX-plus process actually yields a mixture of plutonium and minor transuranic elements – neptunium, americium, and curium – with a total radiation dose-rate "more than three orders of magnitude lower than the IAEA's threshold for self-protection."[2] Moreover, the critical mass of each of the transuranics, and therefore the UREX-plus mixed product, is *intermediate between weapon-grade plutonium and highly-enriched uranium, and therefore usable in nuclear weapons.*

Under the GNEP rubric, the DOE also is seeking to advance a possible follow-on reprocessing technology, called "pyro-processing," for extracting plutonium from the future advanced burner reactor's fuel elements. This electrochemical process has been under development for years, but progress has been slow, and its viability at commercial scale is far from proven. This process would result in a highly

[2] Jungmin Kang and Frank von Hippel, "Limited Proliferation Resistance Benefits from Recycling Unseparated Transuranics and Lanthanides from Light Water Reactor Spent Fuel," *Science and Global Security*, Volume 13: 169-181 (2005).

radioactive byproduct of fission – Ce-144 – remaining in the separated transuranic product stream containing the plutonium. But Ce-144 has a radioactive "half-life" of only 0.8 years, and *will have decayed away to insignificance for "self-protection" purposes by the time the advanced burner reactor fuel is reprocessed*.

### Current Methods for Detecting Small Diversions of Nuclear Material are Unreliable

Available technologies for containing and monitoring the flows of nuclear material in reprocessing and enrichment plants – so-called nuclear "bulk-handling" facilities – are insufficient to meet the IAEA's current standard for "timely detection" of any lost, stolen or diverted bomb-quantity of nuclear material.

Moreover, the IAEA's thresholds for defining such "significant quantities" are four to eight times higher than justified by the underlying technical realities and what has long been achieved by nuclear weaponeers, in some cases half a century ago. These technical realities suggest that it is virtually impossible for the agency to determine whether nuclear material is missing within the time period required to convert it into a usable nuclear weapon. Cognizant of these difficulties, the director of the IAEA had proposed a five-year, worldwide moratorium on constructing such facilities to allow the international community to develop a politically and technically credible regime for managing the nuclear fuel cycle in a way that minimizes proliferation risks.

### Failing to Detect Even a Small Diversion Could Be Catastrophic

Modern nuclear weapons contain as little as 2 to 4 *kilograms* of plutonium. The explosive fission of that much material can produce explosions of the scale that destroyed Hiroshima and Nagasaki, and smaller explosions can be made with even less material. Plutonium recycling at the level sufficient to fuel a significant fraction of the roughly 100 currently operating U.S. reactors would involve *hundreds of thousands of kilograms* of separated plutonium, creating an inverse "needle-in-the-haystack" detection problem of truly daunting proportions.

### There is No Technology that can Eliminate the Risks of Recycling Plutonium

As discussed previously, the Bush administration's plan to pursue the UREX-plus separations process does not appreciably alter the national and international security risks posed by the blended transuranic (but still more than 80 percent plutonium) product. Beyond the characteristics of the reprocessed product itself, however, there is a dimension to the proliferation problem that is often overlooked by reprocessing proponents.

It is the existence of sensitive fuel cycle facilities *per se*, along with the technical expertise required for their construction and use – and not merely the radioisotopic mix of a facility's product – which ultimately determine the nature of the "state-sponsored" proliferation threat from sensitive fuel cycle facilities. After all, once in possession of such a facility, a nation state or subnational agency can remove itself from the international safeguards regime, as North Korea has done and Iran is threatening to do, and the isotopic mix of the product can be adjusted to suit the needs of the owner.

For example, the nominally "civil" uranium enrichment facility being constructed by Iran – currently the object of great international concern – does not and would not contain directly weapons-usable highly-enriched uranium when operated under IAEA safeguards for civil purposes. But the *inherent capability* to produce such dangerous material is posed by Iran's ownership and control of such a plant. In the case of spent fuel reprocessing, the threat of terrorist assault, sabotage, and extremely damaging accidents persist, regardless of the particular separation technology employed.

Ask yourself this. If the administration's proposed plutonium fuel cycle technology really is "proliferation resistant," would DOE propose building it in Pakistan, Iran or North Korea? How about Brazil, Argentina,

Saudi Arabia, Syria, Indonesia, Viet Nam or Taiwan? And why does India plan, with the president's blessing, to keep its fast-breeder reactor in its military program, and not subject to IAEA safeguards?[3]

While the GNEP reprocessing plants may initially be confined to a few "advanced nuclear countries," with the passage of time the technology and trained personnel likely would spread far and wide. Of course, this has already occurred to a limited degree. The United States obviously never sold a reprocessing plant to India, but somehow all those Indian experts DOE trained at Argonne-West and Hanford in the 1960s went home and built one anyway, as did the North Korean experts who originally trained in Russia. Abdul Qadeer Khan, the infamous Pakistani entrepreneur of nuclear proliferation who has aided the clandestine nuclear efforts of North Korea, Iran and Libya, among others, originally worked for a contractor to the URENCO centrifuge enrichment facility in Holland, where he stole blueprints and built a copy of this facility in Pakistan.

Now that the Bush administration has anointed UREX-plus, fast reactors and the commercial use of plutonium as the preferred nuclear fuel cycle for advanced industrial countries – a group that includes both weapon-states and "trustworthy" non-weapon states – the "countries of concern" seeking nuclear weapons will be able to claim they too need to engage in plutonium processing and fast reactor R&D, just as Iran is doing today in claiming it needs to engage in uranium enrichment R&D. It is the international safeguards regime that is in need of repair, not the conventional nuclear fuel cycle.

Finally, there is ample political reason to doubt that the rest of the world will sign-on to a U.S.-led *civil* nuclear oligopoly that neatly matches the existing *military* one enshrined in the Nuclear Nonproliferation Treaty (NPT), which many nations view as only an interim and conditionally legitimate regime, pending the establishment of global arrangements for enabling nuclear disarmament. And there is now every reason to doubt, based on the recent shameful U.S. cave-in in Delhi, that future presidents of Mr. Bush's ilk would have the stomach to maintain this oligopoly for long, or even necessarily the *capability* to do so, short of waging new aggressive wars grounded in an alleged need to preempt foreign threats. The better part of wisdom here is not to promote expanded use of sensitive nuclear fuel-cycle technologies in the first place, and defer any consideration of such use until the NPT disarmament regime and UN structures of global governance and enforcement are far stronger than they are today.

### Liquid-Metal Fast Reactors Have a Poor Safety and Reliability Record

Several of the world's fast reactors have had serious accidents, and few if any can be said to have operated reliably over time as generators of electricity. In October 1966, Detroit Edison's Fermi 1 liquid metal breeder reactor suffered a loss of coolant flow to a portion of the reactor core, leading to the partial melting of four highly-enriched uranium fuel sub-assemblies. It took more than three years to recover from the consequences of this accident, but in preparing for restart in May 1970, separate pipes carrying the reactor's sodium coolant and water burst, dousing the sodium with water, causing a sodium explosion and fire. Restart was finally achieved a few months later, but the reactor was shutdown in August 1972 after failing to gain a license extension from the Atomic Energy Commission and becoming a financial liability to Detroit Edison.

In December 1995, Japan's prototype fast reactor, Monju, suffered a serious accident. Intense vibration caused a thermocouple inside a pipe carrying sodium coolant to break, leading in turn to overheating of the pipe, which gave way at the point of a (possibly defective) weld, spilling hundreds of kilograms of superheated sodium onto the ventilation duct and floor below. Upon contact with the air, the liquid sodium ignited, filling the room with deadly fumes and producing temperatures as high as 1,500 degrees Celsius. The heat was so intense that it melted several steel structures in the room. But it was only when

[3] This is an acutely embarrassing contradiction in the Bush administration's "nonproliferation" policy – simultaneously selling expanded use of fast reactor technology at home as the supposed key to expanding peaceful use of nuclear power worldwide while *overtly condoning* India's plans for using future fast reactors to make plutonium for nuclear weapons.

the fumes from the fire were detected, a full hour and a half after it began, that officials took steps to shut down the reactor.

Fortunately, the leak occurred in the plant's secondary cooling system, which draws heat from the primary loop running through the reactor vessel itself, so the sodium was not radioactive. When investigators finally located the source of the spill they found as much as *3 tons* of solidified sodium. Had such a massive loss of coolant and intensely hot sodium fire occurred in the primary loop, the results could have been disastrous, resulting in a large release of radiation into the environment. The officials in charge of Monju were caught falsifying reports, editing a videotape taken immediately after the accident, and hiding the existence of the real tapes. More than a decade after the accident, Monju still remains shut down.

At 1,200 megawatts, France's Superphenix was the largest and last liquid metal fast breeder reactor operating in Europe for electricity production. It was approved for construction in 1972, but power production did not begin until 1985, and never came close to its rated capacity. Plagued by leaks and corrosion in its sodium cooling system, and a series of minor accidents, Superphenix was shut down in 1990, restarted in 1992, shut down again in 1996 and closed for good in 1997 in a political deal "because of its excessive costs." A 1996 report by the French Accounting Office pegged the total expenditures at that time at 9.1 billion Euros ($10.9 billion USD).

NRDC is aware of only one commercially successful fast reactor endeavor, but not a kilowatt was ever generated. It was the Kalkar demonstration fast breeder, the flagship of the German plutonium breeder program. The project was cancelled before construction was completed, and the site was sold to an entrepreneur, who turned it into a hotel and amusement park complex.

Because pyro-processing produces a metal fuel, some GNEP scientists are now proposing to revert to metal-fueled fast reactors for transmutation. These designs are known to be less safe than fast reactors using ceramic oxide fuels, which in turn are arguably less safe than today's conventional light water reactors.

### GNEP Undermines U.S. Leadership and Credibility on Nuclear Nonproliferation

At the very time when the United States has been demanding that other nations, including such hostile governments as North Korea and Iran, forego their sovereign treaty "rights" to employ the full range of peaceful nuclear technology under international safeguards, overturning the 30-year moratorium on U.S. civil reprocessing would severely damage U.S. nonproliferation objectives and expose the United States to charges of rank hypocrisy.

In reality, strengthening the "proliferation resistance" of current nuclear supply arrangements does not require a single fuel rod to be reprocessed. Nor does it require as yet unrealized technical achievements, or many tens of billion of taxpayer dollars invested in unproven nuclear fuel-cycle facilities.

The "take-back" of spent fuel from countries of proliferation concern and its internationally supervised storage, in qualified permanent underground repositories, can proceed today, completely independent of any long-term programs in certain countries aimed at capturing the "unused" plutonium fuel value contained in this "waste," and thereby reducing its volume. The former neither requires nor precludes the latter. Given the inherent complexities, massive costs, and security risks involved in plutonium recycling, programs such as GNEP should be attempted only when, and if, there is an overwhelming economic and climate-change case for doing so, which is clearly not the case today. Indeed it is entirely possible, indeed probable, that given the rapid technical and economic progress of renewable energy technologies and bio-fuels, and the continuing improvements in the efficiency and cost of uranium enrichment services for conventional nuclear fuels, that the sun will never rise on the "plutonium economy."

Nuclear power itself, while enjoying modest growth in the near term, could well turn out to be a transitional technology, or one that constitutes a cost-effective electricity supply option for only a limited set of capital-rich, technically sophisticated countries with fast growing and densely concentrated power

markets. By rashly announcing the GNEP, President Bush is jumping the gun by at least a half-century, and downplaying realistic clean-energy alternatives in favor of a nuclear alchemist's dream with a proven track record of weapons proliferation and commercial failure.

# PLUTONIUM OVERDOSE

US Department of Energy Projects to Separate, Fabricate and Use Plutonium for Civil and Military Purposes – 2006 to 2017

| Plutonium Projects ($ in 000's) | FY 2006 | FY 2007 | Total Project Cost (Estimated) | Date Complete (FY planned) | Plutonium Facility Annual O&M Costs |
|---|---|---|---|---|---|
| **PLUTONIUM "DISPOSITION" (i.e. getting US and Russian "excess" weapons plutonium <u>into</u> radiotoxic "self-protecting" Mixed Oxide spent fuel, to prevent its ready re-use in weapons)** [a] | | | | | |
| Advanced Recovery and Integrated Extraction System (ARIES), Los Alamos, NM [b] | 41,550 | 29,500 | [R&D funded] | 2007 | N/A |
| Pit Disassembly & Conversion Facility (PDCF), Aiken, SC | 23,760 | 78,700 | 1,499,048 | 2017 (4Q) | TBD (but probably ~ $150 million) |
| New PDCF-MOX Waste Processing Facility | 16,008 | 25,300 | 226,008 | 2012 (3Q) | TBD (but probably ~ $50 million) |
| Mixed Oxide (MOX) Fuel Fabrication Plant, Aiken, SC | 227,425 | 510,235 | 3,632,092 | 2014 | TBD ~ $250 million/yr |
| US Funding for Russian MOX Facility and Fuels Research | 34,163 | 34,695 | [c] 515,600 | 2014 | ?? (Russia would bear cost) |
| Subtotal | 342,906 | 678,430 | 5,872,748 | | $450 million |
| **PLUTONIUM "RECYCLING" (i.e. getting weapons-usable plutonium <u>out of</u> radiotoxic spent fuel, for possible use in a "Global Nuclear Energy Partnership (GNEP)," a "visionary" $100 billion + scheme" for global deployment of U.S. yet-to-be-developed, plutonium-fueled fast reactors.** [d] | | | | | |
| Advanced Fuel Cycle Initiative (AFCI) R&D [e] | 43,005 | 32,000 | [R&D only] | Ongoing activity | (see AFCF below) |
| Systems Analysis & Virtual Advanced Simulation Lab | 4,736 | 10,000 | ?? | 2008 | TBD |
| UREX+ Engineering-Scale Demonstration (ESD) | 13,860 | 155,000 | ~ $1.5 billion[f] | 2011 | TBD ~ $150 million (est) |
| Advanced Fuel Cycle Facility (AFCF) | 6,930 | 20,000 | ~ $1.5 billion[g] | 2016 | TBD ~$250 million (est) |
| UREX + Commercial Scale Reprocessing Plant (2000 MTHM/yr) | 0 | 0 | $10-15 billion | ~ 2020 | TBD ~ $1.0 billion (est) |
| Advanced Burner Reactor (ABR) Prototype | 4,950 | 25,000 | $3-4 billion[h] | ~ 2015 | TBD ~ $ 250 million (est) |
| Gen IV Fast Reactor Research | 10,243 | 6,139 | [R&D only] | (see ABR above) | |
| Idaho National Laboratory (INL) [i] Infrastructure Support (incl. test reactor "Gas Test Loop" upgrade) | 83,724 | 100,396 | ~ $1.6 billion over 10 yrs | 2010 (for ATR Gas Test Loop) | ~ $100 million/yr |
| Subtotal | $167,448 | $348,535 | $17.6 – $23.6 billion | | ~ $1.75 billion |
| Plutonium "Disposition" & Recycling (GNEP) Total | $510,354 | $1,026,965 | $23.6 - $29.6 billion | | ~ $ 2.2 billion |

| DOE Plutonium Projects | FY 2006 | FY 2007 | Total Facility or 10-Year Activity Cost (Est.) | Date Complete (FY planned) | Annual Cost for Operations & Maintenance |
|---|---|---|---|---|---|
| **DOE/NNSA MILITARY PLUTONIUM (i.e. programs ensuring US capabilities to process and fabricate plutonium "pits" for nuclear weapons (Pu-239) and for Space and Defense power sources (Pu-238)** | | | | | |
| Pit Manufacturing & Certification "Campaign"[j] | 238,663 | 237,598 | ~ 2,500,000 | Continuing Activity | > $120 million |
| Plutonium Chemistry & Metallurgy Research Building Replacement (CMRR) | 132,486 | 121,747 | 838,192 | 2011 | TBD |
| Space & Defense Plutonium Infrastructure [k] | 39,303 | 30, 650 | 350,000 | Continuing Activity | ~ $35 million |
| Subtotal | 410,452 | 360,025 | 3,688,192 | | |
| GRAND TOTAL | $920,806 | $1,386,990 | $27.3 – 33.3 billion | | |

## TABLE NOTES

[a] Funded by the NNSA's Defense Nuclear Nonproliferation Program.

[b] The ARIES Project at Los Alamos National Laboratory is an engineering demonstration system for the full-scale Pit Disassembly and Conversion Facility (PDCF) under construction at the Savannah River Site (SRS) in South Carolina.

[c] Estimated US share, FY 2005-2014.

[d] Funded by DOE Office of Nuclear Energy, Science, and Technology

[e] This line amalgamates projects entitled Separations Technology Development, Advanced Fuels Development, Transmutation Engineering, and Transmutation Education.

[f] Preliminary estimate provided by Deputy Secretary of Energy Clay Sell, March 2, 2006.

[g] Ibid.

[h] Sell estimates $2 billion will be expended on the ABR under Bush's GNEP plan through 2011, but the Office of Nuclear Energy's projected completion date for the ABR is 2015, suggesting that perhaps another $1-2 billion of expenditure (and probably much more) will be required to complete the reactor. France's Superphenix Fast Breeder Reactor cost $10 billion to build and operate for 10 years.

[i] INL was formed in FY 2005 from the nuclear energy research components of the former Idaho National Engineering Laboratory (INEL) and Argonne West to become DOE's lead laboratory for advanced civilian nuclear fuel cycle development.

[j] Los Alamos National Laboratory has a fully developed plutonium processing and fabrication complex of its own, centered in Technical Area 55. Some $2 billion has been already been invested to date in upgrading the Plutonium Fabrication (PF-4) facility to produce up to 40 new plutonium pits per year. TA-55 also houses the ARIES pit disassembly and oxide conversion facility, an engineering demonstration facility for the larger PDCF, to be built at the SRS in Aiken, SC, to provide plutonium oxide feed to the planned MOX fuel plant that figures prominently in the President's civilian GNEP plans. PF-4 also processes Pu-238 for defense intelligence and space power missions. In the mid-1990's Los Alamos formulated an ambitious agenda to become the future locus of plutonium and transmutation technology development, wasting some $600 million on plans for deployment of a giant proton accelerator for tritium production and nuclear waste transmutation before the program died in FY 2002. A new building for both military and civilian "actinide research, the CMRR, is also planned for TA-55.

[k] Funded by DOE's Office of Nuclear Energy Research, for FY 07 this budget line includes: $12.2 million for Pu-238 thermo-electric power systems at Idaho National Laboratory; $13.8 million for Pu-238 processing, encapsulation, and scrap recovery at the Plutonium Facility (PF-4) within Los Alamos Technical Area 55; and $4.65 million for facilities that encase Pu-238 pellets at the Oak Ridge National Laboratory.