Further Processing of Minerals and Manufacture of Materials Containing Radioactive and Nuclear Substances

Enrichment of Uranium and processing of spent fuel and fabrication.

Enrichment is a complex high technology process whose development has usually been heavily subsidised by nuclear aspirant governments. Developing a plant in Australia is unlikely to be feasible without using the expertise of the small number of existing consortia that specialize in it.

Enrichment of uranium, even with the more efficient centrifuge process, is still highly energy intensive. A centrifuge plant typically requires 50 to 60 kilowatt hours of electricity per SWU produced. If a plant were to be built in Australia it would thus have to be powered, almost certainly by coal-fired electricity generating plants, thus producing significant increased greenhouse gas emissions and requiring additional generating capacity. This could be used as November 2006 an argument to seek to also build a nuclear reactor. Since operating only one nuclear reactor is a very expensive proposition, this would be likely to be part of a proposal to build more reactors. There are a number of new enrichment plants being built around the world, primarily to replace outmoded inefficient diffusion enrichment plants. This will further increase capacity. There thus does not seem to be a business case for building an enrichment plant in Australia at this time. This has been confirmed by BHP in recent testimony.3 (2006)

India is in the early stages of building a large uranium enrichment centrifuge complex, the Special Material Enrichment Facility (SMEF), in Karnataka. This new facility will significantly increase India’s ability to produce enriched uranium for both civil and military purposes, including nuclear weapons. (ISIS)

What safety issues are involved?

Safety issues involved with enrichment include:

- Storage of depleted uranium in the form of uranium hexafluoride, UF6. This is a highly corrosive and toxic chemical. Storage containers are subject to corrosion and consequently leakage and environmental damage. Storage yards have to be monitored and maintained,
often for many years, until the material is dealt with. The scale of the amounts involved has created an almost intractable problem.

- Transport of the UF6. Potential handling problems and dangers that may arise in the event of an accident.

- Protection against radiation. Workers have to be suitably protected and exposed as little as possible to the ionizing radiation that uranium emits, the danger of which increases with higher levels of enrichment.

<table>
<thead>
<tr>
<th>Isotopic Composition of Natural Uranium</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-234</td>
</tr>
<tr>
<td>atom %</td>
</tr>
<tr>
<td>weight %</td>
</tr>
<tr>
<td>activity %</td>
</tr>
</tbody>
</table>
| activity in 1 g U
nat | 12,356 Bq | 568 Bq | 12,356 Bq | 25,280 Bq |

<table>
<thead>
<tr>
<th>Composition of uranium isotopes in enriched uranium from enrichment of natural uranium (enrichment to 3.5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-234</td>
</tr>
<tr>
<td>weight %</td>
</tr>
<tr>
<td>activity %</td>
</tr>
</tbody>
</table>
| activity in 1 g U
enr | 66,703 Bq | 2,800 Bq | 12,005 Bq | 81,508 Bq |
### Composition of uranium isotopes in enriched uranium from enrichment of uranium recycled from spent fuel

(initially enriched to 3.5%, after burnup of 39 GWd/tHM and delay of 5 years after unload)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>weight %</td>
<td>1.055 $\cdot 10^{-6}$%</td>
<td>1.45 $\cdot 10^{-6}$%</td>
<td>0.09281%</td>
<td>3.82%</td>
<td>1.602%</td>
<td>-</td>
<td>94.485%</td>
<td>100%</td>
</tr>
<tr>
<td>activity %</td>
<td>3%</td>
<td>0.0018%</td>
<td>77.7%</td>
<td>1.1%</td>
<td>13.9%</td>
<td>-</td>
<td>4.3%</td>
<td>100%</td>
</tr>
<tr>
<td>Activity in 1 g U_{env}</td>
<td>8,360 Bq</td>
<td>5 Bq</td>
<td>214,670 Bq</td>
<td>3,056 Bq</td>
<td>38,384 Bq</td>
<td>-</td>
<td>11,763 Bq</td>
<td>276,238 Bq</td>
</tr>
</tbody>
</table>

So we go from 25.28KBq per gram for natural Uranium to 3.5% enriched Uranium having 81.5KBq, to Uranium from spent fuel having 276KBq per gram which is 11 times more radioactive per gram (and 11 times more dangerous) and that is just the Uranium content.

### Composition of uranium isotopes in depleted uranium from enrichment of natural uranium

(from enrichment to 3.5%, tails assay of 0.2%)

<table>
<thead>
<tr>
<th></th>
<th>U-234</th>
<th>U-235</th>
<th>U-238</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>weight %</td>
<td>0.0008976%</td>
<td>0.2%</td>
<td>99.799%</td>
<td>100%</td>
</tr>
<tr>
<td>activity %</td>
<td>14.2%</td>
<td>1.1%</td>
<td>84.7%</td>
<td>100%</td>
</tr>
<tr>
<td>activity in 1 g U_{dep}</td>
<td>2,076 Bq</td>
<td>160 Bq</td>
<td>12,420 Bq</td>
<td>14,656 Bq</td>
</tr>
</tbody>
</table>

A Bequeral = One fission per second

Uranium Radiation Properties

[http://tinyurl.com/o8ma9k4](http://tinyurl.com/o8ma9k4)
One gram of caesium-137 has an activity of \(3.215 \text{ terabecquerel (TBq)}\)\(^\text{[1]}\) = \((3,215,000,000 \text{KBq})\)

\(^{90}\text{Sr}\) has a specific activity of \(5.21 \text{ TBq/g}\)\(^\text{[2]}\) = \((5,210,000,000 \text{KBq})\)

**Plutonium**

Plutonium contained in spent nuclear fuel can be recovered in a reprocessing plant. The recovered plutonium consists of several nuclides, only some of which (Pu-239 and Pu-241) are fissile. Due to the shorter half-life of the plutonium isotopes (Pu-239: 24,065 years), the specific activity of plutonium is much higher than that of uranium, leading to a higher radiation hazard. In addition, radiation hazards can result from short-lived plutonium isotopes, in particular Pu-241, which decays with a half-life of 14.4 years to the gamma-emitter Am-241.

Like enriched uranium, plutonium presents a criticality hazard: if too large amounts are accumulated in one place, uncontrolled chain reactions can occur, causing heavy releases of neutron and gamma radiation.

Since plutonium mostly consists of fissile material (only comparable to highly enriched uranium), it presents a most serious proliferation hazard.

There has not been one enrichment or reprocessing plant anywhere that has not “leaked” radioactive material in excess of the permitted levels into the biosphere and contaminated surrounding land and water. Some of this material has an extremely long half life of tens of thousands or millions of years and cannot effectively be cleaned up or recovered as has been demonstrated by the consequences of the Vixen A & B trials at Maralinga in the late 50,s when 22 Kg of enriched Plutonium was dispersed up to 1000M into the atmosphere. In addition 77Ktons of bombs were detonated in S Australia.

Much of it cannot be recovered and we and our descendants will have to live with it forever.

http://tinyurl.com/pdqvdsp

Radiation arising from human activities typically accounts for up to 20% of the public's exposure every year as global average. In the USA by 2006 it averaged about half of the total …. In comparison, the average dose received by the public from nuclear power is 0.0002 mSv/yr

http://tinyurl.com/q84cdxz

However Radon accounts for 42% which is for the most part released into the biosphere as a result of Uranium mining, milling, enrichment and reprocessing. The very same problem that we have as a result of digging up sequestrated fossilized fuel from eons ago and adding it’s Co2 emissions to the current bio cycle emissions!
Fission Products in spent fuel

Radiation Safety Committee

There are several types of ionising radiation:

- **Alpha** particles are the largest and have the lowest speeds, traveling only a few millimeters into most materials before coming to a stop. They are highly ionising and have the highest relative biological effectiveness (RBE). Alpha particles are emitted from many radioactive elements. They can be stopped by a sheet of aluminium a few millimetres thick.

- **Beta** particles are fast-moving electrons ejected from the nuclei of atoms. These particles are much smaller than alpha particles and can penetrate up to 1 to 2 centimetres of water or human flesh. Beta particles are emitted from many radioactive elements. They can be stopped by a sheet of aluminium a few millimetres thick.

- **Gamma** and **X-rays** are high-energy photons that can penetrate a significant distance into human flesh and water. They can penetrate multiple centimetres of human flesh.

However, if alpha sources are taken into the body, for example by breathing or swallowing radioactive dust, alpha particles can affect the body's cells. Inside the body, because they give up their energy over a relatively short distance, alpha particles can inflict more severe biological damage than other radiations.

Beta particles are fast-moving electrons ejected from the nuclei of atoms. These particles are much smaller than alpha particles and can penetrate up to 1 to 2 centimetres of water or human flesh. Beta particles are emitted from many radioactive elements. They can be stopped by a sheet of aluminium a few millimetres thick.

[http://tinyurl.com/p2vs8jg](http://tinyurl.com/p2vs8jg)

When alpha particle emitting isotopes are ingested, they are far more dangerous than their half-life or decay rate would suggest, due to the high relative biological effectiveness of alpha radiation to cause biological damage, after alpha-emitting radioisotopes enter living cells. Ingested alpha emitter radioisotopes (such as transuranics or actinides) are an average of about 20 times more dangerous, and in some experiments up to 1000 times more dangerous, than an equivalent activity of beta emitting or gamma emitting radioisotopes.

It is estimated that chromosome damage from alpha particles is anywhere from 10 to 1000 times greater than that caused by an equivalent amount of gamma or beta radiation, with the average being set at 20 times.

Researchers are currently trying to use the damaging nature of alpha emitting radionuclide’s inside the body by directing small amounts towards a tumor. The alphas damage the tumor and stop its growth, while their small penetration depth prevents radiation damage of the
surrounding healthy tissue. This type of cancer therapy is called unsealed source radiotherapy.

- http://tinyurl.com/qecrm4o
- α ALPHA – can be stopped after traveling through about 1.2 inches of air, about 0.008 inches (.2mm) of water, or a piece of paper or skin. A thin piece of paper, or even the dead cells in the outer layer of human skin provides adequate shielding because alpha particles can’t penetrate it. However, living tissue inside the body offers no protection against inhaled or ingested alpha emitters.

β BETA – can only be stopped after traveling through about 10 feet of air, less than 2 inches (50mm) of water, or a thin layer of glass or metal. Additional covering, for example heavy clothing, is necessary to protect against beta- emitters. Some beta particles can penetrate and burn the skin.

http://tinyurl.com/q6l2t67

Human Cell size

Human sperm cells consist of a flat, disc shaped head 5.1 µm by 3.1 µm

<table>
<thead>
<tr>
<th>Human Egg</th>
<th>DNA Alpha helix</th>
<th>Human nerve cell process</th>
<th>Human red blood cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 µm</td>
<td>2 nm</td>
<td>1 µm</td>
<td>9 µm</td>
</tr>
</tbody>
</table>

http://tinyurl.com/p6w8mr9

So, an alpha particle can penetrate 200uM (micrometers) ie it could rip through 2 human egg cells or 39, sperm cells (each containing 23 chromosomes) or 200 nerve cells or 2,000 DNA Helixes. I must now apologize to the Commissioners for the following in my submission on Issue 4. Page 18
In air, alphas travel only 3 to 5 centimeters and in living tissue only about 30 micrometers (which is equal to 3 to 5 cell diameters) before they expend their energy and come to rest.

Apparently the 3 to 5 cell diameters is wrong as is the 30 micrometers which should be 200 micrometers = .2 mm.

Specific Genetic Damage Caused by Radon

Most of the epithelial cellular damage is not from radon gas itself, which is removed from the lungs by exhalation, but from radon’s short-lived decay products (half-life measured in minutes or less). When inhaled, these decay products may be deposited in the airways of the lungs and subsequently emit alpha particles as they decay further. The total amount of energy emitted by the progeny is several hundred times that produced in the initial decay of radon. The increased risk of lung cancer from radon primarily results from these alpha particles irradiating lung tissues. When an alpha particle passes through a cell nucleus, DNA is likely to be damaged. More specifically, available data indicates that alpha particle penetration of the cell nucleus may cause genomic changes typically in the form of point mutations and transformations.

Since alpha particles are more massive and more highly charged than other types of ionizing radiation, they are more damaging to the living tissue. As previously described, alpha radiation travels only extremely short distances in the body. Thus, alpha radiation from decay of radon progeny in the lungs cannot reach cells in any other organs, so it is likely that lung cancer is the only major and likely cancer hazard posed by radon.

“cannot reach cells in any other organs,” Really? I did not realise that blood passing through the lungs was devoid of DNA! Is this true?

By breaking the electron bonds that hold molecules together, radiation can damage human DNA, the inherited compound that controls the structure and function of cells. Radiation may damage DNA directly by displacing electrons from the DNA molecule, or indirectly by changing the structure of other molecules in the cell, which may then interact with the DNA. The latter mechanism will be described in more detail later. When one of these events occurs, a cell can be destroyed quickly or its growth or function may be altered through a change (mutation) that may not be evident for several years.

http://tinyurl.com/o3nh4p

enhs.umn.edu/hazards/hazardssite/radon/radonmolaction.html
The tables show that 5Mev alphas will travel .045mm =45 micrometers in water and Beta particles of .54Mev (Sr90) will penetrate 2mm (2,000 micrometers) in water.

http://tinyurl.com/pft8eas

Radiation-Induced Cancer From Low-Dose Exposure
John W. Gofman, M.D., Ph.D. 1990.

For instance, in addition to excessive subdivision of data, and replacement of the entire T65DR database, and exclusion of 15,000 of the study's 91,231 survivors, there are even exclusions of data from the abridged DS86 database and there are prejudgments

I would urge the Commissioners to read this book particularly Ch 18 and 25 as evidence that a) there is no safe dose

And b) that the health effects of the Japanese bombing records have been re-written and edited to suit the nuclear industry. Ie 1965 records were re written in 1986

http://tinyurl.com/qgclkgz

Does uranium enrichment produce nuclear waste?

Since only a small proportion of the original uranium contains Uranium-235, large amounts of waste result from the enrichment process. This is depleted uranium (DU), a name that derives from the fact that much (but not all) of the Uranium-235 has been extracted from it. Despite this, it remains toxic and around 60% as radioactive as naturally occurring uranium. It is estimated that the global stockpile of DU is 1.3 to 1.5 million tonnes, much of which is stored as uranium hexafluoride, UF6.

Weapons Proliferation:

In addition to providing the low enriched uranium for commercial nuclear power stations, enrichment facilities can also produce highly enriched uranium for use in nuclear weapons. Once uranium has been enriched to 3% for reactor fuel much of the work has been done to enrich it to weapons grade. For example, starting with natural uranium, a modern enrichment plant would take about 3.6 tonnes of uranium, and 4,000 SWU to produce the 20 kg of highly enriched uranium required for a modern Hiroshima style bomb. But starting with 3% enriched uranium reactor fuel it would take only about 520 kg of the reactor fuel and 1,500 SWU to do the same job… Further, the same enrichment facility can be used to achieve weapons grade.
Enrichment facilities, supposedly provided for peaceful purposes have been used in this way in the past, and therefore the spread of such facilities present a proliferation hazard. This may grow since the Nuclear Non-Proliferation Treaty framework is faltering in its effectiveness, and as North Korea has shown, countries may withdraw from it with only one month’s notice.

A uranium enrichment plant in Australia could also have a destabilising affect, with concerns having been expressed, for example, by a former Indonesian presidential advisor Dr. Dewi Anwar, who has said that Australia needs to reassure its neighbors that it has no desire to acquire nuclear weapons. “I think it’s very important that Australia does assure the international community that it will not add another security threat to the already very unstable global situation at the moment,” she said.

[http://tinyurl.com/ok9wq7b](http://tinyurl.com/ok9wq7b)

Existing facilities

At present Russia possesses the most advanced uranium enrichment technologies in the world. Enrichment is conducted in four Russian uranium enrichment plants within Atomenergoprom structure. In 2007, at the initiative of former President of Russia Vladimir Putin aimed at creating global infrastructure to support the development of nuclear power engineering in the world

World’s largest supplier of nuclear fuel cycle products and services (in 2007, the volume of commercial export of uranium products (enriched uranium products and reactor fission units) was $1.58 billion). The company has 45 years of experience in foreign trade. It carries out supplies of uranium products for export into 40 countries of the world, providing uranium enrichment services for over 40 % of the world market. The company exports services of uranium oxide concentrate conversion into uranium hexafluoride and raw uranium enrichment services; as well as supplies enriched uranium, isotopes, rare-earth metals and other products. Furthermore, the company imports advanced technological, scientific and medical equipment. TENEX is co-founder of the International Uranium Enrichment Center (IUEC) from the Russian side.


There are three other uranium mines in South Australia, but two have been mothballed temporarily because of low uranium prices. One of those shut is owned by the Russian State-owned nuclear energy company, Rosatom State Atomic Energy, which controls the Honeymoon mine.

Centrifuge Enrichment Plant

In 1992, China and Russia signed a government-to-government agreement for the supply of gas centrifuge enrichment plants for commercial LEU production.[5] The first two phases were constructed at Hanzhong, Shaanxi province, but China decided to build the third phase at Lanzhou in order to utilize the existing infrastructure and workers from the decommissioned gaseous diffusion plant.[6] The Lanzhou centrifuge plant was completed in 2001 and has a capacity of 500,000 SWU/year.[7] Unlike the Hanzhong enrichment facilities, the Lanzhou plant is not under IAEA safeguards, which may be related to the fact that it is co-located with the former military site. In addition, it was reported that China built an additional 500,000 SWU/year indigenous gas centrifuge plant at Lanzhou in 2010.[8]

http://www.nti.org/facilities/724/

It would appear that other countries with much longer and vastly more experience are way ahead of us in this field. Furthermore Russia and China have labour costs which are an order of magnitude lower than Australian labour costs. We would be a Johnny come lately. Like the silicon chip industry I think we have missed the boat.

WIPP Storage (The Waste Isolation Pilot Plant USA)

All transuranics are man-made alpha-emitters. Alpha particles are relatively large, positively charged particles which are easily stopped by a piece of paper or your skin, but which are extremely dangerous if inhaled. Because of its cancer causing properties, the “acceptable” body dose of plutonium is less than one millionth of a gram, an invisible particle. Yet, even this amount can cause cancer 10-30 years after it is inhaled.

The RH-TRU waste contains much more penetrating radiation in the form of Beta particles and Gamma rays which is the reason it has to be handled by machine in special radiation-shielded rooms called Hot Cells. (An RH-TRU waste canister is shown at left. It is a single-shell vented steel container which will hold three 55-gallon drums.) Most of the radioactive content of this waste is made up of fission products and the radionuclide’s are more varied: Strontium-90, Ytrium-90, Cesium-137, Barium-137, Plutonium-241, Americium-241 and Cobolt-60. Ninety-five percent of the remote-handled waste can emit 100 rem per hour at the container surface and 5% can emit up to 1000 rem per hour. This is an enormous amount of radioactivity since a dose of 400 rem will kill 50% of all exposed people. Although RH-TRU waste accounts for only around 4% of the total waste by volume, it may account for 33-45% of the total radioactivity…There were more than 200 fires at Rocky Flats, the largest occurring in 1957 and 1969. These fires spread radioactive contamination in the Denver metropolitan area, particularly to
areas south and east of the site… Elevated levels of plutonium have been found in the remains of cancer victims living near the Rocky Flats site, and many studies indicate ongoing health effects including cancer, leukemia, brain tumors, and other health issues in the surrounding population. (link)

http://tinyurl.com/ow4bvk7

optimalprediction.com/.../plutonium-release-from-the-wipp-radioactive-.

Cost of reprocessing:

In July 2004 Japanese newspapers reported that the Japanese Government had estimated the costs of disposing radioactive waste, contradicting claims four months earlier that no such estimates had been made. The cost of non-reprocessing options was estimated to be between a quarter and a third ($5.5–7.9 billion) of the cost of reprocessing ($24.7 billion). At the end of the year 2011 it became clear that Masaya Yasui, who had been director of the Nuclear Power Policy Planning Division in 2004, had instructed his subordinate in April 2004 to conceal the data.

In March 1999, the U.S. Department of Energy (DOE) reversed its policy and signed a contract with a consortium of Duke Energy, COGEMA, and Stone & Webster (DCS) to design and operate a mixed oxide (MOX) fuel fabrication facility. Site preparation at the Savannah River Site (South Carolina) began in October 2005. In 2011 the New York Times reported "...11 years after the government awarded a construction contract, the cost of the project has soared to nearly $5 billion. The vast concrete and steel structure is a half-finished hulk, and the government has yet to find a single customer, despite offers of lucrative subsidies." TVA (currently the most likely customer) said in April 2011 that it would delay a decision until it could see how MOX fuel performed in the nuclear accident at Fukushima Daiichi.

http://tinyurl.com/q9m5g4f

Along the way, the cost of the South Carolina project, originally about $1 billion, nearly quintupled.

In 2001, Dr. Lyman, a Cornell-trained physicist who has led the battle against mox, published a detailed study in the journal Science & Global Security that concluded the fuel could produce up to 30 percent more cancer deaths.

Energy Department officials do not dispute that there would be additional health consequences, but they see them as less severe than the critics have predicted.

“It’s not that significant — 10 percent or less,” said Kenneth Bromberg, the department’s assistant deputy administrator for fissile materials disposition. In doing so, the Nuclear Regulatory Commission overruled its own Atomic, which had recommended a middle ground requiring some additional security.
The approximate half-lives of some of the isotopes in the spent nuclear fuel are listed below:

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Half-life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strontium-90</td>
<td>28 years</td>
</tr>
<tr>
<td>Caesium-137</td>
<td>30 years</td>
</tr>
<tr>
<td>Plutonium-239</td>
<td>24,000 years</td>
</tr>
<tr>
<td>Caesium-135</td>
<td>2.3 million years</td>
</tr>
<tr>
<td>Iodine-129</td>
<td>15.7 million years</td>
</tr>
</tbody>
</table>

It is clear from the table above that the left over nuclear isotopes from the generation of electricity through nuclear power are extremely long lived and therefore must be shielded from humans and the environment for a long time.

**Storage and Disposal of High Level Nuclear Reactor Waste**

Since the spent nuclear reactor (SNF) fuel is highly radioactive initially it is too dangerous to handle and thus it is very important to shield the radioactivity from humans and the environment. The radioactive material in the SNF generally falls into three categories: (1) un-reacted fuel, usually uranium, (2) fission products, and (3) activation products, most notably plutonium. Because of the nature of radioactivity, on a per-atom or by-weight basis the fission products are by far the most radioactive, and have the shortest half-life. The un-reacted uranium and the plutonium have vastly longer half-lives, but are correspondingly less radioactive. Once the SNF has been removed from the nuclear reactor it is placed in interim storage at the reactor site. Usually this consists of putting the nuclear waste into large pools of water. The water cools the radioactive isotopes and shields the environment from the radiation.

Nuclear waste is typically stored in these supervised pools between 20-40 years. As the SNF ages the radioactivity decreases, reaching the point where it does not need to be water cooled and can be placed in dry storage facilities. Throughout this time there is a great reduction in heat and radioactivity and this makes handling of nuclear waste safer and easier.
After this “cooling off” period the high level waste can be handled in different ways. It can be reprocessed then disposed of permanently or directly disposed permanently in a geological repository. All the proposed disposal techniques employ multiple barriers to isolate the waste from the biosphere for at least 100,000 years.

Many pronuclear activists have been claiming that storage would only be required for three hundred years. Apparently this is false.

http://tinyurl.com/p546zy8

Misleading claims by AREVA

The interest in reprocessing is partly based on false claims by the reprocessing industry that the technology simplifies the nuclear waste disposal problem by reducing the hazard and volume of waste. For instance, the French company AREVA, which reprocesses French spent nuclear fuel, claims that reprocessing "reduces the volume of waste by a factor of at least four."[i] This statement is contradicted by recent data from the U.S. Department of Energy (DOE), which show that reprocessing greatly increases the total volume of radioactive waste, compared to direct disposal of spent fuel.[ii]

The figure and table show the volume of different waste streams generated by three different reactor fuel cycles. In the "once-through" cycle, which reflects the current U.S. strategy, the spent fuel is stored and ultimately disposed of in a geologic repository. In the second fuel cycle, all spent fuel would be reprocessed and the plutonium extracted from reprocessing would be used as new fuel in advanced "fast burner" reactors, which are yet to be developed. The third scenario is similar to the second, except that the recovered plutonium would be used in both fast reactors and current-generation "thermal" reactors. A geologic repository would still be required in scenarios 2 and 3, since reprocessing generates high-
radioactive waste.

In addition to high-level waste, reprocessing generates other types of radioactive waste that require secure disposal. These wastes are more dilute than high-level waste (and hence have greater volume). Although most of the waste falls into the low-level waste category, reprocessing increases the volume by a factor of six to seven relative to the once-through cycle. The United States has three NRC-licensed, commercially operated low-level waste disposal sites that currently accept waste. Reprocessing increases the volume of "greater-than-class-C" low-level waste by a factor of 160. DOE is responsible for disposing of this waste, which contains long-lived radioactive isotopes and cannot be placed in a regular low-level waste site, but as yet has no policy on how to do so.

Relative to the once-through cycle, reprocessing results in somewhat less high-level waste requiring disposal in a geologic repository (23-24 percent by volume). However, this benefit would be insignificant compared to the additional burden posed by the large volumes of low-level and greater-than-class-C wastes.

**The bottom line**

Reprocessing of spent nuclear fuel would increase, not decrease, the total volume of nuclear waste. AREVA's claims to the contrary are inaccurate. Reprocessing is not a sensible answer to the nuclear waste problem.

(http://tinyurl.com/pzb3dl6)

In a “once-through” fuel cycle, in contrast, spent fuel is left intact and simply stored once it is removed from the reactor, for ultimate disposal in a permanent repository. In this case the
plutonium remains imbedded in the highly radioactive spent fuel. Spent fuel contains cesium-137, which emits deadly gamma rays that can penetrate the human body. Someone standing one meter away from a typical spent fuel assembly that has been out of the reactor for a few years could receive a lethal dose in a matter of minutes. Because cesium-137 has a half-life of 30 years, this high dose rate persists for decades. Plutonium in spent fuel is therefore considered “self-protecting” for many decades after discharge.

Commercial reprocessing programs have also produced a glut of separated and vulnerable plutonium. Global stockpiles of separated civil plutonium totaled roughly 250 metric tons as of the end of 2005. Some argue that reprocessing spent fuel will reduce the volume of high-level waste needing disposal in a geologic repository. … However, it is the level of heat generated by the waste—not the volume—that determines how much waste a repository can store … The transuranic elements plutonium, americium and curium are the main sources of heat in spent fuel after a few hundred years; americium and curium remain in the waste stream and would require disposal in a permanent repository. Thus, the PUREX process does not significantly reduce the heat output, or the size of the required repository.

The impact of rising surface temperatures on nuclear power plants. During the heat waves of 2003 and 2006 in Europe, drought reduced the volume of some of the bodies of water used to cool reactors in France and other countries, raising the potential for excess heating of these bodies of water. As electricity demand peaked, Électricité de France sought waivers of the environmental restrictions, while countries such as Germany and Spain reduced power levels or shut down plants entirely. Even so, France ended up having to shut some plants and import electricity to meet demand.

France ships spent reactor fuel to a complex in La Hague, Normandy, for storage and eventual reprocessing. However, the uranium from its reprocessed spent fuel is not being consumed, as it is more expensive to turn into reactor fuel than mined uranium, so thousands of tons have accumulated. But perhaps the biggest failure of this program is its nearly 50-ton stockpile of separated plutonium. France initially intended to use the plutonium in its fast-breeder reactor program. However, this program failed on performance and safety grounds (Phénix and Superphénix were plagued with liquid sodium leaks, and Phénix experienced unexplained reactivity increases). Stuck with a growing stockpile of plutonium, France required Électricité de France to start using MOX fuel made from this plutonium in its light-water reactors—even though MOX is several times more expensive than low-enriched uranium, and its use required reactor modifications and restrictions on operations. So far France has licensed only 20 of its first-generation pressurized water reactors to use MOX fuel. At today’s rate of use of MOX, eliminating the 50-ton stockpile of separated plutonium will take decades.

One of history’s most respected and revered medical and nuclear pioneers, Gofman’s research showed as early as 1969 that "normal" radioactive reactor emissions could kill 32,000 Americans per year.

At the time, Gofman was the chief medical researcher for the Atomic Energy Commission. He told the AEC that reactor emissions must be radically
reduced. The AEC demanded he change his findings, then forced him out when he refused.

http://tinyurl.com/obyyw48

Chernobyl: The Forbidden Truth  Millions of Curies of various radioactive substances were released (some long-lived, some not so long-lived), but no one really knows where it all went and who is absorbing a dose right now. This is, however, a chronic problem with nuclear activities around the world, and not limited to Chernobyl.

In particular, Gofman's NINE ESSENTIAL RULES OF INQUIRY should be required reading for everyone involved in such research

http://tinyurl.com/nnlvyu6b

Issue 2 Submission by Ivan Quail