IKV PAX CHRISTI

DISARM, DISMANTLE & MAKE A PROFIT

A cost-benefit analysis of nuclear modernisation versus nuclear disarmament

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About the project

No Nukes is IKV Pax Christi's campaign for a world free of nuclear weapons. No Nukes is a partner of the International Campaign to Abolish Nuclear weapons (ICAN) and hosts the global secretariat of the Abolition 2000 network. IKV Pax Christi is the joint peace organisation of the Dutch Interchurch Peace Council (IKV) and Pax Christi Netherlands. We work for peace, reconciliation and justice in the world. We join with people in conflict areas to work towards a peaceful and democratic society. We enlist the aid of people in the Netherlands who, like IKV Pax Christi, want to work for political solutions to crises and armed conflicts. IKV Pax Christi combines knowledge, energy and people to attain one single objective: there must be peace!

More information about IKV Pax Christi can be found at www.nonukes.nl and www.ikvpaxchristi.nl. For more information on this paper, and IKV Pax Christi's work on nuclear disarmament, contact Susi Snyder, Programme Manager Nuclear Disarmament, at: snyder@ikvpaxchristi.nl.

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Introduction

Debates are ongoing in nuclear armed countries about the anticipated costs of modernising nuclear arsenals. Spurred by a global financial crisis, governments are looking at ways to reduce expenditures. Rarely, if ever, does anyone ask if there is a way to make money (legally) from the 17,000 or so nuclear weapons on the planet. Instead, discussions range about whether it is worthwhile to spend $10 billion upgrading the B61 bomb[1], or $857 million to produce more M51.1 sea launched ballistic missiles. To date, the authors have not been able to find a public cost benefit analysis of nuclear disarmament versus nuclear modernisation.

The full life cycle costs of nuclear weapons, including long-term disposal of disarmed and dismantled warheads are rarely considered in debates. This may be because there is as little information available about the costs of disarmament as there are about the costs of armament. Nuclear weapons and the spending that has gone into developing them are shrouded in secrecy. It wasn't until Stephen Schwartz' 1994 Atomic Audit that some idea of the actual costs associated with nuclear weapons pricked a thin light in this secret shroud.

Since that publication countless others have written about the costs of modernisation, the costs of maintenance. This study does not seek to counter already published information, instead, it examines the question: Can nuclear disarmament be done at a profit?

Turning aging warheads into cash is not a new proposal; in fact, the Highly Enriched Uranium purchase agreement between the U.S. and Russian Federation in 1993, Megatons to Megawatts, has often been called 'the deal of the century'.

How exactly can you turn nuclear weapons into cash? Ideas have included the Beers not Bombs[2] project, which recycles bronze from nuclear missile systems and turns them into handy bottle openers (and corkscrews for wine aficionados). Others have turned missiles into monuments. This study looks at the materials that put the nuclear in nuclear weapons, and examines the costs associated with getting these materials out of bombs, out of military stockpiles, and into the commercial nuclear market.

According to the International Panel on Fissile Materials there are about 1440 tons of weapons grade uranium and 241 tons of plutonium in the world.[3] Down-blending global stockpiles of existing HEU combined with the HEU from all nuclear arsenals could net somewhere between 158,000 and 166,000 tons of LEU, which would have a commercial sale value between $5,828 – $6,739 million.

While down-blending weapons grade material removes it from potential military use, it does not eliminate the need to prevent these radioactive materials from entering the natural environment. This does not solve, but rather replaces the problems and costs associated with long-term safe and secure storage of nuclear materials. Those costs, however significant, are left out of the calculations in this research, as they are often folded into electric bills from nuclear power suppliers, and not easily isolated.

According to Global Zero, nuclear weapons modernisation and maintenance costs are project at $1,000,000,000,000 (one trillion) USD over the next decade.[4]

From a purely cost-benefit logic, when you compare the estimated costs of maintenance and modernisation of nuclear arsenals, with the potential earnings from down-blending nuclear materials into fuel for nuclear energy reactors, the choice is obvious: Disarm, dismantle, and make a profit.

What Materials?

Fissile materials are the main nuclear components necessary for the development of nuclear weapons. Despite decades of proposals to make their production illegal, to date there has been no treaty preventing their development. Fissile materials used in nuclear weapons do not occur naturally and once created, they need to be isolated from the environment for thousands of years. The production of highly enriched uranium (HEU) for weapons requires isotope separation technology. The most common uranium enrichment technology today is the gas centrifuge, which also is used commercially to make low-enriched uranium for use in power reactor fuel.

Fissile materials are a subset of fissionable materials, and are unique because these atoms are capable of self-sustaining a chain reaction. This difference is what makes these atoms the key ingredient of nuclear weapons. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.[5] Of these, Uranium-235 (U235) and Plutonium-239 (Pu239) are used in nuclear weapons. Large quantities of U235 are used in nuclear energy reactors and during the process some U238 is developed, as well as Pu239.[6] The ability to create fissile materials during nuclear energy production is one of the justifications for strict international controls to ensure that these materials are not diverted for the creation of nuclear weapons.

Fissile materials are highly toxic and need to be isolated from the environment for thousands of years. Right now, there are several ways that these materials are removed from the proliferation stream. France, for example, mixes its nuclear waste with glass in a process called vitrification. Other countries store nuclear energy waste in monitored retrievable storage. Long-term storage plans have been developed, and rejected, for decades.

The production of plutonium and HEU can be damaging to the environment but it can also have adverse effects on the health of anyone exposed to the substances, including workers and communities living nearby. The dangers posed by plutonium and HEU are in fact three-fold: they can be used to make nuclear weapons, they are radioactive and toxic, and their production processes involve other hazardous substances.[7]

The health risks posed by plutonium and uranium are limited as long as exposure is not on a regular basis and as long as the contamination is limited to outside the body. The outer layer of skin insulates the body from the radiation. However, if plutonium does get inside the body, radiation can mutate cells and cause cancer. Penetration of the skin by plutonium and uranium occur commonly through small cuts or scratches and of course through inhalation.[8]

Uranium too, poses a health risk when inhaled or absorbed through wounds. Unlike plutonium, uranium is easily absorbed through the stomach and intestines. Because uranium is less radioactive than plutonium, heavy metal poisoning can occur before the radiation effects manifest themselves. Studies have shown that those working in and around uranium mines suffer inordinate rates of respiratory cancer.[9] Uranium is mined primarily to produce fuel for the commercial market. Current prices for uranium (yellow-cake), before enrichment in today's market are about $42.25 per pound.[10]

Plutonium (Pu239) needs to be chemically separated from spent fuel in order for it to be usable for nuclear weapons or reused as nuclear reactor fuel. This 'reprocessing' produces radioactive waste that necessitates long term storage. Plutonium reprocessing and storage sites have in many cases become contaminated and in some cases contamination has migrated to the groundwater and surrounding areas. Waste from uranium mining specifically, called mill-tailings, poses health risks to surrounding populations, because it contains radioactive isotopes with an extremely long half-life. Studies show that groundwater contamination occurs at nearly all uranium mill-tailing sites.[11]

What are fissile materials used for?

Low enriched uranium (LEU or Uranium-235) is used in most operating power reactors, in some research reactors, and in French naval propulsion reactors.[12] LEU is not used in nuclear weapons, but it does require isolation from the environment.

Highly Enriched Uranium (HEU) was first produced for use in nuclear weapons. It can be combined with plutonium to form the "pit" or "core" of a nuclear weapon, or it can be used alone as the nuclear explosive. The bomb dropped on Hiroshima used only HEU. About 15 kilograms of HEU is sufficient to make a bomb without plutonium.[13] HEU is also used in many research reactors. The U.S., British, and Russian naval propulsion reactors use HEU.[14] In addition HEU is used as a neutron irradiation "target" to make medical radioisotopes.[15]

Fissile material needed to build an atomic bomb ***Source: Union of Concerned Scientists***[16]		
HEU (enriched to 90% U-235)	Simple gun-type nuclear weapon	90 to 110 lbs. (40 to 50 kg)
	Simple implosion weapon	33 lbs (15 kg)
	Sophisticated implosion weapon	20 to 26 lbs. (9 to 12 kg)
Plutonium	Simple implosion weapon	14 lbs. (6 kg)
	Sophisticated implosion weapon	4.5 to 9 lbs. (2 to 4 kg)

The fuel for nuclear reactors needs to have a higher concentration of U235 than already exists in natural uranium ore. This is done by enrichment, whereby the amount of U235 isotope is expanded from 0.7 % to about 5%.[17] Uranium can also be enriched further, and when enriched to about 20% U235 can be used for the construction of a gun-type nuclear device, which is the simplest form of a nuclear weapon. Uranium that is enriched to at least 90% is called weapons-grade uranium.[18]

Plutonium, once it is separated, can be processed and fashioned into the fission core of a nuclear weapon, called a "pit". Nuclear weapons typically require two to four kilograms of plutonium. Plutonium can also be converted into an oxide and mixed with uranium dioxide to form mixed-oxide (MOX) fuel for nuclear reactors.[19]

How are fissile materials regulated?

Oversight of nuclear materials production and use is generally done by national regulatory agencies. International oversight is arranged through the International Atomic Energy Agency (IAEA). One of the requirements of the nuclear Non Proliferation Treaty (NPT) is that countries must negotiate a Comprehensive Safeguards Agreement with the IAEA if they choose to construct nuclear facilities.[20]

Depending on national plans for nuclear energy production, or other non-military nuclear applications, reports and plans need to be filed with the IAEA. These can range from Small Quantities Protocols, to Comprehensive Safeguards Agreements, to Additional Protocols.[21]

Because fissile materials are necessary to produce nuclear weapons, suggestions to ban fissile materials production have been made for decades. U.S. President Dwight D. Eisenhower called for their elimination in his "Atoms for Peace" speech to the UN General Assembly in 1953.[22] Much has been written and said about why no treaty has yet been negotiated.[23] Suffice it to say, that progress is hoped for with the establishment of a Group of Governmental Experts[24] on the issue, but no treaty is likely to be concluded for at least several years.

How much is out there, and where?

Nuclear weapons, and information about nuclear materials have historically been shrouded in secrecy. There is no official international accounting of the number of nuclear weapons in the world, and although there have been recent advancements in transparency (with the U.S., UK, and France revealing at least their upper limits) other nuclear armed states have not revealed their stockpile numbers. There is no comprehensive international assessment of how much fissile material there is in the world, nor is there a relatively realistic accounting of what the eventual permanent disposal costs would be.

Hans Kristensen and Robert Norris of the Federation of American Scientists are leading experts in estimating the size of global nuclear weapons inventories, and according to their reports the current global stockpile of nuclear weapons is about 17,000 weapons. This includes operational warheads and those warheads, which are awaiting dismantlement. The United States and the Russian Federation have the largest arsenals by far, with over 16,000 of the weapons between them. The seven other nuclear armed states hold a combined total of about 1000 weapons. [25]

The global stockpile of highly enriched uranium (HEU) is about 1440 (±125) tons, enough for more than 60,000 simple nuclear weapons. About 98% of this material is held by Russia and the United States. The relatively high uncertainty about the accuracy of the 1440 figure is partly because Russia does not declare how much HEU it produced before it ended production in the late 1980s.[26]

The United States stopped producing HEU in 1992 and has published an official accounting of its HEU production, as has the United Kingdom, which stopped producing in 1962. France too has officially announced an end to HEU production for weapons, while China has indicated this informally.[27] However, India and Pakistan continue to produce HEU, for naval fuel and nuclear weapons respectively, albeit at a lower rate than the blend-down by Russia and the United States. North Korea has a uranium enrichment program, but it is not known if it is producing HEU. Israel has expertise in isotope preparation and may have produced enriched uranium for military purposes in the past.[28]

The global HEU stockpile is shrinking because both Russia and the United States down-blend HEU that they have declared to be excess to their military needs. Russia is down-blending over 30 tons per year to be used as reactor fuel. This is about 10 times the current rate of down-blending in the United States.[29] The U.S. and the UK are the only nuclear weapon states to have declared the sizes of their HEU stockpiles. France has declared only its civilian HEU stockpile, while the other nuclear armed states have released no information on their HEU holdings.[30]

The non-nuclear weapon states account for about 20 tons of HEU, almost all of which was provided to them as research reactor fuel by the nuclear armed states. This stockpile is declining as research reactors are converted to low-enriched uranium fuel or closed down, and the HEU fuel is blended down or returned to the countries of origin.[31] Since 1978, there have been international efforts to convert existing HEU-fuelled reactors to low-enriched fuel and to design all new research reactors to use only LEU fuel. One of these efforts was the (non-binding) commitment made by participating States at the 2010 Nuclear Security Summit, which stated that "*participating States will consider, where appropriate, converting highly-enriched-uranium fuelled research reactors, and other nuclear facilities using highly enriched uranium, to use low enriched uranium, where it is technically and economically feasible.*"[32]

In spite of these efforts, there are still over one hundred research reactors worldwide that use HEU, some of which contain large quantities of weapon-grade material (90–93% U-235). HEU also is used to fuel propulsion reactors in 11 Russian civilian icebreaker and container ships. Starting in the 1950s, the United States and Russia exported research reactors to other countries as part of their respective Atoms for Peace programs. The United States supplied about 17.5 tons of HEU as fuel for these reactors. About 10 tons remain in Germany, France, and Japan, mostly as spent fuel, with a further 2 tons in other EURATOM member states. The Global Threat Reduction Initiative charged with securing and removing U.S.- origin HEU at civilian sites worldwide, has removed a total of over 1,240 kg of HEU from 24 countries, with 15 of these countries now cleaned out of all U.S. origin HEU.[33]

The global stockpile of separated plutonium in 2011 was estimated at about 495 tons. About half of this stockpile was produced for weapons and the other half as part of civilian reprocessing programs. As a result, about 98 per cent of all separated plutonium is in the nuclear armed states today.[34]

The stockpile of separated plutonium for weapons continues to increase because of production in India, Pakistan, and perhaps Israel. The five recognised nuclear weapons states of the Non-Proliferation Treaty

(NPT) stopped production decades ago, but Russia, the United States, and the United Kingdom so far have not begun to dispose of stocks that they have declared excess. France and China have not declared any plutonium as excess to military purposes.[35] There are about 10 tons of plutonium in Japan, the only non-weapon state with a significant program to separate plutonium from spent nuclear fuel.[36]

Plutonium disposition provides different challenges to that of HEU. Plutonium can be blended with uranium oxide to make Mixed Oxide (MOX) fuel, but not all reactors can use this type of fuel. MOX fuel can be developed by mixing plutonium generated during nuclear power plant operations (reprocessing) or by down-blending weapons grade plutonium with depleted uranium. Japan (Tokai), France (Melox) and Russia (Mayak, Ozersk) currently have operating MOX production facilities. There are plans to start up reprocessing facilities in Japan (Rokkasho), Russia (Zheleznogorsk) and in 1999 the U.S. National Nuclear Security Administration entered into a contract with what is now Shaw AREVA MOX Services LLC for the construction and operation of a MOX Fuel Fabrication facility at the Savannah River site in Georgia.[37] but construction of this facility is delayed.[38] Currently, MOX fuel is used in about 40 nuclear reactors in Belgium, Switzerland, Germany and France. Japan also has ten reactors licensed to burn MOX fuel. [39]

How are these materials traded?

The nuclear energy industry is fairly large, with some 435 nuclear power plants in the world. Some countries are seeking to enter the industry- either through developing new power plants or by selling uranium. Other countries are leaving the nuclear industry. In September 2012, Japan announced it would phase out nuclear power, following an earlier similar decision by Germany.[40] Public pressure, reactor accidents (like Three Mile Island (US), Chernobyl (Ukraine) and Fukushima Daiichi (Japan), as well as the resource intensive start up costs and lack of long-term disposal options all contribute to decisions to either phase out or halt construction of nuclear reactors. However, some countries, including Jordan and Saudi Arabia, continue investigating the possibility of developing national nuclear power industries. As previously discussed, every nuclear power plant develops materials that can be extracted for nuclear weapons devices and strict IAEA controls were developed to prevent proliferation in this manner.

Uranium for nuclear power plants is a traded commodity, but trading does not occur in a normal free market place the way that conventional products, services or currencies are traded. Instead, private organisations develop price indicators through monitoring of market activities.[41] Uranium is generally bought as U308 (yellow-cake), converted to UF6 (uranium hexafluoride) and then enriched so that the concentration of U235 is increased to a point at which the material can sustain a chain reaction. It is then manufactured into pellets, which fill the tubes creating the reactor core. Uranium enrichment is measured, and sold, in terms of separative work units, or SWU.[42] At the end of March 2013, U308 was trading at $42.25 per pound, UF6 was averaging about $120 per kilogram, and the SWU price was dropping a bit from the previous quarter to $115.[43]

Nuclear Weapons today- and projections for the future

The nine nuclear armed states are modernizing their arsenals and in some cases building new nuclear weapons production infrastructure.[44] These nuclear armed countries are also modernising the delivery systems – building new missile capabilities, upgrading to new submarine capabilities and some are even considering the option of plane dropped gravity bombs. The modernisations costs of delivery systems designed for nuclear weapons cannot be easily separated from the costs of the weapons themselves. Some delivery systems do have a dual-use capacity, but the drive to develop them is conditioned upon their ability to deliver a nuclear payload. The expenses to both maintain and modernize the nine nuclear arsenals are estimated conservatively at about $104.9 billion, or $6,063,584 per weapon over ten years.[45]

Summary table of nuclear weapons numbers, costs and modernisation plans

Country	Number of Nuclear Weapons[46]	Estimated cost [47]	Modernisation plans[48]
China	240	$7.6 billion	Delivery systems
France	300	$6 billion	Production facilities and delivery systems
India	80-100	$4.9 billion	Delivery systems, uranium enrichment capacity, production facilities
Israel	80	$1.9 billion	Delivery systems
North Korea	<10	$0.7 billion	Delivery systems, uranium enrichment
Pakistan	90-110	$2.2 billion	Plutonium production, delivery systems, infrastructure investments
Russian Federation	8,500	$14.8 billion	Delivery systems, including new strategic bombers
United Kingdom	225	$5.5 billion	Delivery systems (Trident replacement), uranium enrichment, dis/assembly facilities, plutonium fabrication refurbishment
United States	7,700	$61.3 billion	Delivery systems, whole-of-complex refurbishment, capacity for future production
Total	**~17,300**	**At least $104.9 billion over 10 years**	

Down-blending

Russia and the U.S. are down-blending the HEU that they have declared to be in excess of their military needs. Russia is blending down more than 30 tons per year, about ten times the current down-blending rate in the U.S..[49]

The 435 operating nuclear reactors in the world currently use approximately 65,500 tons of enriched uranium per year.[50] About 75% of this is from uranium mining, with the other 25% coming from reprocessing and down-blending. Current down-blending practices produce about 2,650 tons of uranium each year,[51] or about 13% of global reactor requirement.[52] The World Nuclear Agency showed 2011 Uranium mine production to be approximately 54,610 tons, meeting 85% of global demand[53]. Introduction to the market of large quantities of down-blended LEU could significantly alter the demand for freshly mined uranium. Especially after the 2011 Fukushima Daiichi meltdowns, with many countries considering the phasing out nuclear energy, or already doing so, converting all HEU to LEU could easily lead to the complete eradication of uranium mining.

The Russian – U.S. HEU Purchase Agreement: Megatons to MegaWatts

The HEU Purchase Agreement was a twenty-year deal signed in 1993 between the Russian Federation and the United States. Basically, the agreement is that Russia will dismantle existing nuclear warheads, extract the highly enriched uranium, down-blend it to low enriched uranium and sell the material to the U.S., where it will be resold on the commercial market. The original deal was for approximately 500 metric tons of HEU (enough for approximately 20,000 nuclear weapons).[54] The terms of the agreement state that the LEU prices will be reviewed regularly, but at the signing it was estimated to cost about $12 billion,[55] and the U.S. implementing agency (USEC) currently lists the cost at $8 billion.[56]

At one stroke, the HEU purchase provides financial incentives to dismantle thousands of warheads, destroys hundreds of tons weapons-grade material that could otherwise be vulnerable to theft. It also provides employment to thousands of Russian nuclear workers, and provides hundreds of millions of dollars a year to the desperate Russian nuclear complex – all at little net cost to the U.S. taxpayer, since the funds to down-blend the material are recouped when the material is re-sold as commercial fuel. [57] To date, the implementing agencies (USEC for the U.S. and Techsnabexport or TENEX for Russia) have converted 472.5 tons of HEU (enough for about 18,899 warheads) into 13,603 tons of LEU. The programme is set to run until 2013, when 500 tons of HEU, or 20,000 warheads, will have been converted.[58]

The deal is especially good for the U.S. as Russia is reimbursed by the U.S. for the actual cost of down-blending HEU to LEU, probably in the range of $1-$3 million per ton of original HEU. But the U.S. profits most from the huge commercial value of the LEU, in the range of $20 million per ton of original HEU.[59] For the fiscal year 2012, USEC, expected to increase payments to Russia 2% compared to 2011.[60]

Profiting from down-blending

As previously noted, the global stockpile of HEU is approximately 1440 tons. USEC reports that it derives 864 tons of LEU from 30 tons of HEU.[61] That can be broken down to 28.8 tons of LEU for every ton of HEU. With 1,440 tons of HEU in the world, one can therefore estimate that 41,472 tons of LEU can be generated. As LEU (enriched) currently sells for approximately $120 per kilogram[62], or $120,000 per ton, at current market rates, the global stockpile of HEU could sell for approximately $445,824,000.[63] These estimates, however, do not factor in current SWU values of $10.75 per kg of original Uranium.[64]

Country	Current HEU Stockpile[65]	Estimated LEU generation Based on 1 ton HEU = 28.8 tons LEU	Estimated Commercial value Based on market price of $120,000 per ton LEU
Russia	Between 617 and 857 tons	17,769.6 – 24,681.6 tons	$2,132– $2,962 million
United States	610 tons	17,568 tons	$2, 108 million
France	Between 20-32 tons	576- 921.6 tons	$69 – $110 million
China	12-20 tons	345.6 – 576 tons	$41 - $69 million
India	1.2- 2.8 tons	34.56 – 80.64 tons	$4 – $9.6 million
Pakistan	1.75-3.75 tons	50.4 – 108 tons	$6 - $12.9 million
Totals:	1261.95 – 1525.55 tons	36,344.16 – 43,935.84 tons	$4,361 – $5,272 million

Based on USEC reports of material equivalent to 1,201 nuclear warheads (864 tons of LEU derived from 30 tons of HEU).[66] One can use the following formulae:

1201 warheads = 30 tons of HEU 30/1201 = ~0.025 1 warhead = ~0.025 tons of HEU	864 tons LEU = 30 tons of HEU 864/30= 28.8 28.8 tons LEU = 1 ton of HEU	1 warhead = 0.025 tons HEU 0.025 tons HEU = 7.2 tons LEU 17,000 warheads = 122,400 tons LEU

Current down-blending in the Megatons to Megawatts programme shows that each warhead provides about 25 kg of HEU.[67] One can assume variance in the HEU content of all nuclear weapons (and that some are primarily plutonium bombs), but taking USEC data as an example, and assuming only HEU for the purposes of this calculation, down-blending the material in all 17,000 nuclear weapons in the world could produce 122,400 tons of LEU which could generate $1,467,577,019 ($1.4 billion) on the global market.

Down-blending global stockpiles of existing HEU combined with the HEU from all nuclear arsenals could net somewhere between 158,000 and 166,000 tons of LEU. Global market demand is currently about 65,500 tons of LEU per year,[68] which means that down-blending could theoretically produce enough LEU for two to three years. Overall, one can estimate a potential commercial sale value of $5,828 – $6,739 million to turn all existing HEU into nuclear reactor fuel.

Waste management

The production of nuclear materials creates radioactive waste, containing lethally radioactive and long-lived elements. This waste needs to be stored, both temporarily and permanently, which is the most controversial aspect of the production of nuclear power.[69] Radioactive waste disposal tries to ensure long-term safety of nuclear waste by placing it in facilities where the radioactive waste is enclosed by a number of barriers, thus preventing its escape.[70] There are different options of waste disposal, depending on the specifics of national legislation, geological differences and variations in the amount and characteristics of different waste types.[71]

Costs are an important issue in radioactive waste management as related to sustainable development. If the nuclear industry did not set aside adequate funds, a large financial burden associated with plant dismantling and radioactive waste disposal would be passed on. In OECD countries, the costs of dismantling nuclear power plants and of managing long-lived wastes are already included in electricity generation costs and billed to consumers; in other words, they are internalised. Although quite high in absolute terms, these costs represent a small proportion – less than 5% – of the total cost of nuclear power generation.[72] Financial provisions are made for managing all kinds of civilian radioactive waste. Most nuclear utilities are required by governments to put aside a levy (e.g. 0.1 cents per kilowatt hour in the U.S.A, 0.14 ¢/kWh in France) to provide for management and disposal of their wastes.[73] So far, in the U.S. alone, electricity consumers have committed some U.S.$ 28 billion to the U.S. waste fund.[74]

Decommissioning

Regardless of whether the fuel comes from down-blended nuclear warheads or mined and enriched uranium, all nuclear facilities will eventually require decommissioning. This includes all actives undertaken to remove radioactive contamination from the facility as well as those actives aimed at dismantling the facility in such a way that the site can be released from regulatory control and can be reused for other purposes. It enables the safe reuse of a site, as well as any buildings or parts of the facility, for other nuclear, industrial or general purposes, ensuring the protection of people and the environment.[75,76] Site remediation ensures that the land, on which the nuclear facility sat, as well as the surrounding area, is once again fit for use by human beings and animals. "Even though there are many technical, practical and economic reasons for decommissioning nuclear facilities, the most compelling reason is ethical responsibility."[77] The decommissioning of a nuclear facility is estimated to cost $500 million per facility. Decommissioning is generally broken down in to three categories: radiological ($300 million), used fuel ($100-150 million), and site restoration costs ($50 million). Decommissioning is not included in the operating costs of a plant. Instead, the expected future liability ($500 million) is spread across the anticipated life of the plant.[78]

Conclusion

A cost benefit analysis of modernisation versus down-blending clearly demonstrates that down-blending is the more profitable option. It can remove proliferation sensitive materials from the globe, while generating substantial profits. Down-blending does not, however, remove these materials from the environment and does require a continued nuclear power industry, something which many oppose.

In addition to thwarting non-proliferation efforts, maintaining and modernising nuclear weapons is an expensive business. Policies that actively seek to outlaw and eliminate nuclear weapons are the only guarantee that the costs and risks associated with nuclear weapons can be eliminated.[79] The problem is that security trade-offs are all too often assessed in the context of the short timeframes defined by the political life of an administration, rather than by longer-term security costs and risks for future generations.[80] Rarely do these analyses examine relative costs and benefits to the nuclear energy industry.

As this study has begun to demonstrate, there is a way to make a commercial profit off of the proliferation sensitive Cold War legacy. Down-blending all existing HEU for the commercial market will provide a few years of fuel for existing reactors. Generated funds can also be earmarked specifically for decommissioning and waste disposal costs.

When one examines the math, and the potential profits to be made, the choice is obvious: disarm, down-blend, and make a profit.

Notes

[1] http://www.fas.org/blog/ssp/2012/07/b61-12gold.php
[2] https://www.beersnotbombs.com/
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