P-05-837 Green Energy for the Wellbeing of Future Generations in Wales – Correspondence from the Petitioner to the Committee, 01.10.18

Dear Kayleigh

Further to your email of September 24th and attachment I attach our response to the correspondence from the Cabinet Secretary for Energy, Planning and Rural Affairs in line with your deadline of October 2nd for the Petitions Committee meeting on October 9th.

Most of the evidence backing our response is outlined under the appropriate section in the attachment but I also attach a further document which to date has not yet been published backing our arguments about uranium mining. The Author is Pete Roche who has prepared the article for Greenpeace International .

As you can see it is a complex topic and we would be delighted to attend any future Meetings of the Petitions Committee to present our points in more and illustrative detail. We have kept to the 4 page outline as requested but would be happy to elaborate further .

Please confirm you have received and can open both attachments

Thank you for your support and I look forward to further information about the process in due course

Yours sincerely

Mag Richards (Secretariat to Welsh Anti Nuclear Alliance)
https://emea01.safelinks.protection.outlook.com/?url=www.wana.wales&data=02%7C01%7CSeneddPetitions%40Assembly.Wales%7Ccbdcdfe58b514fd5b58c08d6277b2f1b%7C38dc5129340c45148a044e8ef2771564%7C1%7C0%7C636739808409606583&sdata=Lx3lXzeOEqjrhhI7Gxnx2kGX3X0LtlG7gPVjOitKdqc%3D&reserved=0

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Fao David J Rowlands ; Chair Senedd Petitions Committee

Re.“ Green Energy for the Wellbeing of Future Generations”P-05-837
Response to letter from Lesley Griffiths AM Sept 6th 2018

We endorse a number of the statements made by the Cabinet Secretary in her letter dated September 6th specifically :

- An 80% reduction in emissions by 2050 (although Zero Carbon Britain claims 100%)
- Investment in renewable energy technologies and support for local energy projects
- Reduction in the levels of generation from fossil fuels – (this should also include the phasing out of nuclear power for reasons outlined below).
- Improving security of energy supplies including better uses of resources whilst increasing levels of secure low carbon and renewable generation at affordable costs

However, it is the inclusion of Wylfa Newydd and Nuclear projects as part of a low carbon strategy plus the inference they are clean, green and renewable that has led to this Petition

ABSTRACT

The reality is that the nuclear fuel cycle is a filthy, dangerous and unhealthy process leaving a legacy of radioactive wastes at all stages of the fuel cycle; from fuel production to decommissioning. Support for this technology conflicts directly with the sentiments of the “Wellbeing of Future Generations Act (Wales) 2015”. We also challenge the economic basis on which nuclear developments are based.

The process of acquiring and using nuclear fuel is not low carbon as uranium is imported from countries such as Kazakhstan and its production is energy intensive.This fuel travels an average distance of 2,500 + miles before it reaches us, adding to carbon emissions. In addition emissions will increase as the quality of uranium ore declines and supplies diminish.

We could reduce our carbon footprint quicker and in much more sustainable ways by putting our money into renewables NOW rather than waiting for new nuclear builds (due from 2025+) which require enormous government subsidies. For renewable technologies such as wind, hydro and solar there are no imported fuels they are the second biggest source of electricity in the UK, and there is massive scope for Wales to lead the way in developing low carbon sustainable energy whilst creating green jobs across the Country.

A. NUCLEAR ENERGY WILL NOT SORT CLIMATE CHANGE

1. The Nuclear fuel cycle is not low-carbon

Claims that nuclear power is a 'low carbon' energy source fall apart under scrutiny, writes Professor Keith Barnham. Far from coming in at six grams of CO_2 per unit of electricity for

Hinkley C, as the Climate Change Committee believes, the true figure is probably well above 50 grams breaching the CCC's recommended limit for new sources of power generation beyond 2030.

It is only the power station side that is low carbon. Greenhouse gases are emitted at all stages of the nuclear cycle, fuel production, construction, operation, dismantling and waste disposal. Leaving out any of these stages will bias estimates towards lower values. The last two contributions, dismantling and waste disposal are particularly difficult to estimate. Not many commercial reactors have been fully decommissioned. Also there is still no scientific or political consensus on the approach to be used for the long-term storage of waste. https://theecologist.org/2015/feb/05/false-solution-nuclear-power-not-low-carbon

2. Problems with Uranium

Quality of the Ore - The specific nuclear CO2 emission will rise during the next decades, due to the depletion of high-quality uranium resources and dependency on ever decreasing ore quality. Lower grade ores require more energy per unit and consequently cause higher CO2 emission. If no new large high-quality resources are discovered, the nuclear CO2 emission will eventually surpass that of fossil-generated electricity.

According to figures Jan Willem Storm van Leeuwen has compiled from the WISE Uranium Project about 37% of the identified uranium reserves have an ore grade below 0.05%. The analysis shows that using 0.005% concentration uranium ores a nuclear reactor will have a carbon footprint larger than a natural gas power plant. Nuclear power relying on poor ores, at grades less than 200 grams of uranium per tonne rock, emits as much CO2 per kilowatt-hour as coal-fired power stations .https://www.stormsmith.nl/Media/downloads/nuclearEsecurCO2.pdf

Uranium supplies – New nuclear power plants are supposed to have an operational life of 60 years with a lead-in time of 10 -19 years. Plants currently being planned, would reach their end of expected life during 2080 - 2090; power plants now starting to operate, would be shut-down at the end of 2070. If the World Nuclear Association low growth scenario is assumed as a starting point, the currently operated uranium mines would be exhausted between 2043 and 2055. On this assumption it would not be possible to supply a nuclear power plant being planned now with uranium until the end of its lifetime. https://www.energyagency.at/fileadmin/dam/pdf/publikationen/berichteBroschueren/Endbericht_LCA_Nuklearindustrie-engl.pdf

3. Climate Change is NOW - Even at the most optimistic build rate, 10 new reactors by 2025, the UK's carbon emissions would be cut by just 4%. The UK has a binding target of a 34 % cut by 2020, meaning that new nuclear's ability to help meet our obligations is tiny. We have limited time and money to spend so must prioritise technologies with the greatest potential to meet our energy needs and cut emissions.Renewable energy industries will not only power our country but also create jobs, new businesses and help make Britain a world-leader in cutting edge 21st century technologies https://greenpeace.org.uk/what-we-do/climate/energy/dirty-energy/nuclear-power/

This view is echoed by Tom Burke, Chairman of E3G "We have to think about the deadlines for our emissions targets, if we wait for new nuclear plants to be built then we will fail to meet them. Nuclear is also too expensive, and new reactors are actually based on old, twentieth century technology, and are an inherently inflexible energy source. Our modern energy system needs flexibility, nuclear power cannot keep up." https://www.e3g.org/

Nuclear technology does not adapt well to climate change and can only operate under predictable and controlled conditions. Reactors in France had to be shut down during the recent heat wave because their cooling waters were too warm to be discharged without causing damage to ecosystems - and then there are the predicted sea-rise scenarios !

www.independent.co.uk/news/world/europe/france-nuclear-reactors-shut-down-edf-europe-heat-wave-a8477776.htm

4. Zero Carbon Britain (ZCB)– Rethinking the Future – www.zerocarbonbritain.org
The ZCB scenario demonstrates that we could rapidly reduce UK Greenhouse gas emissions to zero by 2030 using only currently available technology. It outlines how we can provide a reliable energy supply with 100% renewable energy sources and flexible carbon neutral back up - without fossil fuels, nuclear power, or gambling on the promise of future technology. In addition it can deliver a modern lifestyle, create employment, improve our wellbeing, and ensure a safe and sustainable future for future generations.

5. Nuclear 's contribution to total world energy is tiny
Currently the nuclear share of the world energy supply is 1.9%, and declining. Even if nuclear power was CO2 free, which it is not, then the reduction of the human CO2 emission could not be more than 1.9%. Most sensible countries are phasing out nuclear in favour of renewable energies such as wind, tidal, solar https://www.stormsmith.nl/i05.html)

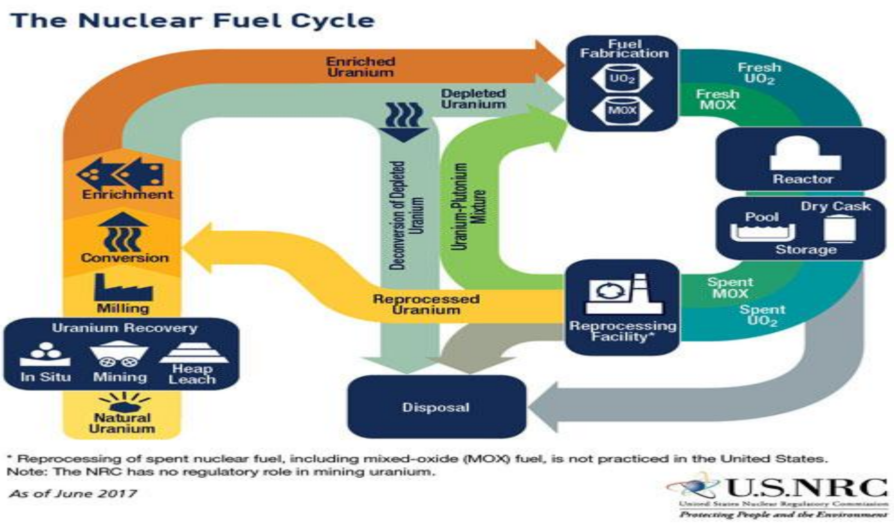
6. The weapons connection – Decades of deceit have been thrown overboard with the new nuclear sales pitch, argues Jim Green. The new sales pitch openly links nuclear power to weapons and argues that weapons programs will be jeopardised unless greater subsidies are provided for the civil nuclear industryhttps://theecologist.org/2018/sep/20/nuclear-power-lobbyist-michael-shellenberger-learns-love-bomb

B. NUCLEAR POWER IS NOT CLEAN, GREEN OR RENEWABLE

Currently nuclear capacity in the UK is almost exclusively owned by EDF who secure supplies of natural uranium from a variety of mining operators in a number of countries, including Niger, Kazakhstan, Canada and Australia. EDF work in partnership with a variety of industrial partners such as the French group AREVA and companies such as Urenco (UK, Germany and Netherlands), Tenex (Russia) and USEC (United States).
https://www.edf.fr/en/edf/nuclear-fuel-cycle-edf-present-at-all-stages

WHAT IS URANIUM ? - How Does it Work?

In a nuclear power station the uranium fuel is assembled so that a controlled chain reaction is achieved with uranium replacing the burning of coal or gas. The heat created by splitting the U-235 atoms is then used to make steam which spins a turbine to drive a generator, producing electricity. The chain reaction is controlled by rods and moderated by water, graphite and/or heavy water depending on the type of reactor.



Stages of production of uranium

1. Mining – Uranium is mostly mined in open pit or underground mines producing large amounts of waste. This waste often contains elevated concentrations of radioisotopes and includes ore with too low a grade for processing. Kazakhstan is the world's top uranium producer, followed by Canada and then Australia - others include South Africa, Niger, Brazil, China, Namibia, Mongolia, Uzbekistan, and Ukraine.

The largest open pit mine in the world is the Rossing Mine in Namibia. Large amounts of material have to be removed as the rock only contains 0.029% of uranium Approximately 1 billion tonnes of material has so far been removed - one third of which was processed in the uranium mill. The remainder is waste which releases radioactive dust and radon gas.

In Niger AREVA (associate of EDF) established mining 40 years ago, creating what should have been an economic rescue for a depressed nation but their operations have been largely destructive. There are great clouds of dust, mountains of industrial waste and sludge sit in huge piles, exposed to the air; and the shifting of millions of tonnes of earth and rock is corrupting the diminishing groundwater source, due to industrial overuse. The " Left in the Dust" Report shows how AREVA extracts Niger's natural resources, earning billions and leaving little behind but centuries of environmental pollution and health risks for the people, where death rates linked to respiratory problems are twice that of the rest of the country .https://www.greenpeace.org/denmark/Global/denmark/p2/other/report/2010/left-in-the-dust.pdf

2. **Uranium milling –** Once the uranium ore is extracted it is refined into uranium concentrate at a uranium mill. It is crushed into a fine powder referred to as *yellowcake*. The unwanted by/product is the uranium mill tailings, normally dumped as sludge in special ponds or piles, where they are abandoned. The sludge still contains about 85% of the initial radioactivity plus heavy metals and other toxic contaminants used during milling. The WISE Uranium project outlines that the tailings present the most serious long-term hazard generated from uranium mining. http://www.wise-uranium.org/stk.html?src=stkd01e

3. **Uranium conversion - Y**ellowcake is then converted into uranium hexafluoride (UF6) gas at a converter facility so it can be used in an enrichment plant. Nuclear fuel for a reactor needs to have a higher concentration of the U^{235} isotope than that which exists in natural uranium ore. Conversion plants operate commercially in the USA, Canada, France, Russia and China and create even more waste.

4. **Uranium enrichment -** During enrichment large quantities of depleted uranium or ' tails are produced. The uranium with a higher concentration of U^{235} (enriched uranium) is used for fabricating fuel for reactors. The tails are a serious waste product. For each tonne of enriched uranium, 7 tonnes of depleted uranium is generated. The ultimate fate of the depleted uranium is unclear, but most of it is stored as UF_6 in steel containers in open yards near the enrichment plants.

5. **Uranium reconversion and nuclear fuel fabrication**
Once the uranium is enriched, it is ready to be converted into nuclear fuel. The fuel assemblies are transported by road or rail and are then placed in the reactor core, where they remain for three to four years, after which they gradually become spent. Spent nuclear fuel is highly radioactive and has to be stored in cooling ponds until a solution is found for disposal. The fuel load for a 900 MW reactor is 157 assemblies containing around 11 million pellets of enriched uranium.

The production of nuclear fuel is a high energy process creating wastes at every stage and to date no safe methods have been found to deal with these wastes. It is unethical to produce more and leave their legacy for future generations to sort out.

Uranium Mining – Pete Roche

The Langer Heinrich uranium mine (LHM) in Namibia has been placed on a care-and-maintenance basis by the Australian operator Paladin Energy.[i] The Company itself was put in the hands of administrators in July 2017 because it was unable to pay a US$277 million debt to EDF.[ii] The only other mine operated by Paladin – the Kayelekera uranium mine in Malawi – was also put into care-and-maintenance in 2014.[iii] Paladin CEO Alex Molyneux said: "*The uranium market has failed to recover since the Fukushima incident in 2011*."[iv]

Both mines will require remediation work to be carried out but it is extremely doubtful that Paladin will have set aside adequate funds to fulfil its responsibilities. Its 2017 Annual Report lists a 'rehabilitation provision' of US$86.93 million to cover both LHM and Kayelekera. For comparison, Energy Resources of Australia has set aside US$403 million for rehabilitation of the Ranger uranium mine in Australia in addition to US$346 million already spent on water and rehabilitation activities since 2012. Remediation of the African mines could be cheaper, not least because of their relative sizes compared with Ranger, but one Malawian NGO, estimates that the Kayelekera mine alone could cost US$100 million.[v]

In 2010 Greenpeace International documented the legacy of waste and environmental destruction left by the French nuclear industry mining of uranium in Niger.[vi] Clouds of dust caused by controlled explosions at the open pit mine carry radioactive gas towards the towns of Arlit and Akokan. Mountains of industrial radioactive waste sit in the open air for decades. And the shifting of millions of tonnes of rock and earth has corrupted the once clean source of groundwater that is also rapidly disappearing due to industrial overuse. In November 2009 Greenpeace and its partners were able to complete a brief scientific investigation of the area measuring radiation levels in and around the mining towns. In some cases readings went above 100 times internationally recommended levels. In about ten years' time the local economy around Arlit and Akokan will dry up as the mines run out of uranium, but the people and a legacy environmental pollution will be left behind for centuries to come.[vii] The waste in Niger includes an estimated 40 million tons of radioactive residues from two mines and 1600 tonnes of contaminated solid waste, as well as additional liquid waste.[viii]

It's a similar story in other parts of the world. In the East Singhbhum district of Jharkhand State in Eastern India there are hundreds of cases of congenital illness and other birth defects in addition to a high incidence of infertility, miscarriages and pre-mature deliveries near the Jadugora uranium mines which have some of the best quality uranium ore, and magnesium diuranate deposits in the world. "*Miners working in the mine areas inhale the dust and radon gas. Besides, the uranium ore are transported in uncovered trucks through roads that are full of bumps. This cause the debris to fall off on the sides of the road. Radiation are also caused by dumping of mine's tailings in uncovered ponds*," said Ankush Vengurlekar, a photojournalist who has documented people's suffering because of the "unsafe" mining.

Locals say villages lying close to the tailing ponds are the worst affected. During the dry season, dust from the tailings blows through these villages. During the monsoon rains, radioactive waste spills into the surrounding creeks and rivers, causing further internal radiation as villagers use the contaminated water for washing and drinking and also use the nearby ponds for fishing.[ix]

Earlier this decade when it looked like there might be a renaissance in nuclear power construction Chinese, Canadian and French firms rushed to exploit uranium deposits in new countries in Africa. In 2010 one commentator said "*Getting a mine going in Texas takes two bookshelves full of authorisations. In Niger you give a shovel to a guy on $2 a day and you're mining uranium.*"[x] Even so, in 2016 almost 75% of world uranium production was still taking place in the top three producing countries, Kazakhstan, Canada and Australia.[xi]

Uranium mining is just the start of the nuclear fuel chain, but these stories serve to illustrate how the nuclear industry, after making a profit, often loads its liabilities onto local residents, taxpayers and electricity consumers. All the way through the nuclear chain, local populations are subjected to increased health risks, and yet more often than not they have not been asked if they are willing to put up with those increased risks.

Uranium Wastes

Most uranium ore is mined in open pit or underground mines. The uranium content of the ore is often between only 0.1% and 0.2%. Therefore, large amounts of ore have to be mined to get at the uranium. In the early years up until the 1960's uranium was predominantly mined in open pit mines from ore deposits located near the surface. Later, mining was continued in underground mines, but many of these closed in the 1980s after prices dropped. The US had lots of underground mines during the Cold War era. After deposits were exhausted many of these were simply abandoned, often without even securing the mine opening presenting a hazard even today.[xii]

Waste rock is produced during both types of mining. This often contains elevated concentrations of radioisotopes compared to normal rock. Other waste piles consist of ore with too low a grade for processing. These waste piles threaten local populations due to the release of radon gas and seepage water containing radioactive and toxic materials.

The largest open pit mine in the world is the Rossing Mine in Namibia. Large amounts of material have to be removed from the pit as the rock only contains 0.029% of uranium Approximately 1 billion tonnes of material has so far been removed - one third of which was processed in the uranium mill. The remainder was deposited on waste rock and low grade ore piles. The waste rock piles release radioactive dust and radon gas into the environment.

According to the seminal work on nuclear chemistry published in 1995 by Hoppin, Rydberg, and Liljenzin:

"*…Ra [Radium] and Rn [Radon] are among the most radio-toxic substances existing, causing bone and lung cancer at relatively low concentrations,* [consequently] *special attention must be devoted to their appearance in nature*"[xiii]

Uranium Milling

Ore mined in open pit or underground mines is crushed and leached in a uranium mill – basically a chemical plant designed to extract uranium from ore. It is usually located near the mines to limit transportation. In most cases, sulphuric acid is used as the leaching agent, but alkaline leaching is also used. As the leaching agent not only extracts uranium from the ore, but also several other constituents like molybdenum, vanadium, selenium, iron, lead and arsenic, the uranium must be separated out of the leaching solution. The final product produced from the mill, commonly referred to as "yellow cake" (U_3O_8 with impurities), is packed and shipped in casks.

A rather more unwanted product is the uranium mill tailings which is normally dumped as sludge in special ponds or piles, where they are abandoned. The largest such piles in the US and Canada contain up to 30 million tonnes of solid material. In Saxony, Germany the Helmsdorf pile near Zwickau contains 50 million tonnes, and in Thuringia the Culmitzsch pile near Seelingstädt 86 million tonnes of solids.[xiv]

Milling does not remove long lived decay products such as thorium-230 and radium-226, nor does it remove all of the uranium - about 5% to 10% remains - so the sludge still contains about 85% of the initial radioactivity along with heavy metals and other toxic contaminants such as arsenic, and chemical reagents used during the milling process. The mining and milling process removes hazardous chemicals from their relatively safe underground location and converts them to a fine sand, then sludge, making them more susceptible to dispersion throughout the environment.

Radon-222 gas emanates from tailings piles and has a half-life of 3.8 days. This may seem short, but due to the continuous production of radon from the decay of radium-226, which has a half-life of 1600 years, radon presents a long-term hazard. Further, because the parent product of radium-226, thorium-230 (with a half-life of 80,000 years) is also present, there is continuous production of radium-226.

After about 1 million years, the radioactivity of the tailings and thus its radon releases will have decreased so that it is only limited by the residual uranium contents, which continuously produces new thorium-230.

Radon release is a major hazard which continues after uranium mines are shut down. The U.S. Environmental Protection Agency (EPA) estimates the lifetime excess lung cancer risk of residents living near a bare tailings pile of 80 hectares at two cases per hundred. Since radon spreads quickly with the wind, many people receive small additional radiation doses. Although the excess risk for the individual is small, it cannot be neglected due to the large number of people concerned. EPA estimated that the uranium tailings deposits existing in the United States in 1983 would cause 500 lung cancer deaths per century, if no countermeasures were taken.[xv]

Due to the long half-lives of the radioactive constituents involved the safety of tailings deposits have to be guaranteed for very long periods of time. After rainfall, erosion gullies can form; floods can destroy the whole deposit; plants and burrowing animals can penetrate into the deposit and thus disperse the material, enhance the radon releases and make the deposit more susceptible to climatic erosion. When the surface of the pile dries out, the fine sands are blown by the wind over adjacent areas. Seepage from tailings piles is another major hazard posing a risk of contamination to ground and surface water. Residents are also threatened by radium-226 and other hazardous substances like arsenic in their drinking water supplies and in fish from the area. The seepage problem is very important with acidic tailings, as the radionuclides involved are more mobile under acidic conditions.

Tailings dam failures have caused pollution problems at uranium mines across the globe. Twenty-one dam failures have been documented by WISE International.[xvi]

Closure of a uranium mill produces large amounts of radioactively contaminated scrap which will have to be disposed in a safe manner. In the case of Wismut's Crossen uranium mill, in

Germany, to reduce cost some of the scrap is intended to be disposed in the Helmsdorf tailings, but there it can produce gases and thus threaten the safe final disposal of the sludge.[xvii]

The WISE International Uranium Project detailed the world inventory of known uranium mill tailings in 2011. The South African tailings are from uranium by-product recovery from gold mining; and part of the Australian tailings are from uranium co-product recovery with copper mining (Olympic Dam). Nevertheless the world's inventory of uranium mill tailings amounts to 2,352.55 million tonnes.[xviii]

Country	**Million tonnes of uranium mill tailings**
Australia	79
Bulgaria	16
Canada	202.13
Czech Republic	89
France	29.318
Germany	174.45
Hungary	29.4
Kazakhstan	165
Kyrgyzstan	32.3
Namibia	350
Russia	56.85
South Africa	700
Ukraine	89.5
USA	235
Uzbekistan	60

Uranium Enrichment

The raw material obtained from uranium mining is known as yellowcake. It contains U_3O_8 and impurities. To use this in electricity generating nuclear power stations it has to be made into nuclear fuel. Firstly the uranium has to be converted to uranium hexafluoride (UF_6), a compound that can easily become a gas. This property is required for the subsequent enrichment process.

Yellowcake still contains some impurities so prior to enrichment has to be further refined before or after being converted to uranium hexafluoride (UF_6), (known as 'hex'). Conversion plants are operating commercially in the USA, Canada, France, Russia and China. This conversion generates yet more waste. Conversion wastes are usually dumped in large compounds next to the conversion plant.

In France, for instance, the Comurhex Malvési conversion plant, converts U_3O_8 to UF_4. Further processing to UF_6 is done at the Comurhex plant in Pierrelatte. On March 20, 2004, a dam failure at a decantation and evaporation pond at the Malvési conversion plant released approx. 30,000 cubic metres of liquid and slurries. The dam failure is believed to have been caused by an "*abnormal presence of water*" due to heavy rain in summer 2003. Production had to be halted again for two months after heavy rainfall at the end of January 2006, to maintain the required safety margin for the ponding water in the compound. However, rain water came into contact with the spilled slurries from the 2004 event still lying outside of the dams, and contaminants thus dissolved were released into the environment. On March 5, 2006, strong winds resulted in an overflow of several decantation ponds due to insufficient safety margins of the ponding water levels, leading to another spill of nitrate-contaminated waters.

On June 20, 2006, a further spill of an unreported amount of contaminated slurries occurred which covered a surface area of 350 square meters and went undetected for a month.[xix]

The concentration of the fissile isotope uranium-235 in natural uranium is only around 0.71%. To make nuclear fuel for most reactors this has to be increased to around 3 - 5%. This is known as the enrichment process. In commercially available enrichment plants this is done by a physical process, either by gas diffusion, or by using a centrifuge. For each tonne of enriched uranium, 7 tonnes of depleted uranium (DU) are generated. The ultimate fate of the depleted uranium is mostly unclear, but most of it is stored as UF_6 in steel containers in open yards near the enrichment plants. The U.S. has launched a program to convert the depleted uranium hexafluoride to a chemical form that is more suitable for long term storage.

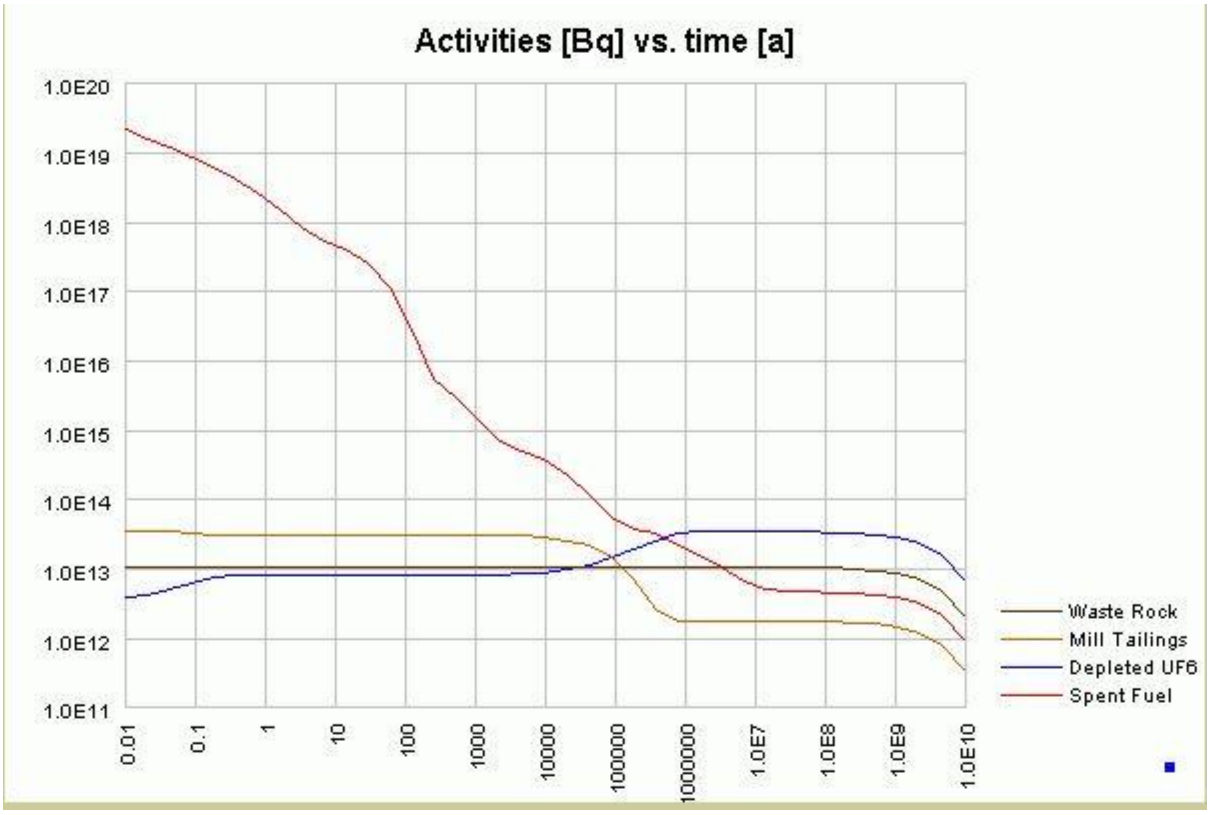
The most recent inventory of worldwide depleted uranium that appears to be available come from the OECD's Nuclear Energy Agency[xx] in 1999:

Country	**Stored as**	**Stocks in tU**
USA	UF_6	480,000
Russia	UF_6	450,000
	Metal & oxide	10,000
France	U_3O_8	140,000
	UF_6	50,000
UK (BNFL)	UF_6	30,000
Netherlands, Germany, UK (Urenco)	UF_6	16,000
Japan	UF_6	10,000
China	UF_6	2,000
South Korea	UF_6	200
Total		1,188,200

The OECD report said stocks of depleted uranium arising from the enrichment process are expected to increase by up to 57 000 tU annually for the foreseeable future – so an almost 5% increase every year.

The next step in nuclear fuel production is to convert the enriched UF_6 to uranium dioxide for use in nuclear fuel rods. Minor amounts of waste are produced at this stage of the process.

To illustrate the kinds of timescales we need to take into account, the chart below[xxi] compares the radioactivity of the various wastes generated by a 1,000MW nuclear power reactor each year. Initially the activity of the spent fuel is by far the greatest, but this decreases continuously. The radioactivity of depleted uranium, on the other hand, actually increases in the long term, so that after half a million years it overtakes spent fuel. (NB. both scales are logarithmic).



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i Paladin Energy, 25 May 2018, 'LHM Confirmation of Care & Maintenance', https://www.asx.com.au/asxpdf/20180525/pdf/43v8z12d7zf1r0.pdf

ii Nuclear Monitor #847, 21 July 2017, 'Paladin Energy goes bust', https://www.wiseinternational.org/nuclear-monitor/847/paladin-energy-goes-bust

iii Market Wired 7 Feb 2014, Paladin Energy Ltd. 'Suspension of Production at Kayelekera Mine, Malawi', http://www.marketwired.com/press-release/paladin-energy-ltd-suspension-of-production-at-kayelekera-mine-malawi-tsx-pdn-1876805.htm

iv Mining Technology, 30 April 2018, 'Paladin begins consultations to place LHM mine on care and maintenance', www.mining-technology.com/news/paladin-begins-consultations-place-lhm-mine-care-maintenance/

v Green, J. Paladin Energy puts second African uranium mine into care-and-maintenance, Nuclear Monitor #862, June 2018

vi For an update on Arlit see African Arguments 18th July 2017 http://africanarguments.org/2017/07/18/a-forgotten-community-the-little-town-in-niger-keeping-the-lights-on-in-france-uranium-arlit-areva/

vii Left in the Dust, AREVA's radioactive legacy in the desert towns of Niger, Greenpeace International 2010 https://www.greenpeace.org/denmark/Global/denmark/p2/other/report/2010/left-in-the-dust.pdf See also https://www.youtube.com/watch?v=ioRtzOWm07A

viii History and consequences of uranium mining in Niger from 1969 to 2017 by Almoustapha Alhacen, Arlit, Niger. https://static1.squarespace.com/static/58bd8808e3df28ba498d7569/t/59bd250780bd5e7ca76585f3/1505568010268/Almoushapha_20170910_+English_HN.pdf

ix Anwar, T. *Uranium Mining in Jharkhand: Radioactive Poisoning Ravaging Lives in Villages*, Newsclick 21st June 2018 https://newsclick.in/uranium-mining-jharkhand-radioactive-poisoning-ravaging-lives-villages

x Sunday Times 7th February 2010 https://www.thetimes.co.uk/article/the-great-uranium-stampede-c7p3m6h9xxd

xi World Nuclear Association July 2017 http://www.world-nuclear.org/information-library/facts-and-figures/uranium-production-figures.aspx

xii See Slide 8 http://www.wise-uranium.org/stk.html?src=stkd01e

[xiii] Hoppin, G. Rydberg, J. Liljenzin, J.O. Radiochemistry and Nuclear Chemistry, Butterworth, Heinmann, Oxford 1995
[xiv] For more information see Uranium Mining and Milling Wastes: An Introduction by Peter Diehl http://www.wise-uranium.org/uwai.html
[xv] Federal Register / Vol. 48, No. 196 / Friday, October 7, 1983 / See page 45929.
[xvi] See Chronology of Uranium Tailings Dam Failures, http://www.wise-uranium.org/mdaf.html
[xvii] http://www.wise-uranium.org/uwai.html
[xviii] See slide No.61http://www.wise-uranium.org/stk.html?src=stkd01e
[xix] http://www.wise-uranium.org/stk.html?src=stkd02e
[xx] Management of Depleted Uranium, OECD/NEA 2001 https://www.oecd-nea.org/ndd/pubs/2001/3035-management-depleted-uranium.pdf
[xxi] WISE Uranium Project, Slide Talk, Nuclear Fuel Production (Conversion, Enrichment, Fuel Prod.), March 2007, Slide No.22 http://www.wise-uranium.org/stk.html?src=stkd02e