NUCLEAR POWER IS NOT THE RIGHT SOLUTION FOR THE 21RST CENTURY'S ENERGY NEEDS

A ONE STOP RESOURCE ON THE DANGERS OF NUCLEAR POWER

(AND THE FACTS TO BACK THEM UP)

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About two months ago I was online and responded to a posting about nuclear power and I wrote that I did not like it. I received a torrent of criticism and abuse that went beyond the pale. I was told that I was anti-science, that I was ignoring the facts to advance a radical environmental agenda and that I was a fear monger. I was taken aback by this hyperbolic attack, but I also wondered if I was holding on to an old, outdated attitude which needed to be reevaluated. So I undertook an odyssey that I did not expect to take. At first I hoped that the fears I'd carried for decades were indeed, no longer necessary because the technology had become safe and the problems I remembered, had been solved.

I started a research project that soon took over my life to find out about the nuclear industrial complex, and what the truth was about it. In the process I would read over 200 articles and a dozen research papers about all the aspects of the industry I could think of. As I found information, I would copy it ,and soon I had stacks of paper everywhere in my apartment. I searched out information from the mainstream media, energy trade journals, Wikipedia and both pro and anti-nuclear groups to help me get to the truth about whether nuclear power was the safe reliable energy source pro-nuclear advocates say it is, or if it's the dangerous ticking time bomb that its critics claim. In the beginning, I tried to report just the facts, free of opinion and my personal prejudice. After a month my approach changed, when I realized that there were no good things to report about nuclear power, besides the fact that it provided power night or day, come rain or

shine-that's it. The negative financial and health costs soon became so clear and overwhelming that I gave up trying to find positive things about the industry and this report became staunchly anti-nuclear.TICK, TICK, TICK…..

I am not a scientist, a writer or a scholar, but I am the Copy And Paste King. Very little in the report is written by me, because the technical and medical subjects covered here are beyond my knowledge. I could not express anything on these topics as well as the original authors, so I didn't. For the most part, I have tried to let the facts speak for themselves and to keep my opinions to myself, although at times that was impossible. This report is the mother lode of quote mining, El Dorado. Although I did read every article and report, often more that once, I do not consider myself an expert on nuclear power; I give that appellation to the dedicated doctors, engineers, physicists, scientists and journalists who have dedicated their lives to bringing the dangerous reality of the nuclear industry to our attention by speaking truth to power.I've used these people's hard work to paint a picture of the past half century's quest to develop this regrettable power source. My main focus is the civilian power sector, but I do briefly highlight the research done on survivors after the military's use of atomic weapons.

Globally, the nuclear industrial complex, military and civilian, is estimated to be worth $175 billion dollars per year and so, wields huge economic and political clout. All 5 permanent members of the UN Security Council are nuclear states, and most of those have large nuclear export industries, and work to spread the technology everywhere they can.These 5 members have tremendous power in shaping UN policy, and the

nuclear industry, through the IAEA is the only industry that reports directly to them. The US gets 20% of its power from nuclear, and France gets a whopping 75% from it, but the industry is in a financial free fall, because it is much too expensive when compared to renewables and natural gas.If it were not for the subsidies it receives, it would have died decades ago. When all of the taxpayer handouts are totaled up, they are worth more than the energy nuclear reactors produce, as much as 15 cents per kilowatt hour, at a time when utilities can buy solar electricity on the wholesale market for 5 cents per kilowatt hour with a 20 year contract. The industry complains that government regulations are holding them back in the US, but that is just a weak excuse because the truth is that the financial sector won't invest a dime in such a risky and dangerous venture, and the price just keeps going up.

There is no part of the nuclear fuel cycle that has not spread misery and death, from when the uranium is mined from the earth to when we attempt to store the dangerous radioactive waste. This entire industry poses a danger to the survival of life on earth as we know it, because of the genetic damage that is caused by the radiation it produces. The evidence to prove this is clear and convincing, but it is overshadowed by the huge propaganda campaign and misinformation being spread by nuclear advocates. This is most obvious after nuclear disasters like Chernobyl or Fukushima when the public is force fed lies about the effects of the radiation unleashed when a reactor melts down. This report attempts to pull the curtain back and expose these lies, who tells them and why. It's like the X-Files told us," the truth is out there ", sometimes you just have to dig to find it.

I share this information, not as the last word on the subject, but as a foundation for making better arguments against nuclear power and to start the conversation armed with the facts. My hero's throughout this process have been David Lochbaum, Edwin Lyman PhD, Dr. Ian Fairley, Dr. Rosalie Bartell, Doug Koplow, Dr. Helen Caldicott and an army of others who's work inspired me to delve deeper and deeper into this research. I can only hope that this report serves to bring their collective works to wider attention and inspires others as much as it did me.

For me, some of the important realizations about the industry came when I learned about the industry's regulating bodies and their true function. At first I could not believe how these agencies really worked, it seemed too conspiratorial and Machiavellian, but then after studying their history and their responses to nuclear disasters at Chernobyl and Fukushima, their policies started to make sense. Statistics can be manipulated to prove anything, and with enough money those false results can be spread to a lot of people through mass media. Despite reports from many doctors, epidemiologists, and public health officials on the ground in the disaster areas, reporting dire consequences from these events, the story that most people hear is of minimal damage from the radiation. And they believe it. But that is not the truth.

The longest part of this report is about tritium contamination; it gets special attention because it is a grave ongoing problem, which is inherent in the production of nuclear energy. Low level ionizing radiation is the most prevalent radiation threat we face, and

understanding how this impacts our health is very important because tritiated water is being pumped into our environment billions of gallons at a time all over the world, constantly. Unlike nuclear disasters, tritium contamination is not an accident, but it's effects are just as deadly, but you are not likely to hear that from the media and certainly not from the industry. In the atmosphere tritium poses a very small risk, however when it becomes internalized from breathing it in, or by ingesting contaminated food it becomes much more dangerous, lethal in fact. Studies of OBT,(organically bound tritium) are ignored or dismissed by the "official" sources and only the less dangerous atmospheric studies are publicized. The genetic heritage of all living things is under assault from this radioactivity and even if we stopped polluting the environment with it today, it would persist there for generations.

The National Cancer Institute reports that between 1950 and 1995 total cancer incidence in the US went up by 55%, with similar growth in Europe. Non-smoking related cancers are responsible for about 75% of the overall increased incidence of cancer since 1950, and this increase cannot be explained in terms of better detection or an ageing population. Cancer incidence increases in parallel with the gross national product of any given country and its level of industrialization but the obvious explanation given for this phenomenon – environmental pollution, chemical and radioactive – is often not discussed in meaningful ways.

Another eye opening moment occurred when I looked into how the dose levels and their effects are determined by these agencies and governments, and how the effects of low

level ionizing radiation is misrepresented or dismissed altogether when reporting on them. I now understand how reports about the health consequences of a nuclear accident often vary from dozens of people affected, to tens of thousands of people, depending on who is doing the reporting and why. The patterns of deception and lies are easy to see when you know what to look for.

In their brilliant book,"Merchants of Doubt", authors Naomi Oreskes and Eric M. Conway described how the truth can be twisted and hidden from the public by powerful corporate interests in the pursuit of profit at all costs.The nuclear industrial complex's history, is that story on steroids. Sometimes, things get rather technical but don't let that scare you, it's usually for just a couple of pages and it's included because it's an important part of understanding this complex subject. This report certainly isn't the most professional one you will ever read, but I believe that after reading it you'll never be fooled by the lies about nuclear power again.This is not a new story, it involves power, money and greed, but never in the history of man have the consequences been so high.

Please excuse my ham handed attempt at producing this document, this is my first time using any word processing app, prior to doing this report I didn't know how to copy and paste, or even the most basic elements of how to write a report like this on a computer. As a matter of fact I hadn't written anything like this since 1975, and my results back then earned me a mark of D- from my teacher, I hope that you will be kinder than she was. I owe a big thank you to my sister, Joan, for patiently teaching me how to navigate through the many questions I had in writing this.

“Our world faces a crisis as yet unperceived by those possessing the power to make great decisions for good and evil. The unleashed power of the atom has changed everything save our modes of thinking, and thus we drift toward unparalleled catastrophe.” ~Albert Einstein

“Now, I am become Death, the destroyer of worlds.”~ J. Robert Oppenheimer
from the Bhagavad-gita

“It is true that the amount of radiation created by bomb tests so far offers no serious threat to the well-being or existence of mankind as a whole. But it is also true that there is no amount of radiation so small that it has no ill effects at all on anybody. There is actually no such thing as a minimum permissible dose. Perhaps we are talking about only a very small number of individual tragedies - the number of atomic age children with cancer, the new victims of leukemia, the damage to skin tissues here and reproductive systems there - perhaps these are too small to measure with statistics. But they nevertheless loom very large indeed in human and moral terms.”
~John F. Kennedy

“Nuclear power is one hell of a way to boil water!” ~ Albert Einstein

“Once presented, the facts will speak for themselves.” ~ Helen Caldicott

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THE EVOLUTION OF NUCLEAR REACTORS

Wikipedia described the way nuclear reactors have changed over the years like this:

- Generation 1:" Reactors were developed in 1950-60s and very few are still running today. They have been referred to as "early prototypic reactors".

- Generation 2:" Developed in mid 1960s, "active safety system" was often being used in this generation's reactors. The safety system involves electrical or mechanical operation on command, which means they are activated by human controllers and cannot operate if electrical power systems are shut down. About 90% of nuclear power plants operating today employ these reactors.Many of them have incorporated some passive or inherent safety features requiring no active controls or operational intervention for accidents avoidance in the event of malfunction, and may rely on gravity, natural convection or resistance to high temperatures".

- Generation 3: "Advanced Reactors developed in Mid-1990s, their designs incorporate further passive safety systems which is to increase reactor safety by operating without human intervention or electrical power. European Pressurized Water Reactor (EPR) and the Westinghouse Advanced Plant 1000 (AP1000) pressurized water reactor belong to this group."

There are about 12 Generation 3 in service now but they have been in use for too short a time for an accurate assessment of their performance yet. As of late 2015 there were a total of 66 reactors under construction, the highest number in 25 years.It can be assumed that some portion of these 66 reactors will be Generation 3. Because of the high costs of building a nuclear reactor and the sometimes decade long time to construct one, these projects have a significant incidence of being abandoned prior to finishing them, historically almost 50%".

- Generation 4: "Designs of this type of reactors are still on the drawing board and will not be operational before 2030 - 2040 They will tend to have closed fuel cycles and burn the long-lived actinides now forming part of spent fuel, so that fission products are the only high-level waste and the time taken for its radioactivity to fall to a safe level will be far shorter. Many designs will be fast neutron reactors. Generation 4 reactors are only theoretical at this point so it is too early to even speculate their practical performance".

- Molten-salt-fueled reactors "(MSRs) supply the nuclear fuel in the form of a molten salt mixture. They should not be confused with molten salt-cooled high temperature reactors (fluoride high-temperature reactors, FHRs) that use a solid fuel.[1] Molten salt reactors, as a class, include both burners and breeders in fast or thermal spectra, using fluoride or chloride salt-based fuels and a range of fissile or fertile consumables. LFTRs are defined by the use of fluoride fuel salts and the breeding of thorium into uranium-233 in the thermal spectrum."

- Nuclear fusion reactors “The two main varieties, magnetic confinement reactors and inertial confinement reactors. The strategies for creating fusion reactors are largely dictated by the fact that the temperatures involved in nuclear fusion are far too high to be contained in any material container”.

“The strategy of the magnetic confinement reactor is to confine the hot plasma by means of magnetic fields which keep it perpetually in looping paths which do not touch the wall of the container. This is typified by the tokamak design, the most famous example of which is the TFTR at Princeton.3The strategy of the inertial confinement reactor is to put such high energy density into a small pellet of deuterium-tritium that it fuses in such a short time that it can't move appreciably. The most advanced test reactors involve laser fusion, particularly in the Shiva and Nova reactors at Lawrence Livermore Laboratories.”

HOW LONG CAN A NUCLEAR REACTOR LAST?

Most of the reactors operating in the United States were originally licensed for 35 or 40 years, now the Nuclear Regulatory Commission is issuing new operating permits in increments of 20 years that will allow them to keep operating for 60 to 80 years. Eighty reactors have been relicensed (some plants have more than one reactor) and many more will be eligible for renewal by 2025. The NRC has never declined to approve an

application for a renewal by a licensee regardless of its safety record, which has caused some environmental groups to oppose their decisions because operating nuclear reactors beyond their original design lifetimes poses the problems of system failures, structural degradation and the possibility of meltdowns. Leaks in buried pipes that carry water for cooling are a widespread problem in plants all across the nation.In 2014 the NRC's own technical staff recommended changing the relicensing rules for plants that wanted to extend to 60 or 80 years of operation, but the NRC commissioners ruled against them. How heavy doses of radiation affect or alter material like steel and concrete is not completely understood at this point.A process known as embrittlement takes place in reactors after years of neutron bombardment making steel change it's molecular structure and become less flexible.Neutrons are the trigger for nuclear fission and cause a self sustaining reaction where the nuclear fuel releases an enormous amount of energy and pummels the pressure vessel millions and millions of times a year and it causes changes to the microstructure of the metal.This can lead to cracking in the pressure vessel, one of the most serious conditions that can limit the operating life of a plant, and while it has been observed for over 30 years it is still not been understood. What the exact effect that the radiation has on the concrete is also not well known, but over the years large areas of the reactor building become increasingly radioactive.Pipes and seals corrode, baffle bolts rust and crack in this very corrosive environment. Replacing parts is a common activity and the required maintenance can have unexpected results. For damaged metal, a possible method to fix it is annealing, which has been used in Russia but never in the US. The process entails heating the metal of the pressure vessel to remove the damage done to it by the radiation. It is not

known how long the metal will benefit from the process, and in light of that fact, in some cases the entire pressure vessel could need to be replaced.

David Lochbaum is the Director of the Nuclear Safety Project for the Union of Concerned Scientists. He leads UCS's efforts to "ensure the safety of nuclear power in the United States by monitoring licensed commercial nuclear plants to identify and publicize safety risks". He has more than seventeen years of experience in commercial nuclear power plant start-up testing, operations, licensing, software development, training, and design engineering.On reactor safety, Lochbaum states" The chance of one reactor experiencing a meltdown among a fleet of 100 reactors operating within the NRC's safety goal for 40 years is nearly one in three (32.97 percent), or slightly higher than the risk from taking two turns on a six-chamber revolver during Russian roulette. The chance of a meltdown from that fleet operating for 60 years rises to 45.12 percent, or slightly higher than taking three Russian roulette turns. And the meltdown risk from the fleet operating for eighty years is 55.07 percent, or roughly the risk from taking four and one half Russian roulette turns".....

"Time is a risk factor being ignored by the NRC. When the NRC began renewing licenses for20 and perhaps 40 additional years, the agency did not revisit its safety goal and seems tolerant of the meltdown risk rising to one in two or greater. This is a failure to recognize that aging takes a significant safety toll on nuclear reactors-not just because parts wear out over time, but also because refurbishment and replacement sometimes have unanticipated consequences."....

The bathtub curve is a term used in the industry that describes the way that reactors perform over their lifetimes and the problems they encounter, especially at the beginning and end of their operation. A reactor is at relatively high risk when it first comes on line because of material imperfections, assembly errors, worker mistakes and other break in problems. After the initial period of operation this risk lowers as the reactor's operator works out the problems, and then the risk rises again later because of the degradation caused by age and the effects of the radiation on the mechanical system and the structure of the building itself. When reactors go through a large scale rebuilding process they must go back to beginning of the bathtub curve again and the higher risk that comes with it.

There are numerous examples where utilities have attempted to rebuild a reactor, including replacing the core and doing extensive damage to the concrete in the process. In some cases the steam generators were replaced with faulty equipment that did not survive the break in period. Construction delays and huge cost over runs are very common in the industry, and when coupled with the failures in the break in period, after spending hundreds of millions of dollars these projects are often cancelled. One of the biggest problems confronting the nuclear industry is the wide spread leaking of buried pipes that are almost impossible to inspect without digging them up.Many of these pipes are embedded in the concrete foundations of the facilities and replacing them would require a huge investment to repair and they are left in place to continue corroding and leaking radioactive water into the environment.

As many as 20 nuclear plants are slated for possible shut down or rebuilding in the next decade; replacing them with technology that doesn't add C02 to the atmosphere is imperative in the on going attempt to combat climate change.

DESIGN FLAWS AND MAINTENANCE ISSUES

In this section I will report on a few of the most infamous examples where either the basic design of a reactor was badly flawed, or lack of routine maintenance could have caused a catastrophic accident, a meltdown. Nuclear reactors are designed with safety systems which are redundant, meaning that several safety features are employed to ensure the reactors safe operation for any of it's important systems. Even with the best physicists and engineers working on a new reactor design, problems occur that are caused directly by that design rather than by operator error. The total lack of safe, responsible oversight only makes matters worse. By seeing some examples of this we can understand just how corrupt and incompetent the industry really is. The effects of radiation in these two meltdowns at Chernobyl and Fukushima will be covered thoroughly later in the report, but here are brief recaps of those disasters. Then, when a regulatory agency lets the utilities get away with gross malfeasance, it can lead to "near misses", serious problems that increase the chance of a meltdown by a factor of ten, and unfortunately they happen more often than you'd think. Just a short example on the

problems at Indian Point will show how bad the situation is across the country, because the other plants are just as bad

CHERNOBYL

The Chernobyl meltdown started at 1 a.m. on the morning ofApril 26, 1986 in the town of Chernobyl in Ukraine, near the borders with Russia and Belarus. 600,000 to 800,000 firefighters from all over the former Soviet Union worked for over two years to put out the fire and to bury radioactive equipment, homes and buildings. They built a “sarcophagus” over the the burned out plant to try to contain the radiation. In total 350,000 people have been relocated from the area surrounding Chernobyl.

On August 23, 1986 Robert Gillette wrote for the LA Times, “ Human error was the overriding cause of the Chernobyl nuclear accident, but the reactor's design made it a difficult one to manage, according to nuclear safety experts who have read the Soviet Union's government report on the disaster “.

“The Soviet-designed RBMK (reaktor bolshoy moshchnosty kanalny, high-power channel reactor) is a pressurised water-cooled reactor with individual fuel channels and using graphite as its moderator. It is also known as the light water graphite reactor (LWGR). It is very different from most other power reactor designs as it derived from a

design principally for plutonium production and was intended and used in Russia for both plutonium and power production.

The combination of graphite moderator and water coolant is found in no other power reactors in the world. As the Chernobyl accident showed, several of the RBMK's design characteristics,– in particular, the control rod design and a positive void coefficient – were unsafe. A number of significant design changes were made after the Chernobyl accident to address these problems.

These analysts say that Soviet authorities appear to recognize that operator errors at the Chernobyl plant on the night of April 25-26 were not the sole cause of the accident, and that technical flaws in the reactor's design contributed to the worst accident in the 44-year history of nuclear energy."

"In particular, they said, a distinctive feature of the Chernobyl design, which sets it apart from conventional nuclear power plants in most of the world, is its tendency to generate a sudden and uncontrollable burst of power if large steam bubbles, or "voids," are allowed to form in the reactor core, as they did before the accident."

"This peculiarity of the Chernobyl type of graphite reactor, called a positive void effect, is now seen as a decisive factor in the accident, one that transformed successive blunders on the part of Soviet operators over a period of hours into a catastrophe"……

“There is no secure containment in the sense accepted in the West. The reactor core is located in a reinforced concrete lined cavity that acts as a radiation shield. The core sits on a heavy steel plate, with a 1000 tonne steel cover plate on the top. The extensions of the fuel channels penetrate the lower plate and the cover plate and are welded to each. The steam separators of the coolant systems are housed in their own concrete shields”.

“There is no indication in the Soviet report of plans to enclose the remaining Chernobyl-type reactors in steel-and-concrete structures. IAEA analysts believe that such a housing, which is hugely expensive, would have greatly reduced the amount of radioactive wastes blown out by the initial explosion on April 26 and released by the subsequent fire in the reactor's graphite core.”

FUKUSHIMA

The Fukushima Disaster was caused byThe Great East Japan Earthquake which measured 9.0 on the richter scale, on March 11, 2011.The huge double earthquake was centered 130 km off shore, lasted for about 3 minutes and moved the island of Japan a few meters and subsided the local coastline half a meter. A tsunami inundated over 560 square km and killed 19,000 people. The entire coastal region around Fukushima was devastated and over 1,000,000 homes and buildings were destroyed. There were 11 reactors at 4 power stations operating at the time the quake hit, and none sustained serious damage from it. The main problem centered on Fukushima Daiichi units 1-3 first, with unit 4 becoming a problem later.The size of the tsunami caused by the

earthquake was under estimated in the design, even though officials knew of updated information revealing the possibility of a much bigger tsunami.

The World Nuclear Association wrote in April 2016 “ The Tsunami counter measures taken when Fukushima Daiichi was designed and sited in the 1960s were considered acceptable in relation to the scientific knowledge then, with low recorded run-up heights for that particular coastline. But some 18 years before the 2011 disaster, new scientific knowledge had emerged about the likelihood of a large earthquake and resulting major tsunami of some 15.7 meters at the Daiichi site. However, this had not yet led to any major action by either the plant operator, Tepco, or government regulators, notably the Nuclear & Industrial Safety Agency (NISA). Discussion was ongoing, but action minimal. The tsunami countermeasures could also have been reviewed in accordance with IAEA guidelines which required taking into account high tsunami levels, but NISA continued to allow the Fukushima plant to operate without sufficient countermeasures such as moving the backup generators up the hill, sealing the lower part of the buildings, and having some back-up for seawater pumps, despite clear warnings “.

Time magazine reported the following in 2011, “ The failings of the Fukushima nuclear reactor were so substantial that three General Electric scientists who helped design the now imperiled reactors resigned from the company”.

“Dale Bridenbaugh helped assess the design of the Mark 1 nuclear reactor upon its creation back in 1975. His findings portray an extreme lack of confidence in the

reactor's ability to contain pressure in case of a meltdown. Bridenbaugh and two engineering colleagues couldn't handle the pressure themselves, leading them to drop out of the project and resign their positions with the company."

On February 24, 2016 the BBC reported " The operator of the Fukushima nuclear power plant hit by a tsunami in 2011 has admitted that it should have announced sooner that there was a nuclear meltdown at the site….It was two months before it was acknowledged there had been a meltdown.Tokyo Electric Power Company now says the public declaration should have been done within days of the disaster.Experts have long said the melting began within hours of the reactor being struck by the tsunami.For the first time, the company, also known as Tepco, admitted there were clear internal regulations stating when a meltdown should be declared - when damage to the reactor core exceeds 5%".

"The company told Japanese authorities that damage to one of the reactor cores had already passed 50% three days after the disaster, but it did not acknowledge this publicly for two months".

"Tepco says it will investigate why the procedures were not followed.The meltdown at Fukushima in March 2011 happened because the plant lost power after it was swamped by the tsunami. It lost the ability to cool the nuclear reactor, leading to an explosive build-up of heat and gas.Some 160,000 people were evacuated from the surrounding

areas in the following weeks, and continuing high radiation levels mean most have never been able to return home".

The Daily Beast's Jake Adelstein reported in 2015 reported some very distressing facts about the wide spread denial in nuclear regulatory agencies around the world when he wrote about an IAEA report on the Fukushima disaster,"A major factor that contributed to the accident was the widespread assumption in Japan that its nuclear power plants were so safe," it noted."In the aftermath of Fukushima, former Prime Minister Kan Naoto, who was in charge during 2011's triple disaster, acknowledged nuclear's lethal uncertainties—and then one more, Nuclear power is a huge risk. Not to mention the possibility of human error. And the Fukushima accident also showed the world how vulnerable nuclear power plants could be to terrorism," Naoto wrote in his memoirs in 2012. "Terrorists don't have to bomb them, they just need to get inside and cut the power to potentially unleash great destruction."

"Unarmed guards protect Japan's nuclear power plants, and background checks are not required for employees. Members of organized crime, the yakuza, staff construction teams and work within the plants. The Japanese government has acknowledged in reports that not only is there a threat from outsiders storming the nuclear plants, but also a high risk from workers already inside—in other words, terrorists might walk through the front doors as employees".

"The report should have been taken as a warning. It was mostly ignored"

INDIAN POINT

The Indian Point Nuclear Power Plant is located in Buchanan, New York, 34 miles north of New York City. In one of the most populated areas in the country, if a nuclear meltdown were to take place, over 17,600,000 people would be within the distance that the US government warned was unsafe, and they were too close to the Fukushima Nuclear Power Plant when it melted down. The 50 mile exclusion zone around the plant could need to be evacuated, and there is no plan to do it. The so-called plan has been referred to as a " fantasy document " by civil authorities and scholars knowledgable on the subject.On March 20,2011 The New York Times explained the situation in relation to Fukushima, "In the case of a comparable disaster here, this is what a 50-mile circle around the Indian Point nuclear plant on the Hudson River in Westchester County would look like: past Kingston in Ulster County to the north; past Bayonne and Elizabeth, N.J., to the south; almost to New Haven in the east; and into Pennsylvania to the west. It includes almost all of New York City except for Staten Island; almost all of Nassau County and much of Suffolk; all of Bergen County, N.J.; all of Fairfield, Conn.

"No operating American plant has ever been shut down because of the lack of an acceptable evacuation plan. But you don't have to look far to find how critical the issue can be: The Shoreham nuclear plant on Long Island was completed and then shut down without producing any commercial electric power after representatives of Mario M.Cuomo, then the governor of New York, declined to certify its evacuation plan. Last week, another Governor Cuomo called Indian Point too big a risk to remain open."

The New York Times wrote on March 20, 2011" The most in-depth analysis of the evacuation planning for Indian Point was a 256-page report commissioned by Gov. George E. Pataki and completed in 2003 by a firm headed by James Lee Witt, former director of the Federal Emergency Management Agency.It concluded that the plans were drafted to comply with regulations rather than to create an effective strategy to protect the population, and that they assumed people would comply with government directives rather than do what seemed to be in their own best interests.

Citing these and other concerns, the report said: "It is our conclusion that current radiological response system and capabilities are not adequate to overcome their combined weight and protect the people from an unacceptable dose of radiation in the event of a release from Indian Point."

Evacuation is not the only problem plaguing Indian Point, here are just some of the other situations that make people call the place "a disaster waiting to happen".

The environmental group Riverkeeper filed a petition in 2012 to close down Units 2 and 3 because the licensee failed to mitigate the risk of a hydrogen explosion if a severe accident took place. Commenting on the petition The Natural Resource Defense Council reported on the petition and stated," When a core meltdown occurs in a nuclear reactor, such as the triple melt-down that occurred during Japan's Fukushima nuclear accident in March 2011, the final barrier to protect the public from a radiological release is the reactor's containment. The NRC does not require owners of pressurized water reactors with large dry containments to control the hydrogen that would be generated in

a meltdown. An NRC task force report on insights from the Fukushima Dai-ichi accident claims that the pressure spike of potential hydrogen explosions would remain within the design pressure of large dry containments According to the own safety analyses, however, conducted a decade ago, hydrogen explosions inside large dry containments could cause pressure spikes exceeding 110 pounds per square inch,which is about twice the design pressure of Indian Point's containments".

"If a meltdown were to occur at either of Indian Point's two reactors, a large quantity of potentially explosive hydrogen would be produced when reactor core materials, principally the zirconium alloy tubes that contain the nuclear fuel, chemically reacted with steam. There is no assurance today that Indian Point's owner, Entergy, could control the total quantity of hydrogen generated in a meltdown—which could exceed 1,000 kilograms—and prevent a hydrogen detonation that would breach the containment and spew radioactive contamination into the regional environment."….

Mr.Jerry Nappi ,a representative of Entergy said that there is "equipment inside containment that automatically turns hydrogen gas into harmless water…" to which the petition responded " is almost certainly referring to the hydrogen recombiners that the plant has in each of its containments. (Indian Point Unit 2's containment has two "passive" i.e., self-actuating or "autocatalytic") hydrogen recombiners, which do not require electricity, and Indian Point Unit 3's containment has two electrically-powered thermal hydrogen recombiners.) These safety devices spontaneously recombine hydrogen and oxygen molecules,yielding steam and heat, when the local hydrogen concentration in the air exceeds about 1 percent by volume"

“Hydrogen recombiners are intended to maintain the hydrogen concentration in the containment below levels that can support a hydrogen explosion (i.e., at about 4 percent by volume and above). However, contrary to Entergy’s assurance of safety, there are only two recombiners in each of Indian Point’s containments, and they have a very limited capacity: each recombiner can only eliminate several grams of hydrogen per second, while up to five kilograms of hydrogen per second could be produced at certain points during a severe accident”.

“During a meltdown at Indian Point, the two hydrogen recombiners would clearly not be capable of eliminating all, or even a significant fraction, of the hydrogen produced within the time frame needed to prevent an explosion. In fact, the NRC has itself stated that hydrogen recombiners would be “ineffective at mitigating hydrogen releases from risk-significant beyond design-basis accidents”—i.e., partial or complete core melts.”

“In countries that seek to minimize the hydrogen explosion risk from these types of accidents, “a fleet of typically 40 units are installed inside a light water reactor (LWR) containment.” So it appears that Indian Point has only 5 percent of what European nuclear regulators regard as a prudent complement of hydrogen recombiners.”

” Ironically, however, according to the NRC, hydrogen recombiners are not even needed to mitigate hydrogen in design-basis accidents. In 2003, the agency eliminated the requirement for hydrogen recombiners, stating that the “Commission has found that hydrogen release [in a design-basis loss-of-coolant accident] is not risk-significant because the...hydrogen release does not contribute to the conditional probability of a

large release [for] up to approximately 24 hours after the onset of core damage."In a severe accident (meltdown), more than 100 percent of the active fuel cladding could chemically react with steam, because additional reactor core materials could also undergo rapid oxidation. Interestingly, an Indian Point safety study discusses a case in which interaction of the molten core with concrete would produce more than 6000 pounds (2721.5 kilograms) of hydrogen.In light of these technical and regulatory conclusions, one wonders why a spokesman for Entergy would continue to cite a mere two recombiners in each Indian Point containment as an adequate defense against the severe accident scenario described in the Riverkeeper petition.In summary: during a severe accident at Indian Point, opening potential purge lines would: 1) result in a radiological release that would contaminate the local environment, 2) not be capable of purging all or even a significant fraction of the hydrogen produced within the time frame needed to prevent an explosion, and 3) make the venting lines vulnerable to hydrogen combustion. Additionally, the potential purge lines—intended either for use during regular operation or design basis accidents—are not designed to withstand the high pressures expected to occur in the containment in a severe accident. Furthermore, there are no legally-binding regulations stipulating procedures for purging hydrogen from PWR large dry containments, and "strategies" for purging hydrogen in a PWR severe accident are ill-defined ".

"Entergy's technical information for Indian Point Unit 2's license renewal application states that "[t]he purpose of the post-accident containment vent...system was originally to provide a backup to the hydrogen recombiner as a method to reduce the hydrogen concentration in containment atmosphere post-[loss-of-coolant accident]"—in other

words, after a design-basis accident.Hence, Unit 2's post-accident containment vent system is not designed to cope with the rate and quantity of hydrogen production in a core meltdown scenario. The system is equipped with a filter for the "hydrogen-bearing gases from containment;" however, the filter has a very low capacity: a flow rate of 200 standard cubic feet per minute (when the containment pressure is at 1.9 pounds per square inch gauge, with a residence time in the charcoal filters of approximately 0.4 seconds.A flow rate of 200 standard cubic feet per minute is very low compared to the capacity of some European filtered-vent systems designed for de-pressurization in a meltdown, which have venting capacity of 3.5 to 12 kilograms per second for the steam-air-hydrogen mixture at pressures as high as 58 to 87 pounds per square inch. Hence, in the meltdown scenario, Indian Point Unit 2's post-accident containment vent system would not be very useful because the containment pressure would significantly exceed the filter's flow and pressure capacity".

Corrosion had occurred on the stainless steel bolts that hold together the baffle assembly and it was so bad that 27% of them needed to be replaced. The Huffington Post explains, "An escalating series of problems began with an enhanced inspection of the interior of the Indian Point 2 reactor during a scheduled refueling. New York Attorney General Eric Schneiderman had insisted in a series of legal actions starting in 2007 that Entergy go beyond the visual inspection by a camera lowered into the radioactive coolant and utilize more intensive ultrasonic testing. That revealed that 227 of the 882 bolts, more than one in four, were damaged due to the intensive wear and tear in the interior. That is a failure rate never recorded in any reactor in the world. And loss of the bolts and the directed coolant could lead to a fuel meltdown ".

In 2007 when Indian Point's plant owner applied to the NRC for a 20 year extension of it's operating license it was found that a flood alarm could be installed for about $200,000.00. The alarm would reduce the risk of a meltdown by 20% and reduce the amount of radiation plant staff would be exposed to by 40%, at a cost of 2 cents per person living within 50 miles. The plants owner concluded that it was a cost effective safety improvement, but in 2016 the flood alarm has never been installed, and the NRC has done nothing about it either.

The Union of Concerned Scientists described the NRC's and the industry's response this way,"When three of the six Fukushima Daiichi reactors overheated, plant workers scrambled to lower reactor core pressure by depressurizing the containment building so they could inject cooling water. They couldn't open the containment vents from the control room, however, because there was no electric power. Without enough cooling water, the reactors melted down".

"To avoid the possibility of this happening at the 30 currently operating U.S. reactors that share the same containment design as those at Fukushima, the NRC staff recommended that the agency not only require plant owners to install reliable, "hardened" vents that could be easily opened during an electricity outage, but also compel owners to add filters to avoid releasing radioactive material into the surrounding community. Four countries with the same type of GE reactors—Finland, Germany, Sweden and Switzerland—require filtered vents and Japan is planning to do so".

“The nuclear industry, however, argued that the FLEX program obviated the need for filtered vents, despite the fact that filters would be more dependable than relying on plant workers to perform complex tasks under very trying circumstances. After years of analysis, the NRC staff reversed its original recommendation, asserting that that neither vent filters nor the industry’s proposed alternatives were justified. Last August, NRC commissioners voted to do nothing”.

From an environmental perspective, a nuclear power plant contaminates the environment even when it is operating properly, because radioactive steam escapes from the plant’s cooling system and from all parts of the reactor’s buildings and machinery. In order to keep the fuel rods cool, reactors need enormous quantities of water, Indian Point uses up to 2.5 billion gallons per day from the Hudson River and in the process kills about a billion fish and other aquatic organisms a year.

As if all of these dangerous conditions were not enough to close this plant down consider this: Spectra Energy is building The Algonquin Incremental Market pipeline, a 42 inch in diameter pipeline designed to carry fracked natural gas from the Marcellus shale formation to Canada and is being built under Indian Point. It was originally going to be run within 150 feet of the plants reactors, but that created such a furor it was moved farther away. This plan was finalized without any outside agency doing a safety study. Independent hazard assessment engineers who reviewed the plan called it, “ seriously deficient and flawed “

These brief descriptions are an incomplete accounting of dangerous conditions that exist within the nuclear power industry. These problems are not unique to these power plants because many of the reactors in service globally are similar in design, and the bureaucrats that regulate them don't do their jobs any better than these guys. I will go into much further detail on the problem of leaking radioactive tritium into the environment because of poor maintenance and routine operation later in the report.

THE LIGHTS ARE ON, BUT THERE'S NOBODY HOME

The International Atomic Energy Agency (IAEA),the International Commission on Radiological Protection (ICRP) and the Nuclear Regulatory Commission (NRC) are the main regulatory bodies to be focused upon in this part of this paper. The IAEA and the ICRP have global influence creating the safety standards and practices used by the industry,while also promoting its expansion, two areas which are often in conflict. The NRC operates in the US only, but the same conflict exists. These responsibilities create an inherent tension because in practice, promoting the expanded use of nuclear power, while determining its safe use cannot be done without one of these responsibilities being relegated to second place.Safety lost to politics and money. It is in this arena that the political/economic nature of the industry stresses the safe operation of nuclear reactors to the limit, and sometimes far beyond it. The involvement of the United Nations, its 5 member Security Council and the World Health Agency (WHO) is heavily weighted in favor of the nuclear industrial complex and its promotion.

NUCLEAR REGULATORY COMMISSION

Wikipedia describes the agency in the following way, “The Nuclear Regulatory Commission(NRC) is an independent agency of the United States government tasked with protecting public health and safety related to nuclear energy. Established by the Energy Reorganization Act of 1974, the NRC began operations on January 19, 1975 as one of two successor agencies to the United States Atomic Energy Commission. Its functions include overseeing reactor safety and security, administering reactor licensing and renewal, licensing radioactive materials, radionuclide safety, and managing the storage, security, recycling, and disposal of spent fuel….”

“Prior to 1975 the Atomic Energy Commission was in charge of matters regarding radionuclides. The AEC was dissolved, because it was perceived as unduly favoring the industry it was charged with regulating.The NRC was formed as an independent commission to oversee nuclear energy matters, oversight of nuclear medicine, and nuclear safety…”

“The U.S. AEC became the Energy Research and Development Administration (ERDA) in 1975, responsible for development and oversight of nuclear weapons. Research and promotion of civil uses of radioactive materials, such as for nuclear non-destructive testing, nuclear medicine, and nuclear power, was split into the Office of Nuclear Energy, Science & Technology within ERDA by the same act. In 1977, ERDA became the United States Department of Energy (DOE). In 2000, the National Nuclear Security

Administration was created as a subcomponent of DOE, responsible for nuclear weapons”….

The NRC's mission is to regulate the nation's civilian use of byproduct, source, and special nuclear materials to ensure adequate protection of public health and safety, to promote the common defense and security, and to protect the environment. The NRC's regulatory mission covers three main areas:

- Reactors - Commercial reactors for generating electric power and research and test reactors used for research, testing, and training
- Materials - Uses of nuclear materials in medical, industrial, and academic settings and facilities that produce nuclear fuel
- Waste - Transportation, storage, and disposal of nuclear materials and waste, and decommissioning of nuclear facilities from service”.

INTERNATIONAL ATOMIC ENERGY COMMISSION

Wikipedia details the IAEA’s history and the organizations mission this way. “The International Atomic Energy Agency (IAEA) is an international organization that seeks to promote the peaceful use of nuclear energy, and to inhibit its use for any military purpose, including nuclear weapons. The IAEA was established as an autonomous organization on 29 July 1957. Though established independently of the United Nations

through its own international treaty, the IAEA Statute, the IAEA reports to both the United Nations General Assembly and Security Council".

"The IAEA has its headquarters in Vienna. The IAEA has two "Regional Safeguards Offices"which are located in Toronto, Canada, and in Tokyo, Japan. The IAEA also has two liaison offices which are located in New York City, United States, and in Geneva, Switzerland. In addition, the IAEA has three laboratories located in Vienna and Seibersdorf, Austria, and in Monaco".

"The IAEA serves as an intergovernmental forum for scientific and technical cooperation in the peaceful use of nuclear technology and nuclear power worldwide. The programs of the IAEA encourage the development of the peaceful applications of nuclear technology, provide international safeguards against misuse of nuclear technology and nuclear materials, and promote nuclear safety (including radiation protection) and nuclear security standards and their implementation".

"The United States also called for an international scientific conference on all of the peaceful aspects of nuclear power. By November 1954, it had become clear that the Soviet Union would reject any international custody of fissile material, but that a clearing house for nuclear transactions might be possible. From 8 to 20 August 1955, the United Nations held the International Conference on the Peaceful Uses of Atomic Energy in Geneva, Switzerland. In October 1956, a Conference on the IAEA Statute was held at the Headquarters of the United Nations to approve the founding document for the IAEA,

which was negotiated in 1955-1956 by a group of twelve countries.The Statute of the IAEA was approved on 23 October 1956 and came into force on 29 July 1957".

"The IAEA as an autonomous organization is not under direct control of the UN, but the IAEA does report to both the UN General Assembly and Security Council. Unlike most other specialized international agencies, the IAEA does much of its work with the Security Council, and not with the United Nations Economic and Social Council. "

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

The ICRP does not serve in a regulatory function and works is based upon the findings of the agencies that came before it, namely the AEC, NRC and the ICRP. Wikipedia says this about the agency "The International Commission on Radiological Protection (ICRP) is an independent, international, non-governmental organization, which provides recommendations and guidance on radiation protection".

"It was founded in 1928 by at the second International Congress of Radiology in Stockholm, Sweden and was then called the International X-ray and Radium Protection Committee (IXRPC). In 1950 it was restructured to take account of new uses of radiation outside the medical area, and given its present name".

“The ICRP is a sister organisation to the International Commission on Radiation Units and Measurements (ICRU). In general terms ICRU defines the units, and ICRP recommends, develops and maintains the International System of Radiological Protection which uses these units”.

“The International System of Radiological Protection has been developed by ICRP based on (i) the current understanding of the science of radiation exposures and effects and (ii) value judgements. These value judgements take into account societal expectations, ethics, and experience gained in application of the system.”

Despite these lofty goals to protect the health of people and environment from the ravages of radiation, this is what one of the founders of the ICRP had to say about the organization he pioneered.The Washington Blog wrote,“ One of the original five ‘health physicists’ to set radiation safety standards was Karl Z. Morgan. Dr. Morgan served on the International Commission on Radiological Protection (ICRP), which set up most radiation standards. He also directed the Health Physics Division at Oak Ridge from 1944 until his retirement in 1972. In recent years, Dr. Morgan has publicly criticized the ICRP for failing to protect human health. In a 1994 article for the American Journal of Industrial Medicine, Dr. Morgan wrote: “The period of atmospheric testing of nuclear weapons by the United States, the United Kingdom, France and the USSR is a sad page in the history of civilized man. Without question, it was the cause of hundreds of thousands of cancer deaths. Yet there was complete silence on the part of the ICRP. During these years (1960-1965), most members of the ICRP either worked directly with

the nuclear weapons industry or indirectly received most of their funding for their research from this industry."

" The ICRP's alliance with the nuclear industry includes ties to the International Congress of Radiology. In his 1999 autobiography, The Angry Genie: One Man's Walk Through the Nuclear Age (ISBN 0-8061-3122-5), Dr. Morgan related his concern about the ICRP's refusal to address the danger of excessive X-ray exposure during diagnostic procedures and dentistry. Until the passage of the Radiation Control for Health and Safety Act of 1968, some X-ray equipment used in the 1950s and 1960s delivered 2 to 3 rem per X-ray. X-ray doses as low as 1.6 rem increase a woman's chance of developing cancer, according to a 1974 study by Baruch Modan [Lancet (Feb. 23,1974), pp 277-279]. The Act did not address the cumulative effect of multiple, routine, and often unnecessary X-rays".

THE UNITED NATIONS AND THE WORLD HEALTH ORGANIZATION

What is the relationship between these nuclear industry regulators and a radiation safety advisory commission and the UN and the WHO? The IAEA and the ICRP have a much more influential and direct involvement with the UN and the WHO than the NRC does, because they are internationally chartered groups and the NRC is not. But all three groups function promoting the nuclear industry, either directly or indirectly. The 2017 military and civilian nuclear industry is valued at $ 175 billion dollars per year

globally, and the 5 permanent members of the UN Security Council are all nuclear states, and most are exporters of nuclear technology. The IAEA reports directly to the Security Council on all aspects of the industry including information sharing, research and investigations concerning health and security. Since 1959 the IAEA has had an agreement with the WHO that gives it control over how the WHO is run and the standards it uses concerning health and safety. Since this agreement was made, the WHO is not able to disseminate information, undertake research, or provide assistance to populations affected by nuclear accidents without the approval of the IAEA .The agency has been criticized for many years about its lack of transparency and secrecy in the way it conducts its business. Recently IAEA has severely limited access to it's archives and restricted the public and members of the press from symposiums and conferences that had been open in the past.

Perhaps the most disconcerting aspect of all is the IAEA's establishment of, and adherence to policies based on old or discredited scientific information, and requiring the WHO to do the same. These policies are most obvious in the areas related to dosimetry and epidemiology, where the IAEA and the WHO consistently misreport the damage resulting from low level ionizing radiation contamination, when compared to independent associations and professionals. This is widely known in the scientific and medical communities and seen as a clear sign that they are overly influenced by the industry, which is their source of funding.This is not a matter of differing professional observations about complex subjects, but a long standing history of bending to industry demands, rather than following the scientific evidence where it leads.

Dosimetry and epidemiology are very complex topics and the models used to arrive at the correct answers can vary legitimately; but the differences in the casualty reports between these agencies and those of independent sources regarding Chernobyl and Fukushima cannot be justified. The number of reported deaths, illnesses and the effects of low level radiation on the health and well being of people must be rationally discussed.In both of these nuclear disasters, doctors, coroners, public health officials and scientists on the ground in the devastated areas reported a vastly higher number of deaths and illnesses as well as a much broader spectrum of diseases resulting from the meltdowns than were reported by the IAEA, WHO or the government agencies. The effects of low level radiation are under-estimated, if not entirely dismissed by " official " sources, despite overwhelming evidence to the contrary, and as a result, the suffering of countless people goes unreported and untreated. This approach of manipulating the parameters of the research allows the nuclear industry to try to control the dialogue on the effects of radiation.

After Hiroshima and Nagasaki, American scientists restricted research on radiation to only people who were within 3 miles of the epicenter of the bombing and had received burns from the blast. People who lived outside of the 3 mile zone were excluded ,even though they suffered from the exposure to lower levels of radiation. Instead of observing the effects of low level radiation on the actual victims outside the 3 mile zone, a hypothetical statistical analysis was done on the victims of high level radiation and it was extrapolated down to simulate lower doses. In effect, a political decision was made to manipulate the data on the bombing to make the scale of the suffering appear to be

less than it really was, making the terrible consequences of nuclear war seem less frightening to the public.This kind of sleight of hand is still done by the nuclear industry and its representatives to deceive the public into believing that this technology is safe, but the goal is economically motivated. Allison Katz, writing for Le Monde commented, " IndependentWHO, the group organising the action (a protest rally), accuses the WHO of a cover-up of the health consequences of the catastrophe, and failing to assist populations in danger.The WHO, they insist, must end the agreement made in 1959 which binds it to the International Atomic Energy Agency (IAEA) and prevents it from initiating a programme or activity in the area of nuclear power without consulting the IAEA "with a view to adjusting the matter by mutual agreement".Independence from the IAEA would permit the WHO to conduct a serious, scientific evaluation of the disaster and provide appropriate health care to contaminated people."

"According to its statutes, the IAEA (a UN agency which reports to the Security Council) is mandated to "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world". It is in fact a lobby, industrial and military, which should have no role to play in public health policymaking or research".

"The IAEA has vetoed conferences planned by WHO on radioactivity and health and, in turn, the WHO has endorsed the nuclear lobby's grotesque statistics on mortality and morbidity relating to the Chernobyl accident – 56 dead and 4,000 thyroid cancers. Denial of disease inevitably implies denial of health care. Nine million people live in

areas with very high levels of radioactivity; for 21 years now these populations have had no choice but to consume contaminated food, with devastating effects on their health" .

"For the nuclear lobby, any research indicating harm from ionising radiation represents a commercial threat that must at all costs be averted. Research on damage to the human genome (one of the most serious consequences of the contamination) was not part of the international project requested of the WHO in 1991 by the health ministers of Ukraine, Belarus and the Russian Federation. Yet dental caries was made a research priority. And although these countries had addressed their research request to the WHO, it was the IAEA which planned the project".

"This conflict of interest has already been fatal for hundreds of thousands of people according to studies by independent scientists and institutions. And the greatest burden of disease and death is yet to come given long latency periods, the increasing concentration of radionuclides in internal organs from food grown in contaminated soil, and damage to the human genome over many generations".

"Hundreds of epidemiological studies in Ukraine, Belarus and the Russian Federation have established that there has been a significant rise in all types of cancer causing thousands of deaths, an increase in infant and perinatal mortality, a large number of spontaneous abortions, a growing number of deformities and genetic anomalies, disturbance and retardation of mental development, neuropsychological illness,

blindness, and diseases of the respiratory, cardiovascular, gastrointestinal, urogenital and endocrine systems”

“For 50 years dangerous concentrations of radionuclides have been accumulating in earth, air and water from weapons testing and reactor incidents. Yet serious studies of the effects of radiation on health have been obscured – not least by the World Health Organisation". In another piece for Le Monde Allison Katz reported,” In June 2007 Gregory Hartzl, World Health Organisation (WHO) spokesman for Sustainable Development and Healthy Environments, claimed that the proceedings of the international conference held in Geneva in 1995 on the health consequences of the Chernobyl disaster had been duly published. This was not so. And the proceedings of the Kiev conference in 2001 have never been published either. Challenged by journalists a few months later, the WHO repeated the claim, providing references to a collection of abstracts for the Kiev conference and just 12 articles (out of hundreds) submitted to the Geneva conference “.

“But who will believe them? Four months after the meltdown Morris Rosen, the IAEA’s director of nuclear safety, wrote: “Even if there were an accident of this type every year, I would still regard nuclear power as a valuable source of energy”. Public information on the real health consequences of Chernobyl could seriously change the debate about nuclear options. And that is why the WHO is afraid of the children of Chernobyl.
For decades the tobacco, agrochemical and petrochemical lobbies have obstructed implementation of public health and environmental measures that might interfere with

their profits. But the nuclear lobby is incomparably more powerful than any of these as it comprises governments of nuclear states, most significantly, the United States, the United Kingdom and France, and powerful intergovernmental organisations. The disinformation emanating from industrial and military lobbies is overwhelming – and dangerously, it carries state authority".

"Furthermore, the corruption of science also concerns our most prestigious academic institutions which, as an editorial in The Lancet reported, "have become businesses in their own right, seeking to commercialise for themselves research discoveries rather than preserve their independent scholarly status". Peer-reviewed studies, cited as evidence of the safety of nuclear activities, all too often emanate from, or are financed by, the nuclear lobby.Corporate science, through denial, cover-ups and lies, has brought us to the brink of self-destruction in relation to global warming. So how can we contemplate trusting corporate science in relation to nuclear power? While the emissions responsible for climate change are amenable to control (in theory), nuclear technology and its waste products are not, and its consequences, even if nuclear activities ceased tomorrow, will affect life on earth for millennia".

"The "science" that has informed the nuclear debate in general, and the Chernobyl catastrophe in particular, is corporate science in which the industry is judge and jury in relation to the health consequences of its own activities. The entire edifice of nuclear institutions, governmental, regulatory, military, industrial, scientific, research and

intergovernmental, including Euratom and some UN agencies, is one incestuous happy family"

"The flaws in this pseudo science range from the flagrant and preposterous to the subtle and dishonest, as shown by expert Chris Busby, journalist Wladimir Tchertkoff, as well as the Permanent People's Tribunal."The first category includes falsification and suppression of data; failure to measure exposure, screen for cancer and investigate the relationship between the two; attacks on independent researchers and their institutions; censorship of studies revealing adverse effects, discounting thousands of untranslated studies from the three most affected countries; and exclusion from conference agendas of entire scientific domains (such as the health effects of chronic, low dose, internal radiation, accounting for almost all the contamination in populations around Chernobyl)".

"The second category involves dozens of manipulations of data, among them: averaging exposures over entire populations and ignoring local sources of concentrated contamination; ending studies after 10 years thereby excluding long term morbidity and mortality; qualifying five year survival as "cure", only considering cancer, those still alive and the three most affected countries; claiming decreases in childhood cancers when in fact children have become adults with cancer and therefore no longer appear in that database".

"According to the National Cancer Institute, cancer incidence (all sites) in the US increased by 55% between 1950 and 1995; the trends in Europe and other

industrialised nations are similar. Non-smoking related cancers are responsible for about 75% of the overall increased incidence of cancer since 1950, and cannot be explained in terms of better detection or ageing. Cancer incidence increases in parallel with gross national product and industrialisation but the obvious explanation for this phenomenon – environmental pollution, chemical and radioactive – is ignored. Perversely, victims are blamed for their lifestyles".

The 5 permanent members of the UN Security Council have enormous economic and political power and the use it to enhance their interests the geopolitical landscape. Since all of the members come from nuclear states, the decisions they make are biased in favor of the nuclear industry with a majority of these states having large industries exporting nuclear technology to other countries; this includes selling the technology to governments that have not had it in the past, as well as the parts and technical skills to maintain and rebuild aging reactors. This can be an extremely lucrative business for the industry, but it can become a huge economic drain on the customer countries because nuclear power needs to be subsidized because of the enormous capital costs involved.

In the US the NRC, like its international counterparts, also serves in the dual role of marketing the expansion of nuclear power and determining the safety regulations the industry incorporates for nuclear industry workers and the public who buy the electricity. There are so many examples of the NRC failing to do their job of following sound scientific evidence to determine the safe limits of radiation exposure, that the health of

millions of people is at stake. They also prove themselves to be dangerously incompetent on the important issues surrounding the correction of design flaws and plant maintenance. The only responsibility they take seriously is shamelessly promoting the industry, protecting their economic bottom line and soliciting for even more subsidies from the American taxpayers. When problems are found at a power facility that pose serious safety risks, the NRC allows the licensees to make decisions about whether to fix the situation or not based on a cost benefit analysis. In many cases, the repairs or design flaws are neglected and never fixed and the NRC looks the other way and does nothing about it. This became such a big problem that in 2016 7 NRC employees publicly petitioned the agency to take action against plant operators for violating regulatory requirements. This safety problem affects every operating nuclear plant in the US, except one.

The NRC's response to this emergency was that the agency would :

- 1) ENFORCE CURRENT REQUIREMENTS
- 2) GRANT ENFORCEMENT DISCRETION FOR LICENSEES WHO DETERMINE ELECTRIC POWER SYSTEMS ARE INOPERABLE.
- So, the NRC staff plans to ENFORCE CURRENT REQUIREMENTS, unless plant owners violate current requirements, and then in that case the NRC plans to GRANT ENFORCEMENT DISCRETION to allow reactors with inoperable electric power systems to continue operating.This is unfortunately business as usual.

Three U.S. senators have called for a congressional probe on safety issues at the nation's aging nuclear plants following a pair of new exposés. In a special series called "Aging Nukes," the Associated Press revealed that the U.S. Nuclear Regulatory Commission and the nuclear power industry have been working in tandem to weaken safety standards to keep aging reactors within the rules. Just last year, the NRC weakened the safety margin for acceptable radiation damage to reactor vessels

The Washington Blog reported in 2011 about the NRC's lack of action following Fukushima,"As part of his ongoing investigation into U.S. nuclear safety since the Fukushima meltdowns, today Rep. Edward J. Markey (D-Mass.) … released a blockbuster new report that details how four Commissioners at the Nuclear Regulatory Commission (NRC) colluded to prevent and then delay the work of the NRC Near-Term Task Force on Fukushima, the entity tasked with making recommendations for improvement to NRC regulations and processes after the Fukushima meltdowns" …

"The actions of these four Commissioners since the Fukushima nuclear disaster has caused a regulatory meltdown that has left America's nuclear fleet and the general public at risk," said Rep. Markey. "Instead of doing what they have been sworn to do, these four Commissioners have attempted a coup on the Chairman and have abdicated their responsibility to the American public to assure the safety of America's nuclear industry. I call on these four Commissioners to stop the obstruction, do their jobs and quickly move to fully implement the lessons learned from the Fukushima disaster."

The nuclear industry is a potent political force in Washington by virtue of the number of lobbyists it has, and the tremendous amounts of money they have to spend to make sure that the taxpayer subsidies they are used to keep coming in. Since the price of renewables and natural gas have come down nuclear energy is more at risk than ever, and lobbyists are looking for even more money to prop up the industry. Between 2000 and 2010 the nuclear industrial complex waged an aggressive campaign to woo legislators into providing even more subsidies, spending $600 million dollars on lobbying and nearly $63 million directly on campaign contributions to both sides of the aisle.

Some politicians have a plan to build a total of 100 reactors over the next 20 years and the energy they would produce would cost significantly more than any other form of energy per kilowatt hour when all of the subsidies are factored in. 100 reactors built in 20 years is little more than a dream because the time required to finance and build one plant is a decade, if everything goes right. Ex-politicians and retired nuclear executives are involved in ” Astroturfing “, or creating the appearance that the industry has strong grass-roots support appeal, and the industry pays them very well to lobby for them.This activity also has the support of the labor unions like the AFL-CIO, who would stand to benefit from the large number of jobs that would be created by plant construction. The Nuclear Energy Institute,is an industry trade group that has many allies in congress, and its influence can be seen in The Whitehouse as well. President Obama received $210,000 for his presidential campaign, and two of his closest advisors, Rahm Emmanuel and David Axelrod have close ties to the industry. These attempts to

manipulate the public are designed to be almost invisible, and to not draw attention to their plans.

Since climate change legislation became necessary, the nuclear industry saw a chance for a second lease on life.It has pushed hard on the fact that their power produces very little C02, and it picked up some allies in the environmental movement and from Democratic politicians who had opposed them in the past. These new alliances will last only as long as the dangerous realities involved with nuclear power are overshadowed by the distortions and half truths being peddled by the pro-nuclear advocates.But whether this industry is a viable player in the energy market or not is dependent upon the subsidies it receives from the American people, and whether they learn the truth about it.

Is it any wonder that with all the economic power and the extraordinary level of political muscle that the nuclear industrial complex has, that its dangerous problems have been hidden from the eyes of the public? Is it any wonder that showing any opposition to the industry leads to being professionally discredited and marginalized? Those that do object are represented as misguided crack pots and fear mongers, but there are signs of change and people in positions of power are stepping up and questioning if nuclear power is the best answer to our energy needs. Despite all its money and friends in high places the management of the NRC is weak and it is obviously unable to run the agency with the competency the American people deserve.

In testimony given to the US Senate on a bill to establish criteria for developing new reactor technology, Edwin Lyman PhD, Senior Scientist, Union of Concerned Scientists, said,“There are numerous issues of concern to us that are not addressed in S.2795. For example, one of the major problems with NRC’s approach to advanced reactors, as articulated in the NRC’s Advanced Reactor Policy Statement, is that it does not require new reactors to be safer than existing reactors. UCS believes that this policy inhibits true innovation in reactor design that could lead to significantly safer nuclear power in the future. For instance, the NRC recently rejected a staff proposal that new reactors should be designed to be more robust than operating reactors, and to rely less on portable emergency equipment, in the event of a Fukushima-like station blackout”.

COMING TO A NUCLEAR PLANT NEAR YOU

“The Union of Concerned Scientists also reported on the industry’s performance in 2015, it wrote,“The Nuclear Regulatory Commission (NRC) is the arm of the federal government charged with enforcing safety regulations at U.S. nuclear power plants. Every year they respond to safety and security “near misses,” defined as events that potentially increase the risk of a reactor meltdown by at least 10 times. In 2015, there were 10 near misses at U.S. reactors, or nearly half the number of incidents reported in 2010 and 2011”.

“Despite this encouraging safety trend, one owner—Entergy—was responsible for three of the 10 near misses last year, and received 64 percent of the sanctions issued by the NRC for violating safety regulations. Because the NRC analyzes each near miss separately—and not holistically—it’s difficult to determine whether the issue lies with Entergy’s management team, or with systemic issues affecting the fleet as a whole”.

Pilgrim Nuclear Power StationEntergy Nuclear Operations | Plymouth, Massachusetts

- In probably the most serious nuclear power safety incident of 2015, pressure release valves malfunctioned during a winter storm-induced loss of power. The NRC issued eight separate safety violations for the near miss, citing poor worker performance and inadequate planning procedures.

Indian Point Power StationEntergy Nuclear Operations | Buchanan, New York

- In May, 2015, an electrical transformer exploded at Indian Point’s Unit 3 reactor, causing a small fire and triggering the fire protection system. Although the fire was extinguished, water pooled on the floor of the adjacent “switchgear” room, where electricity is transmitted to emergency systems. Had the water level exceeded five inches, the switchgears would have short-circuited, causing a station blackout.

River Bend Power StationEntergy Nuclear Operations | St. Francisville, Louisiana

- Following a series of unplanned shutdowns, the NRC found that River Bend’s reactor vessel operated outside its design limitations for nearly 20 years, and that

workers at the plant were using outdated and incorrect procedures to operate the system. Inaccurate training contributed to their poor performance.

Calvert Cliffs Power Station Constellation Energy | Lusby, Maryland

- Nuclear reactors are intended to shut down when they detect fluctuations in the electric grid. But when they shut down, their emergency generators are supposed to supply electricity to safety equipment—which the backup generators at Calvert Cliffs did not, following a reactor shutdown in April 2015.

Duane Arnold Power Station NextEra Energy | Palo, Iowa

- After re-applying a special coating to the inside of a critical water containment unit, workers noticed debris floating on the water's surface. Deficiencies in the coating itself were later blamed for corroding the unit, highlighting the increased chance of failure during the early stages of safety upgrades.

Fort Calhoun Power StationOmaha Public Power District | Fort Calhoun, Nebraska

- Following a routine refueling and the rebuilding of several critical makeup water valves, the reactor at Fort Calhoun attempted to restart. Although the rebuilt valves were less affected by the radiation that degraded the original parts, they were unexpectedly susceptible to the high-temperatures of an operating nuclear reactor, and failed within hours.

North Anna Power Station Virginia Electric & Power Company l Mineral, Virginia

- The NRC sent a special inspection team to North Anna following a security-related event on August 15, 2015. Due to a policy adopted after the events of September 11, 2001, the NRC no longer publicly discloses the causes and corrective actions for security-related problems.

Virgil C. Summer Power Station South Carolina Electric & Gas Company l Parr, South Carolina

- Workers boring holes in the concrete basement of Virgil C. Summer's Unit 2 reactor mistakenly cut through metal reinforcing bars embedded in the concrete and the containment vessel's metal shell. The workers had not been given a maximum drilling depth, and were found by the NRC to be insufficiently knowledgeable and improperly trained.

All of the information I've collected here involves the production, harnessing and use of nuclear energy and the radiation it produces. Most people know the basic properties of radiation, but here is a quick review.

RADIATION

Wikipedia describes the 4 kinds of radiation like this, "In physics, radiation is the emission or transmission of energy in the form of waves or particles through space or

through a material medium. This includes:electromagnetic radiation, such as radio waves, visible light, x-rays, and gamma radiation (γ) particle radiation, such as alpha radiation (α), beta radiation (β), and neutron radiation (particles of non-zero rest energy)acoustic radiation, such as ultrasound, sound, and seismic waves (dependent on a physical transmission medium)gravitational radiation, radiation that takes the form of gravitational waves, or ripples in the curvature of spacetime”.“Radiation is often categorized as either ionizing or non-ionizing depending on the energy of the radiated particles. Ionizing radiation carries more than 10 eV, which is enough to ionize atoms and molecules, and break chemical bonds. This is an important distinction due to the large difference in harmfulness to living organisms. A common source of ionizing radiation is radioactive materials that emit α, β, or γ radiation, consisting of helium nuclei, electrons or positrons, and photons, respectively. Other sources include X-rays from medical radiography examinations and muons, mesons, positrons, neutrons and other particles that constitute the secondary cosmic rays that are produced after primary cosmic rays interact with Earth's atmosphere”.

“Gamma rays, X-rays and the higher energy range of ultraviolet light constitute the ionizing part of the electromagnetic spectrum. The lower-energy, longer-wavelength part of the spectrum including visible light, infrared light, microwaves, and radio waves is non-ionizing; its main effect when interacting with tissue is heating. This type of radiation only damages cells if the intensity is high enough to cause excessive heating. Ultraviolet radiation has some features of both ionizing and non-ionizing radiation. While the part of the ultraviolet spectrum that penetrates the Earth's atmosphere is non-ionizing, this

radiation does far more damage to many molecules in biological systems than can be accounted for by heating effects, sunburn being a well-known example. These properties derive from ultraviolet's power to alter chemical bonds, even without having quite enough energy to ionize atoms. ”

BACKGROUND RADIATION

Wikipedia defines background radiation this way, “Background radiation is the ubiquitous ionizing radiation present in the environment. Background radiation originates from a variety of sources, both natural and artificial. Sources include cosmic radiation, naturally occurring radioactive materials such as radon, and fallout from nuclear weapons testing and nuclear accidents”.

“The term background radiation can have different meanings, depending whether we are considering an ambient radiation dose, or we wish to differentiate between an incidental background and a particular source of radiation of concern”.

“For example, in considering radiation safety , background radiation is defined by the International Atomic Energy Agency as "Dose or dose rate (or an observed measure related to the dose or dose rate) attributable to all sources other than the one(s) specified. So a distinction is made between sources of dose which are incidentally in a location, which are defined here as being "background", and the dose due to a specified

source. This is important where radiation measurements are taken of a specified radiation source, and the incidental background may affect this measurement. An example would be detection of radioactive contamination in a gamma ray background, which could increase the total reading above that expected from the contamination alone".

There are natural sources of background radiation and anthropogenic (man made) sources that are ubiquitous in the environment. Man made sources of radionuclides in the environment are nuclear weapons use and tests, accidents like Chernobyl and Fukushima and the operation of nuclear reactors and radiological medicine The variability of anthropogenic sources of radiation and radioactivity relates directly to population distribution and the level of technology found in different parts of the world. How radiation and radioactivity are distributed locally is determined by wind, humidity and rain patterns.There is more radiation in the atmosphere at high altitudes than there is at sea level, for example, one is exposed to 31 millirem per year in Los Angeles while one would be exposed to 12,200 millirem per year if you were in a spy plane flying at 80,000 feet.

There are also several dozen radionuclides that are found in the earth and they vary from locality to locality, these are called primordials. Billion of years ago the earth had much higher background radiation from these terrestrial elements than exists now, because they have decayed. over time.These primordials can have a half life, (the time it takes for a specific radioisotope to loose half of its original value), as long as several

billion years or as short as a few microseconds.The level of background radiation has increased since the beginning of the Atomic Age due to anthropogenic sources.

The Partial Nuclear Test Ban Treaty signed in 1963, stopped the atmospheric testing of weapons, but the environmental damage remains with us.The effect that these radioisotopes have on our health is the subject of much discussion and disagreement that will be covered in the coming pages.The dose rate and the effects of exposure to low level ionizing radiation is not contested by mainstream medicine (with the exception of some in nuclear medicine) but is by the nuclear industry and it's advocates.

Hyperbole and name calling is common by some on both sides of the issue and emotions run high because so much is on the line with nuclear energy, but the science is overwhelmingly clear. By following the facts it is easy to see industry propaganda for what it is, junk science.

DOSIMETRY

Wikipedia has an extensive breakdown on the specifics of how different dose criteria are used determine the many ways radiation can affect the body. Here are some basics,"Whilst Dosimetry in its original sense is the measurement of the absorbed dose delivered by ionizing radiation, the term is better known as a scientific sub-specialty in

the fields of health physics and medical physics, where it is the calculation and assessment of the radiation dose received by the human body".

"Internal dosimetry due to the ingestion or inhalation of radioactive materials relies on a variety of physiological or imaging techniques. External dosimetry, due to irradiation from an external source is based on measurements with a dosimeter, or inferred from other radiological protection instruments".

"Dosimetry is used extensively for radiation protection and is routinely applied to occupational radiation workers, where irradiation is expected, but regulatory levels must not be exceeded. It is also used where radiation is unexpected, such as in the aftermath of the Three Mile Island, Chernobyl or Fukushima radiological release incidents, where the public irradiation is measured and calculated from a variety of indicators such as ambient measurements of radiation and radioactive contamination".

"Other significant areas are medical dosimetry, where the required treatment absorbed dose and any collateral absorbed dose is monitored, and in environmental dosimetry, such as radon monitoring in buildings."

EPIDEMIOLOGY

Wikipedia gives a snapshot of this very complex topic by stating, “Epidemiology is the study and analysis of the patterns, causes, and effects of health and disease conditions in defined populations. It is the cornerstone of public health, and shapes policy decisions and evidence-based practice by identifying risk factors for disease and targets for preventive healthcare. Epidemiologists help with study design, collection, and statistical analysis of data, amend interpretation and dissemination of results (including peer review and occasional systematic review). Epidemiology has helped develop methodology used in clinical research, public health studies, and, to a lesser extent, basic research in the biological sciences”.]

“Major areas of epidemiological study include disease etiology, transmission, outbreak investigation, disease surveillance, forensic epidemiology and screening, biomonitoring, and comparisons of treatment effects such as in clinical trials. Epidemiologists rely on other scientific disciplines like biology to better understand disease processes, statistics to make efficient use of the data and draw appropriate conclusions, social sciences to better understand proximate and distal causes, and engineering for exposure assessment”.

THE LINEAR NO THRESHOLD MODEL

The LNT model assumes a direct and proportional relationship between radiation exposure and cancer risk with all radiation doses.

The National Academy Of Science describes and endorses the LNT as follows,“A preponderance of scientific evidence shows that even low doses of ionizing radiation, such as gamma rays and X-rays, are likely to pose some risk of adverse health effects, says a new report from the National Academies' National Research Council”.

“The report's focus is low-dose, low-LET -- "linear energy transfer" -- ionizing radiation that is energetic enough to break biomolecular bonds. In living organisms, such radiation can cause DNA damage that eventually leads to cancers. However, more research is needed to determine whether low doses of radiation may also cause other health problems, such as heart disease and stroke, which are now seen with high doses of low-LET radiation”.

“The committee's report develops the most up-to-date and comprehensive risk estimates for cancer and other health effects from exposure to low-level ionizing radiation. In general, the report supports previously reported risk estimates for solid cancer and leukemia, but the availability of new and more extensive data have strengthened confidence in these estimates”.

“Specifically, the committee's thorough review of available biological and biophysical data supports a "linear, no-threshold" (LNT) risk model, which says that the smallest dose of low-level ionizing radiation has the potential to cause an increase in health risks to humans. In the past, some researchers have argued that the LNT model exaggerates adverse health effects, while others have said that it underestimates the harm. The preponderance of evidence supports the LNT model, this new report says”.

"The scientific research base shows that there is no threshold of exposure below which low levels of ionizing radiation can be demonstrated to be harmless or beneficial," said committee chair Richard R. Monson, associate dean for professional education and professor of epidemiology, Harvard School of Public Health, Boston. "The health risks – particularly the development of solid cancers in organs – rise proportionally with exposure. At low doses of radiation, the risk of inducing solid cancers is very small. As the overall lifetime exposure increases, so does the risk." The report is the seventh in a series on the biological effects of ionizing radiation”.

In the blog Mining Awarness+, I found the following critical information on LNT,“The following is from a November 2012 document by Oak Ridge Institute for Science and Education (ORISE), associated with Oak Ridge National Lab: “The Medical Aspects of Radiation Incidents’ Revised: 11/14/2012, The Radiation Emergency Assistance Center/ Training Site”Impacts Of Ionizing Radiation, from p. 44: ”Within minutes to hours after exposure to ionizing radiation, proteins are modified and activated, and large-scale changes occur in the gene expression profiles involving a broad variety of cell-process

pathways. There are presently approximately 90 known proteins that show changes in expression or undergo post-translational modifications after exposure to ionizing radiation…."

."Before coming to this conclusion, the committee reviewed articles arguing that a threshold or decrease in effect does exist at low doses. Those reports claimed that at very low doses, ionizing radiation does not harm human health or may even be beneficial. The reports were found either to be based on ecologic studies or to cite findings not representative of the overall body of data. Ecologic studies assess broad regional associations, and in some cases, such studies have suggested that the incidence of cancer is much higher or lower than the numbers observed with more precise epidemiological studies. When the complete body of research on this question is considered, a consensus view emerges. This view says that the health risks of ionizing radiation, although small at low doses, are a function of dose. Both the epidemiological data and the biological data are consistent with a linear model at doses where associations can be measured".

Internationally LNT is accepted as the gold standard on radiation dosing and it is accepted by most medical associations and doctors.In 2015 the US Environmental Protection Agency ruled that it rejected the hormesis model and that it would continue to support the LNT model and all of its environmental standards would recognize that there is no safe level of radiation exposure

THE HORMESIS MODEL

Wikipedia had this to say about the matter,"Radiation hormesis (also called radiation homeostasis) is the hypothesis that low doses of ionizing radiation (within the region of and just above natural background levels) are beneficial, stimulating the activation of repair mechanisms that protect against disease, that are not activated in absence of ionizing radiation. The reserve repair mechanisms are hypothesized to be sufficiently effective when stimulated as to not only cancel the detrimental effects of ionizing radiation but also inhibit disease not related to radiation exposure (see hormesis).This counter-intuitive hypothesis has captured the attention of scientists and public alike in recent years".

"While the effects of high and acute doses of ionising radiation are easily observed and understood in humans (e.g. Japanese Atomic Bomb survivors), the effects of low-level radiation are very difficult to observe and highly controversial. This is because the baseline cancer rate is already very high and the risk of developing cancer fluctuates 40% because of individual life style and environmental effects, obscuring the subtle effects of low-level radiation. An acute dose of 100 mSv may increase cancer risk by ~0.8%. However, children are particularly sensitive to radioactivity, with childhood leukemias and other cancers increasing even within natural and man-made background radiation levels (under 4 mSv cumulative with 1 mSv being an average annual dose from terrestrial and cosmic radiation excluding radon which primarily doses the lung). There is also indication that exposures around this dose level will cause negative

subclinical health impacts to neural development. Students born in regions of Sweden with higher Chernobyl fallout performed worse in secondary school, particularly in math. “Damage is accentuated within families (i.e., siblings comparison) and among children born to parents with low education..." who often don't have the resources to overcome this additional health challenge”.

“Hormesis remains largely unknown to the public. Any policy change ought to consider hormesis first as a public health issue (versus an industrial regulatory issue). This would include the assessment of the public concern regarding exposure to small toxic doses. In addition, impact of hormesis policy change upon the management of industrial risks should be studied”.

“Government and regulatory bodies disagree on the existence of radiation hormesis and research points to the "severe problems and limitations" with the use of hormesis in general as the "principal dose-response default assumption in a risk assessment process charged with ensuring public health protection."

“Quoting results from a literature database research, the Académie des Sciences — Académie nationale de Médecine (French Academy of Sciences — National Academy of Medicine) stated in their 2005 report concerning the effects of low-level radiation that many laboratory studies have observed radiation hormesis. However, they cautioned that it is not yet known if radiation hormesis occurs outside the laboratory, or in humans”.

“Reports by the United States National Research Council and the National Council on Radiation Protection and Measurements and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) argue that there is no evidence for hormesis in humans and in the case of the National Research Council, that hormesis is outright rejected as a possibility despite population and scientific evidence. Therefore, estimating Linear no-threshold model (LNT) continues to be the model generally used by regulatory agencies for human radiation exposure”.

THE BIG DEBATE

Why is there such a big difference between what the studies the NRC, IAEA, ICRP the UN and the WHO have done on the death and health problems caused by Chernobyl and Fukushima and those of independent organizations? The differences are not trivial, and cannot be described as a matter of a professional difference of opinion. Hundreds of studies have been done on this and yet no consensus has been reached between these two opposing camps and to find out why the methodologies being used must be understood.

On the topic of dosing the NRC has recently petitioned to change from the LNT model ,to Hormesis; and the IAEA and the ICRP the WHO support LNT on paper, but in reality use the hormetic model in their studies, and to establish safety policy. Epidemiological studies used by these agencies employ criteria that favor the nuclear

industry by using methods that focus the studies on a limited data base which lessens the observable effects that can be reported, which will be explained later in the report. The propaganda the industry produces is filled with manipulated information, and ridiculous statements like" All the radiation releases in US nuclear accidents amount to less than what you would receive from getting an X-ray " or my personal favorite comes from Japan, right after Fukushima, Mr Yamashita who is, "One of the main advisors to the Japanese government on Fukushima announced: "If you smile, the radiation will not affect you.If you do not smile, the radiation will affect you.This theory has been proven by experiments on animals". If you believe lines like that, well, then I have a bridge to sell you. The methodologies used by industry in dosimetry and epidemiology are just ridiculous, dishonest and dangerous. The industry wants you to believe that the biggest threat that to public health is an irrational fear of radiation, or Radiophobia. There does not seem to be anything that pro-nuclear advocates will not do or say to make sure the industry keeps making money, regardless of the harm it does.

When the NRC petitioned the government to change from LNT to Hormesis they really had no other choice, because the ambient radiation in US nuclear power plants had increased to such a high level that they could not adhere to LNT anymore and still maintain that they are safe places to work. The exposure to radiation of workers is described by the NRC as an "acceptable amount" (acceptable to who?), and that amount has inevitably risen over time as the plants grow more radioactive year after year.

The Voice of Orange County added to the conversation by reporting that while the NRC was petitioning for using the hormetic model, they were also engaged in shutting down research on the effects of radiation, they wrote “Do the regular radioactive emissions from nuclear power plants (NPP) increase the risk of cancer? No one knows for sure whether living near a NPP can cause cancer, but on Sept. 8 the Nuclear Regulatory Commission (NRC) terminated a study designed to find out. It would have been carried out by the prestigious National Academy of Sciences which spent 5 years planning the study”.

“The NRC also said that it already knows the answer: low-level radiation coming from NPP is harmless. It continues to cite a now thoroughly discredited study by the National Cancer Institute (NCI) which examined this issue a quarter of a century ago and failed to find cancer streaks. The nuclear industry prefers this study because it likes the results.We now know that the NCI study failed because it studied only cancer deaths, not incidence, and it studied only where people died, not where they lived or worked. It also averaged people living very near a NPP with those who lived far away. Also worrisome are recent studies in Europe which discovered that children who live near a NPP double their risk of cancer. The NAS is well-aware of this and designed part of the study to focus on children”.

“Instead of treating cancer as a scientific issue, the nuclear industry treats it as a PR challenge. Frequent attempts are made to trivialize the dangers of radiation. Often this involves the Radiation- Is-Everywhere tactic complete with ludicrous examples (“It’s just

like eating a banana," or "It's just like flying to Denver"). They like to show how little radiation is in an average X-ray but they are careful not to mention that radioactive exposure is cumulative: every dose adds. Since Edison has been ejecting radiation into the atmosphere and ocean regularly for almost a half-century, the total accumulation of even low-level radiation could be a serious health hazard".

"The idea that there are thresholds below which radiation is harmless was put to rest by the 2007 report of the National Research Council entitled Biological Effects of Ionizing Radiation (better known as the BEIR VII Report). It concluded that there is a linear relationship between radiation dose and cancer-causing cell damage and that there is no such thing as a threshold below which radiation is harmless. This Linear No Threshold model is now settled science".

By accepting hormesis, the NRC will then increase the amount of radiation workers can be exposed to, it will also increase the exposure the public can get. Remember, hormesis advocates assert that exposure to low level radiation is not harmful and that it is even beneficial, but there is little support for this outside nuclear related industries. Nuclear state governments and industry are applying tremendous pressure on LNT supporters to changeover and use hormesis, but there is great resistance to do that. There is no practical use for hormesis, for instance, if someone is going to get radiation therapy for cancer does the doctor first expose the patient to a preemptive small dose to prepare them for their therapy? Absolutely not! Radiation contamination is cumulative, and one exposure is added upon the previous one and the one before that.The only

conceivable reason to support hormesis is to allow for an ever increasing level of radiation exposure in nuclear related industries. In no way am I suggesting that anyone not get treated for a disease with radiation therapy, but to do it if necessary, understanding the LNT model.

The effects of high radiation exposure is well understood and there is little disagreement about its effects. It is the effect of exposure to low level ionizing radiation that has generated such a rancorous debate. It is low level ionizing radiation that most people are exposed to in nuclear facilities and from events like Chernobyl and Fukushima. Any first responders who were exposed to high radiation doses fighting the fires and involved in those early efforts to remediate the disasters are probably very sick or dead by now. It is the fate of the victims of low level radiation that needs to be understood.

THE NUMBERS / WHAT REALLY HAPPENED

According to Wikipedia,"During mid-1986 the official Soviet death toll rose from 2 to 31, a figure that has often been repeated. Following the disaster itself, the USSR organized an effort to stabilize and shore up the reactor area, still awash in radiation, using the efforts of 600,000 "liquidators" recruited from all over the USSR. Some organizations claim that deaths as a result of the immediate aftermath and the cleanup operation may number at least 6,000, but that exceeds the number of workers believed, by the National Committee for Radiation Protection of the Ukrainian Population, to have died

from all causes (including, for example, old age and traffic accidents). The UNSCEAR report cites only evidence for thyroid cancers among children and teens (adults are quite resistant to iodine-131 poisoning) and some small amount of leukemia and eye cataracts among the most irradiated of the workers; no evidence for hard cancers has been found, despite waiting beyond the elapse of the usual ten year latency period."

Slate had this to say about the disaster nearly 20 years later, "Given all the uncertainty, current estimates of the number of deaths caused by Chernobyl differ widely. In 2005, the United Nations predicted 4,000 deaths. Three years later, its committee on atomic radiation abandoned the linear no-threshold model for predicting Chernobyl cancer deaths from doses below the lifetime equivalent of four abdominal CAT scans because of "unacceptable uncertainties."

In 2014 The Ecologist wrote an excellent piece on the controversy,saying this about the difficulty finding agreement, "Nor would anyone expect them to because of the data gaps and methodological problems mentioned above, and because the main part of the problem concerns the exposure of millions of people to low doses of radiation from Chernobyl fallout".

"For a few fringe scientists and nuclear industry insiders and apologists, that's the end of the matter - the statistical evidence is lacking and thus the death toll from Chernobyl was just 50".

“If they were being honest, they would note an additional, unknown death toll from cancer and from other radiation-linked diseases including cardiovascular disease”.

“But for those of us who prefer mainstream science, we can still arrive at a scientifically defensible estimate of the Chernobyl death toll by using estimates of the total radiation exposure, and multiplying by an appropriate risk estimate”.

“The International Atomic Energy Agency estimates a total collective dose of 600,000 person-Sieverts over 50 years from Chernobyl fallout. Applying the LNT risk estimate of 0.10 fatal cancers per Sievert gives an estimate of 60,000 deaths”.

“On the other hand, LNT may underestimate risks. The BEIR report (published by The National Academy of Science)states that "combined analyses are compatible with a range of possibilities, from a reduction of risk at low doses to risks twice those upon which current radiation protection recommendations are based."

“So the true death toll could be lower or higher than the LNT-derived estimate of 60,000 deaths. A number of studies apply that basic method - based on collective radiation doses and risk estimates - and come up with estimates of the Chernobyl cancer death toll varying from 9,000 (in the most contaminated parts of the former Soviet Union) to 93,000 deaths (across Europe)”.

“UN reports from the IAEA and WHO in 2005-06 estimated up to 4,000 eventual deaths among the higher-exposed Chernobyl populations (emergency workers from 1986-1987, evacuees and residents of the most contaminated areas) and an additional 5,000 deaths among populations exposed to lower doses in Belarus, the Russian Federation and Ukraine”.

“The estimated death toll rises further when populations beyond those three countries are included. For example, a study by Cardis et al reported in the International Journal of Cancer estimates 16,000 deaths. Dr Elisabeth Cardis, head of the Radiation Group at the World Health Organization's International Agency for Research on Cancer, said:"By 2065 (i.e. in the eighty years following the accident), predictions based on these models indicate that about 16,000 cases of thyroid cancer and 25,000 cases of other cancers may be expected due to radiation from the accident and that about 16,000 deaths from these cancers may occur."About two-thirds of the thyroid cancer cases and at least one half of the other cancers are expected to occur in Belarus, Ukraine and the most contaminated territories of the Russian Federation."

UK radiation scientists Dr Ian Fairlie and Dr David Sumner estimate 30,000 to 60,000 deaths. Dr Fairlie notes that statements by UNSCEAR indicate that it believes the whole body collective dose across Europe from Chernobyl was 320,000 to 480,000 person-Sieverts”.

“From this an estimate of 32,000 to 48,000 fatal cancers can be deduced (using the LNT risk estimate of 0.10). According to physicist Dr. Lisbeth Gronlund:"53,000 and 27,000 are reasonable estimates of the number of excess cancers and cancer deaths that will be attributable to the accident, excluding thyroid cancers. (The 95% confidence levels are 27,000 to 108,000 cancers and 12,000 to 57,000 deaths.)”

"In addition, as of 2005, some 6,000 thyroid cancers and 15 thyroid cancer deaths have been attributed to Chernobyl. That number will grow with time.”

"Much lower numbers of cancers and deaths are often cited, but these are misleading because they only apply to those populations with the highest radiation exposures, and don't take into account the larger numbers of people who were exposed to less radiation."

Notice how the data from the UN and IAEA and the ICRP have considerably lower casualties than the independent studies that have been done. The highly manipulated criteria used in their studies show how those agencies “cooked the books”, and made the casualities seem much lower than they really were. These agencies claim that there was no risk from low level ionizing radiation for the 7,000,000 people all over Europe who were exposed to it, yet sheep in England and reindeer in Lapland were ordered to be slaughtered by authorities because they were irradiated.

Rosalie Bertell, Ph.D authored “Limitations of the ICRP for Worker and Public Protection from Ionizing Radiation”, which I recommend to anyone who wants to get a better understanding of the subject, writes” The mathematical and biological elegance of the International Commission on Radiological Protection (ICRP) intellectual structure, which has the obvious mark of the physicist, should not be allowed to blind us to its inability to address the full spectrum of worker and public health problems caused by the routine and/or accidental exposures to ionizing radiation inseparable from the operations in the nuclear fuel cycle. I am referring to the very narrow administrative decisions which limit the focus of ICRP concern, and make possible the simplifications designed for administrating its recommendations. For example, the recognized biological endpoints deemed to be of concern for regulatory purposes are limited to: radiation induced fatal cancers and serious genetic diseases in live born offspring”.

“There are many administrative decisions embedded into the elaborate (artificial) methodology for calculating effective whole body dose and for calculating the expected number of radiation induced fatal cancers. The strengths of the ICRP approach rest primarily on its ability to quickly convert a multidimensional problem, that is, a mixture of radionuclides, having a variety of energies and types of emissions, multiple pathways to humans, and a variety of target human organs, into a linear system amenable to management decisions. This is a recognized mathematical achievement. However, in risk assessments, long term chronic exposure, the aftermath of a disaster, or in worker compensation hearings, these same techniques cloud reality and work effectively

against justice for the victims. The elegant mathematics must not be allowed to cover up the injustices".

"In terms of its own claims, ICRP does not offer recommendations of exposure limits based on worker and public health criteria. Rather, it offers its own risk/benefit trade-off suggestion, containing value judgements with respect to the "acceptability" of risk estimates, and decisions as to what is "acceptable" to the individual and to society, for what it sees as the "benefits" of the activities. Since the thirteen members of the Main Committee of ICRP, the decision makers, are either users of ionizing radiation in their employment, or are government regulators, primarily from countries with nuclear weapon programs, the vested interests are clear. In the entire history of the radiologist association formed in 1928, and ICRP, formed when the physicists were added in 1952, this organization has never taken a public stand on behalf of the public health. It never even protested atmospheric nuclear weapon testing, the deliberate exposure of atomic soldiers, the lack of ventilation in uranium mines, or unnecessary uses of medical X-ray".

"This paper will examine the credibility of the Atomic Bomb Studies as a basis for the radiation protection standards, the adequacy of the biological mechanisms and endpoints chosen for standard setting, the adequacy of research on other possible biological mechanisms and endpoints, and the decisions made by ICRP on the "acceptability of the detriment" to the individual and to society, relative to comparable decisions made by health professionals for chemical hazards".

“In the early 1950's, when it was generally recognized that using the erythema dose, the dose which actually burnt the skin, was not adequate as a guide to radiation protection, many different biological endpoints were proposed as guides to regulatory standards: reproductive problems, tumors, congenital malformations, cataracts, blood disorders. Other possible biological endpoints were added later: obesity, hormonal disruptions, auto-immune diseases, developmental disorders, mental and physical retardation. ICRP decided that people should only be concerned about fatal cancers, and the only biological mechanism to be considered would be direct damage to DNA. Most of the other endpoints are dismissed as transient, not consequential, not damaging of the gene pool, or not fatal. This is an administrative, not a scientific decision, with which we may well wish to disagree. Even with respect to fatal cancers, those which were promoted or accelerated by the radiation exposure are not counted, because they are not considered to be "radiation induced”

The IAEA uses similar sleight of hand to minimize the publics perception of the damages created by nuclear accidents,:

- if radiation-caused cancer is not fatal, it is not counted in the IAEA’s figures
- If a cancer is initiated by another carcinogen, but accelerated or promoted by exposure to radiation, it is not counted
- If an auto-immune disease or any non-cancerous disease is caused by radiation, it is not counted
- Radiation-damaged embryos or fetuses which result in a miscarriage or stillbirth do not count

- A congenitally blind, deaf of malformed child whose illnesses are radiation-related are not included in the figures because this is not genetic damage, but rather teratogenic, and will not be passed on later to the child's offspring.
- Causing the genetic predisposition to breast cancer or heart disease does not count since it is not a "serious genetic disease" in the Mendelian sense.
- Even if radiation causes a fatal cancer or serious genetic disease in a live born infant, it is discounted if the estimated radiation dose is below100mSv (mSv is the amount of radiation one would get from 100 X-rays)
- Even if radiation causes a lung cancer, it does not count if the person smokes.
- By using whole body averaging the radiation that is present in one organ is recalculated and spread out over the entire body, that way the arbitrary cut off point of 100 mSv is never reached, and any dose less than 100mSv is not counted. The IAEA professes to support the LNT model, but in reality, they discount all exposure under 100 mSv.

Other artificial criteria include using the dose concentrations in their studies that men can tolerate for women, children and the unborn, when it is clearly understood that women tolerate less radiation than men do. Children and the unborn are particularly sensitive to low level ionizing radiation and if exposed to the dose that an adult male could tolerate it would cause serious damage. By using this calculus the overall number of expected cancers drops dramatically.

Studies are statistically calculated to end at 50 years, despite scientists knowing the fact

that it only covers 80% of the people expected to be affected by low level radiation exposure, and that 20% of the “dose commitment” is still yet to come.

Unrealistically low ‘fatal-cancer yields” are used when compared to established norms. Meaning that the projections of fatalities from radiation exposure are lower than estimates that would normally be used by epidemiologists .By correcting the “fatal-cancer yield” the norm, the number of fatalities would rise by a factor of three.

The use of overly large survey areas to map radiation makes the average dose appear smaller than it actually is. Just like whole body averaging appears to reduce the dose concentration in the human body, spreading the radiation out over a very large area misleadingly appears to lessen the contamination by statistically diluting it. Usually a large circle is drawn around the site of a meltdown and people are led to believe that the radiation is evenly spread throughout the circle. But radiation does not spread that way, it doesn’t emanate out from the center of the circle like ripples on a pond after a stone is thrown in. Prevailing winds can blow the radiation in a specific direction and rain can wash it down from the atmosphere. It can be very concentrated in one part of the circle and lower in another part.

The pro nuclear agencies often base their findings on the effects of only the atmospheric low level ionizing radiation and omit the far more damaging effects of internalized radiation which has a much longer half life.

Wikipedia described the consequences of Fukushima the way the Japanese government and nuclear advocates had decided upon, namely; “The Fukushima Daiichi nuclear disaster has no confirmed casualties from radiation exposure, though six workers died due to various reasons, including cardiovascular disease, during the containment efforts or work to stabilize the Earthquake and Tsunami damage to the site.

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), released a report on the Fukushima accident April 2, 2014. It stated that the scientists have found no evidence to support the idea that the nuclear meltdown in Japan in 2011 will lead to an increase in cancer rates or birth defects. None of the workers at the plant have died from acute radiation poisoning. In contrast, indirect mortality due to forced evacuation from the nuclear contamination area is said to count more than 1600 people.

Understanding how these pro-nuclear governments and agencies contrive and manipulate the data it is easy to understand how the differences in the casualty and death projections are calculated. Statistics are being used to hide the grim reality of radiation contamination despite the horrific consequences to the victims of low level ionizing radiation. Contrary to the scenario that the pro nuclear advocates asserted about the repercussions of the Fukushima meltdown, reports are beginning to reveal the truth.

CBS News reported on June 7, 2016 on a young woman who has come forward to speak about how she has been affected, “ She suffers from the only disease that the medical community, including the United Nations Scientific Committee on the Effects of Atomic Radiation, has acknowledged is clearly related to the radioactive iodine that spewed into the surrounding areas after the only nuclear disaster worse than Fukushima's, the 1986 explosion and fire at Chernobyl, Ukraine”.

“Though international reviews of Fukushima have predicted that cancer rates will not rise as a result of the meltdowns there, some researchers believe the prefecture's high thyroid-cancer rate is related to the accident”.

“The government has ordered medical testing of the 380,000 people who were 18 years or under and in Fukushima prefecture at the time of the March 2011 tsunami and quake that sank three reactors into meltdowns. About 38 percent have yet to be screened, and the number is a whopping 75 percent for those who are now between the ages of 18 and 21”.

Another important area of research is on how radiation affects the environment. Many have claimed that wildlife is thriving in the highly-radioactive Chernobyl Exclusion Zone.

To find out if this is true,” Washington’s Blog spoke with one of the world’s leading experts on the effects of radiation on living organisms: Dr. Timothy Mousseau”.

“Dr. Mousseau is former Program Director at the National Science Foundation (in Population Biology), Panelist for the National Academy of Sciences’ panels on Analysis of Cancer Risks in Populations Near Nuclear Facilities and GAO Panel on Health and Environmental Effects from Tritium Leaks at Nuclear Power Plants, and a biology professor – and former Dean of the Graduate School, and Chair of the Graduate Program in Ecology – at the University of South Carolina”.

Indeed, Mousseau found – in studies of plants, insects and mammals – that:

- Most organisms studied show significantly increased rates of genetic damage in direct proportion to the level of exposure to radioactive contaminants.
- Many organisms show increased rates of deformities and developmental abnormalities in direct proportion to contamination levels
- Many organisms show reduced fertility rates
- Many organisms show reduced life spans
- Many organisms show reduced population sizes
- Biodiversity is significantly decreased, many species locally extinct
- Mutations are passed from one generation to the next, and show signs of accumulating over time
- Mutations are migrating out of affected areas into populations that are not exposed (i.e. population bystander effects)

Dr Helen Caldicott, founder of Physicians for Social Responsibility wrote a response to comments from a journalist who minimized the effects of the radiation contamination after nuclear disasters for The Guardian newspaper in 2011, in which she replied,“1) Mr Monbiot, who is a journalist not a scientist, appears unaware of the difference between external and internal radiation.”

“Let me educate him.”

“The former is what populations were exposed to when the atomic bombs were detonated over Hiroshima and Nagasaki in 1945; their profound and on-going medical effects are well documented.”

“Internal radiation, on the other hand, emanates from radioactive elements which enter the body by inhalation, ingestion, or skin absorption. Hazardous radionuclides such as iodine-131, caesium 137, and other isotopes currently being released in the sea and air around Fukushima bio-concentrate at each step of various food chains (for example into algae, crustaceans, small fish, bigger fish, then humans; or soil, grass, cow's meat and milk, then humans). After they enter the body, these elements, called internal emitters, migrate to specific organs such as the thyroid, liver, bone, and brain, where they continuously irradiate small volumes of cells with high doses of alpha, beta and/or gamma radiation, and over many years, can induce uncontrolled cell replication, that is, cancer. Further, many of the nuclides remain radioactive in the environment for

generations, and ultimately will cause increased incidences of cancer and genetic diseases over time."

"The grave effects of internal emitters are of the most profound concern at Fukushima. It is inaccurate and misleading to use the term "acceptable levels of external radiation" in assessing internal radiation exposures. To do so, as Monbiot has done, is to propagate inaccuracies and to mislead the public worldwide (not to mention other journalists) who are seeking the truth about radiation's hazards."

"2) Nuclear industry proponents often assert that low doses of radiation (eg below 100mSV) produce no ill effects and are therefore safe. But , as the US National Academy of Sciences BEIR VII report has concluded, no dose of radiation is safe, however small, including background radiation; exposure is cumulative and adds to an individual's risk of developing cancer."

"3) Now let's turn to Chernobyl. Various seemingly reputable groups have issued differing reports on the morbidity and mortalities resulting from the 1986 radiation catastrophe. The World Health Organisation (WHO) in 2005 issued a report attributing only 43 human deaths directly to the Chernobyl disaster and estimating an additional 4,000 fatal cancers. In contrast, the 2009 report, "Chernobyl: Consequences of the Catastrophe for People and the Environment", published by the New York Academy of Sciences, comes to a very different conclusion. The three scientist authors – Alexey V Yablokov, Vassily B. Nesterenko, and Alexey V Nesterenko – provide in its pages a

translated synthesis and compilation of hundreds of scientific articles on the effects of the Chernobyl disaster that have appeared in Slavic language publications over the past 20 years. They estimate the number of deaths attributable to the Chernobyl meltdown at about 980,000."

"Monbiot dismisses the report as worthless, but to do so – to ignore and denigrate an entire body of literature, collectively hundreds of studies that provide evidence of large and significant impacts on human health and the environment – is arrogant and irresponsible. Scientists can and should argue over such things, for example, as confidence intervals around individual estimates (which signal the reliability of estimates), but to consign out of hand the entire report into a metaphorical dustbin is shameful."

"Further, as Prof Dimitro Godzinsky, of the Ukranian National Academy of Sciences, states in his introduction to the report: "Against this background of such persuasive data some defenders of atomic energy look specious as they deny the obvious negative effects of radiation upon populations. In fact, their reactions include almost complete refusal to fund medical and biological studies, even liquidating government bodies that were in charge of the 'affairs of Chernobyl'. Under pressure from the nuclear lobby, officials have also diverted scientific personnel away from studying the problems caused by Chernobyl."

I return again to the work of Rosalie Bertell Ph.D., GNSH and the presentation she gave to the European Parliament on February 5, 1998 in which she described the horrific consequences suffered by the Rongelap People as a result an intentional exposure by the US government when they detonated a hydrogen bomb. She testified that, “On March 1, 1954, the US exploded a 15 Megaton hydrogen bomb at Bikini, and no one informed the Rongelap People, who lived downwind of the testing site. The Weather men stationed at Rongerik Atoll, slightly further away from Bikini than Rongelap, have publicly testified that they warned the military that the winds were traveling in the direction of inhabited Atolls. The US Navy ship, Gypsy, stationed just off the tip of Rongelap, was ordered to move away from the fallout area, but the Rongelap People were not warned”.

“About 72 hours after the heavy fallout on Rongelap, which polluted the land, drinking water and food, the Rongelap People were evacuated to the Kwajalein Atoll military base for medical examination and care. Many suffered sever radiation sickness, burns, epilation (hair loss), and depleted blood counts. They were forced to stay on Kwajalein for three years, until the US Military declared their Atoll again "safe for inhabitation". In moving this population of about 87 people back to the Rongelap Atoll, the US chose a population of relatives (Rongelapese who were not on the Atoll at the time of the fallout), matched for age and sex, to return to the Atoll as a "control" group for their research”.

“Money appropriated by the US Congress for the health of the Rongelap People was given to the Brookhaven National Laboratory for their research program. The Laboratory

purchased and outfitted a ship which they used in the summer to travel from Long Island, New York, via the Panama Canal, to the Marshall Island, which is about half way between Hawaii and Japan. Their medical program consisted primarily in conducting blood tests of the Rongelap "cases" and "controls", and examinations for thyroid nodules or other thyroid abnormalities. The medical "care" given to the Marshallese consisted of referral slips to local health professionals noting some medical problem which had been found during the examination and recommending medical diagnosis or treatment (often not available in the substandard facilities in the Trust Territory). If they found a thyroid abnormality, this Brookhaven team would recommend flying the Marshallese to the Cleveland Clinic in the US for a thyroidectomy, calling this preventive surgery (preventing thyroid cancer by removal of the thyroid gland)".

"In 1978, the US Department of Energy conducted an extensive investigation of the residual radiation on Rongelap Atoll. The Rongelap People after seeing the reports of their still contaminated Atoll and food web, evacuated themselves and began a struggle with the US Congress for cleanup and compensation. Finally in the late 1980's, the Congress agreed that the Island was still uninhabitable, although the experimental population had been living there from 1957 to May 1983, some 26 years. The nuclear scientists working for the US Department of Energy and the US Department of Defense claimed that the Rongelap People were irrationally fearful of the radiation and that their evacuation was uncalled for. Eventually the Congress not only commended the Rongelap People, but they ordered a cleanup of the Atoll to a level guaranteeing that exposures of the people would not exceed 0.25 mSv per year, well below the 5 mSv per

year standard used in the US. This same standard for cleanup was used by the US on the Johnston Atoll, another US nuclear test site in the Pacific”.

“The medical examination of the Rongelap People included many reports of "monster" and molar births. According to the People they actually began to photograph these abnormalities, which at first they had hidden thinking it was their own fault to have such abnormal pregnancies. When the photographs were shown the American researchers, the pictures were seized. They burned them in front of the people saying: "This is what we think of your evidence". We heard this story from many different people on the Atoll”.

“In a cross sectional study which we undertook in 1988 (Ref. 14), we included 297 children, 134 adult females and 113 adult males, randomly chosen from Rongalapese in the US DOE "exposed" category, i.e. in the actual fallout, "control" category, i.e. relocated on the contaminated Atoll with the exposed group in 1957, and "neither" of the above, and their children. We found the following proportions with serious chronic illness among adult Rongelapese born prior to the 1954 hydrogen bomb detonation”:

Category of Exposure	Males	Females
Exposed	88.5%	88.6%
Controls	63.6%	76.8%
Neither	55.6%	58.1%

“Serious congenital disease or malformation in living children (realizing that with the substandard medical facilities many were miscarried, stillbirths or infant deaths)”:

Category of Parental Exposure	For children 15 years or under in 1988 (born since 1973)
Exposed*	15.3% with serious congenital diseases of malformations
Controls	21.% with serious congenital diseases or malformations
Neither	8.3% with serious congenital diseases or malformations

”*This category had a higher rate of miscarriages and still births. There were 59 (1.6 grandchild per adult) offspring in this category, while the other two categories included 81 (4.1 grandchild per adult) and 84 (3.1 grandchild per adult) children respectively”.

Category of Parental Exposure	For those 16 to 34 years old in 1988 (born between 1954 and 1972)
Exposed**	No children
Controls	2.1% with serious congenital diseases or malformations
Neither	2.0% with serious congenital diseases of malformations

“**There were only 13 live children (0.36 per adult) in this survivor group, whereas there were about 50 (48, 2.4 per adult and 51, 1.9 per adult) respectively representing the other two exposure categories”.

“In the survivor population, those over 35 years of age in 1988, 2.4% were found to have congenital diseases or malformations”.

“Using the three age groups as roughly representing three generations of Rongelapese -- those exposed, their offspring and the third generation -- we find some startling changes in health parameters”:

THYROID RELATED PROBLEMS:

Category	Exposed	Control	Neither
Alive in 1954	58.3%	5.0%	18.5%
First Generation Offspring		8.3%	11.8%
Second Generation Offspring	1.7%		1.2%

”It seems that we should have expected the thyroid abnormalities at Chernobyl! However, the world medical community was completely unprepared for the crisis since this Rongelap data was not widely known by the non-US Government scientists”.

Tumors and Cysts

Category	Exposed	Control	Neither
Alive in 1954	25.0%	5.0%	7.4%
First Generation Offspring	15.4	4.2%	7.8%
Second Generation Offspring		2.5%	1.2%

HEART PROBLEMS:

Category	Exposed	Control	Neither
Alive in 1954	22.2%	15.0%	7.4%
First Generation Offspring	7.7%	6.3%	3.9%
Second Generation Offspring	5.1%	13.6%	3.6%

MENTAL AND NEUROLOGICAL ABNORMALITIES:

Category	Exposed	Control	Neither
Alive in 1954	2.8%		3.7%
First Generation Offspring	7.7%	6.3%	2.0%
Second Generation Offspring	1.7%		1.2%

“These figures likely indicate the teratogenic effects on the first generation born on the contaminated Atoll after the relocation there of the exposed and control population in 1957”

REPRODUCTIVE PROBLEMS

EXPERIENCED BY WOMEN:

Category	Exposed	Control	Neither
Alive in 1954	66.7%	60.0%	46.2%
First Generation Offspring	25.0%	36.4%	22.7%

ADULT ONSET DIABETES:

Category	Exposed	Control	Neither
Over 35 years of age	11.5%	7.9%	5.2%

“It seems clear that limiting ones concern to fatal cancers may provide neat mathematical simplicity, but it is unrelated to the reality of the suffering of the survivors of radiation exposure. The Investigation Committee of Atomic Bomb Victims of the Hannan Chuo Hospital, Osaka, Japan, undertook a study of 1,233 atomic bomb survivors (554 males, 678 females, and 1 unknown) living in Osaka (Ref.15). This study was undertaken in 1994, and the average age of the survivors was 59.5 years. The survivors were compared with the data for the same age group of the Standard Japanese Population “.

“More than 90% of the survivors were under medical service and more than 50% experienced frequent hospitalizations, about 2.5 time higher than in their unexposed peer group. They found the following”:

Disease	% Survivors with relative morbidity to disease	% General public with relative morbidity to disease
Lumbago	28.4%	3.6%
Hypertension	23.9%	1.7%
Ocular Disease	18.0%	5.0%
Neuralgia and Myalgia	12.3%	4.7%
Leukopenia	12.1%	13.4%

Gastritis	9.9%	4.5%
Gastroduodenal Ulcer	9.8%	4.7%
Ischemic Heart Disease	9.8%	4.7%
Liver Disease	9.0%	6.4%
Diabetes	8.2%	2.7%

“Similar findings have been reported at international NGO forums on the damage and its aftermath for atomic bomb survivors in Japan, and documented in the 1986 report of the Association of Victims of Atomic Bombs of Japan. Recently the RERF has acknowledged that in their limited survivor group they have found excess relative risk of cerebro-vascular and cardiac diseases, and gastro - intestinal diseases, especially liver disease, in those who were younger the 40 years at the time of bombing. One can only conclude that the official radiation studies were either incompetent to report these disease or uninterested in them”.

In a rare fact based report from the WHO, the dangerous effects of low level radiation are revealed,“New results from a study coordinated by the International Agency for Research on Cancer (IARC), the cancer agency of the World Health Organization, show that protracted exposure to low doses of ionizing radiation increases the risk of death from solid cancers. The results, published today in The BMJ [the prestigious British

Medical Journal], are based on the most powerful study to date and provide direct evidence about cancer risks after protracted exposures to low-dose ionizing radiation".

"The present study demonstrates a significant association between increasing radiation dose and risk of all solid cancers," says IARC researcher Dr Ausrele Kesminiene, a study co-author. "No matter whether people are exposed to protracted low doses or to high and acute doses, the observed association between dose and solid cancer risk is similar per unit of radiation dose."

"A collaboration among international partners, evaluated the exposures of more than 300 000 nuclear workers in France, the United Kingdom, and the USA over a period of time between 1943 and 2005".

"The scientists involved in the study come from government agencies such as the U.S. National Institute for Occupational Safety and Health, Public Health England Centre for Radiation, Chemical and Environmental Hazards and the International Agency for Research on Cancer, as well as universities including the University of North Carolina, Chapel Hill and Drexel University."

"The study confirms – once again – what we've been saying for years".

"For example, a major 2012 scientific study proves that low-level radiation can cause huge health problems. Science Daily reports:"Even the very lowest levels of radiation

are harmful to life, scientists have concluded in the Cambridge Philosophical Society's journal Biological Reviews. Reporting the results of a wide-ranging analysis of 46 peer-reviewed studies published over the past 40 years, researchers from the University of South Carolina and the University of Paris-Sud found that variation in low-level, natural background radiation was found to have small, but highly statistically significant, negative effects on DNA as well as several measures of health."

"The review is a meta-analysis of studies of locations around the globe …. "Pooling across multiple studies, in multiple areas, and in a rigorous statistical manner provides a tool to really get at these questions about low-level radiation."

"Mousseau and co-author Anders Møller of the University of Paris-Sud combed the scientific literature, examining more than 5,000 papers involving natural background radiation that were narrowed to 46 for quantitative comparison. The selected studies all examined both a control group and a more highly irradiated population and quantified the size of the radiation levels for each. Each paper also reported test statistics that allowed direct comparison between the studies."

"The organisms studied included plants and animals, but had a large preponderance of human subjects. Each study examined one or more possible effects of radiation, such as DNA damage measured in the lab, prevalence of a disease such as Down's Syndrome, or the sex ratio produced in offspring. For each effect, a statistical algorithm

was used to generate a single value, the effect size, which could be compared across all the studies."

"The scientists reported significant negative effects in a range of categories, including immunology, physiology, mutation and disease occurrence. The frequency of negative effects was beyond that of random chance."

There are many, many more reports that could be referenced on the effects of radiation on the environment and living creatures. The information included here barely scratches the surface on the research available on the subject, and it is well worth the effort to spend some time and learn what the dedicated professionals who work in public health and the anti-nuclear movement have contributed to this important research.

TRITIUM / WATER, WATER EVERYWHERE….

I have included the following information from Wikipedia on the properties of Tritium that are important in understanding it and how its release from nuclear power plants is endangering our health. "Tritium (/ˈtrɪtiəm/ or /ˈtrɪʃiəm/; symbol T or 3H, also known as hydrogen-3) is a radioactive isotope of hydrogen. The nucleus of tritium (sometimes called a triton) contains one proton and two neutrons, whereas the nucleus of protium (by far the most abundant hydrogen isotope) contains one proton and no neutrons. Naturally occurring tritium is extremely rare on Earth, where trace amounts are formed

by the interaction of the atmosphere with cosmic rays. The name of this isotope is formed from the Greek word τρίτος (trítos) meaning “third”….

“All atomic nuclei, being composed of protons and neutrons, repel one another because of their positive charge. However, if the atoms have a high enough temperature and pressure (for example, in the core of the Sun), then their random motions can overcome such electrical repulsion (called the Coulomb force), and they can come close enough for the strong nuclear force to take effect, fusing them into heavier atoms”….

“The tritium nucleus, containing one proton and two neutrons, has the same charge as the nucleus of ordinary hydrogen, and it experiences the same electrostatic repulsive force when brought close to another atomic nucleus. However, the neutrons in the tritium nucleus increase the attractive strong nuclear force when brought close enough to another atomic nucleus. As a result, tritium can more easily fuse with other light atoms, compared with the ability of ordinary hydrogen to do so….”

“The same is true, albeit to a lesser extent, of deuterium. This is why brown dwarfs (so-called failed stars) cannot utilize ordinary hydrogen, but they do fuse the small minority of deuterium nuclei”.

“Like the other isotopes of hydrogen, tritium is difficult to confine. Rubber, plastic, and some kinds of steel are all somewhat permeable. This has raised concerns that if tritium were used in large quantities, in particular for fusion reactors, it may contribute to

radioactive contamination, although its short half-life should prevent significant long-term accumulation in the atmosphere".

"The high levels of atmospheric nuclear weapons testing that took place prior to the enactment of the Partial Test Ban Treaty proved to be unexpectedly useful to oceanographers. The high levels of tritium oxide introduced into upper layers of the oceans have been used in the years since then to measure the rate of mixing of the upper layers of the oceans with their lower levels"…..

"Tritium is an isotope of hydrogen, which allows it to readily bind to hydroxyl radicals, forming tritiated water (HTO), and to carbon atoms. Since tritium is a low energy beta emitter, it is not dangerous externally (its beta particles are unable to penetrate the skin),but it can be a radiation hazard when inhaled, ingested via food or water, or absorbed through the skin. HTO has a short biological half-life in the human body of 7 to 14 days, which both reduces the total effects of single-incident ingestion and precludes long-term bioaccumulation of HTO from the environment. Biological half life of tritiated water in human body, which is a measure of body water turn over, varies with season. Studies on biological half life of occupational radiation workers for free water tritium in the coastal region of Karnataka, India show that the biological half life in winter season is twice that of the summer season"..…

"According to the U.S. EPA, "a recently documented source of tritium in the environment is [self-illuminating] exit signs that have been illegally disposed of in municipal landfills.

Water, which seeps through the landfill, is contaminated with tritium from broken signs and can pass into water ways, carrying the tritium with it…."

"Tritium has leaked from 48 of 65 nuclear sites in the US. In one case, leaking water contained 7.5 microcuries (0.28 MBq) of tritium per litre, which is 375 times the EPA limit for drinking water".

"The US Nuclear Regulatory Commission states that in normal operation in 2003, 56 pressurized water reactors released 40,600 curies (1.50 PBq) of tritium (maximum: 2,080; minimum: 0.1; average: 725) and 24 boiling water reactors released 665 curies (24.6 TBq) (maximum: 174; minimum: 0; average: 27.7), in liquid effluents"….

CBS News reported on tritium leaks on June 21, 2011 and they noted,"Radioactive tritium has leaked from three-quarters of U.S. commercial nuclear power sites, often into groundwater from corroded, buried piping, an Associated Press investigation shows".

"The number and severity of the leaks has been escalating, even as federal regulators extend the licenses of more and more reactors across the nation"…..

"Tritium, which is a radioactive form of hydrogen, has leaked from at least 48 of 65 sites, according to U.S. Nuclear Regulatory Commission records reviewed as part of the AP's yearlong examination of safety issues at aging nuclear power plants. Leaks from at

least 37 of those facilities contained concentrations exceeding the federal drinking water standard -- sometimes at hundreds of times the limit"….

"Previously, the AP reported that regulators and industry have weakened safety standards for decades to keep the nation's commercial nuclear reactors operating within the rules. While NRC officials and plant operators argue that safety margins can be eased without peril, critics say these accommodations are inching the reactors closer to an accident"….

"Any exposure to radioactivity, no matter how slight, boosts cancer risk, according to the National Academy of Sciences. Federal regulators set a limit for how much tritium is allowed in drinking water. So far, federal and industry officials say, the tritium leaks pose no health threat".

"But it's hard to know how far some leaks have traveled into groundwater. Tritium moves through soil quickly, and when it is detected it often indicates the presence of more powerful radioactive isotopes that are often spilled at the same time "

"For example, cesium-137 turned up with tritium at the Fort Calhoun nuclear unit near Omaha, Neb., in 2007. Strontium-90 was discovered with tritium two years earlier at the Indian Point nuclear power complex, where two reactors operate 25 miles north of New York City"….

"The tritium leaks also have spurred doubts among independent engineers about the reliability of emergency safety systems at the 104 nuclear reactors situated on the 65 sites. That's partly because some of the leaky underground pipes carry water meant to cool a reactor in an emergency shutdown and to prevent a meltdown. More than a mile of piping, much of it encased in concrete, can lie beneath a reactor."

CBS News also reported on February 23, 2016 on the continuing problem and wrote. "The recent radioactive leak at New York's Indian Point nuclear power plant is prompting renewed calls for the site to be shut down, amid growing concerns about the potential damage a nuclear accident could do in one of the most densely populated parts of the country"…..

"In the past year alone there have been a number of mishaps at Indian Point, including a power failure in the reactor core, a transformer fire, an alarm failure, and the escape of radiated water into groundwater. The plant sits about 25 miles north of New York City, so a serious mishap could potentially put millions of people in harm's way"…..

"It's a disaster waiting to happen and it should be shut down," Paul Gallay, president of Riverkeeper, a watchdog organization dedicated to protecting the Hudson River, told CBS News"….."Earlier this month, Entergy Corporation, which owns Indian Point, reported increased levels of tritium-contaminated water at three monitoring wells, with one well's radioactivity increasing by as much as 65,000 percent"…..

“However, Jerry Nappi, a representative for Entergy Corporation, said that the most recent issue at Indian Point would not have any impact on human health or life in the river. "Concentrations would be undetectable in the river," Nappi told CBS News. "We know from more than 10 years of hydrological studies on the site that it [radioactive contaminants] can't reach drinking water sources in nearby communities”.”

On The New York Times opinion pages Andrew Revkin wrote on June 12,2014 that, “Now, news that two monitoring wells detected a spike in levels of tritium, a radioactive isotope of hydrogen, has raised important questions about the aging infrastructure at the complex. I asked the Nuclear Regulatory Commission to provide some details on what’s been found, and then asked for a reaction from David A. Lochbaum, director of the Nuclear Safety Project at the Union of Concerned Scientists and he said,“The N.R.C. should enforce its regulations or change its name to N.C.”

Lochbaum continued “First, the good news. The indications of elevated tritium levels strongly suggest a leak of radioactively contaminated water from Indian Point (it’s not irrefutable evidence of an ongoing or recent leak since it could be past leakage finally reaching the monitoring wells due to recent rainfall.) This is good news in the sense that all the monitoring wells are fairly recent additions to the site. More than 12 years ago, leakage would either not have been detected or only detected after people started dying, a la Love Canal. So, strange as it seems, awareness is a good thing. It provides time to implement measures to protect people and the environment”…..

“Turning to the bad news, the NRC needs to get off the bench and into the regulating game. All the rhetoric about 20,000 picocuries per liter and neighbors drinking two quarts a day for a year is totally irrelevant.”….

“N.R.C.’s regulations do not allow a drop of radioactively contaminated water to leave Indian Point except via monitored and controlled pathways. Even if the monitoring wells constituted a monitored pathway (which they don’t despite the name), it’s not a controlled pathway. Thus, N.R.C.’s regulations are being violated. But N.R.C. does not enforce those regulations. N.R.C. could impose a fine of $130,000 per day. That would give Entergy ample incentive to quickly find the leak (and stop the fine tally) and to implement steps to prevent future leaks (and future fines”).

“But noooooo. The N.R.C. instead invoked the “no blood, no foul” rule and becomes Entergy’s ally in allowing ongoing leaks (and ongoing crimes.)”

It isn’t just leaks that arouse concern about tritium, because it is regularly released by most nuclear power plants in the world. The Voice of Orange County reported on October 14. 2015 about the San Onofre reactor in California, which was closed down in June 2016, and detailed the low safety standards used by the NRC to regulate tritium.”The dirty little secret of the nuclear industry is that all NPP regularly discharge radiation into the environment. Nuclear power plants cannot operate without these discharges, and the NRC sets standards for what is allowable. They have instituted a motivational and aspirational standard called ALARA which means: As Low as

Reasonably Achievable. They set limits of discharge based on estimates of how much radiation can be tolerated by the average statistical adult male even though we know that women, children, and the human fetus are far more vulnerable. Their regulations carefully state what is allowable, not what is safe. The real question should be what is safe, not what is permissible by the NRC. No one knows for sure what is safe which is why the cancer study was proposed in the first place".

"San Onofre has been ejecting gaseous radionuclides into the atmosphere since 1968. They have also pumped large quantities of low-level effluent radioactive waste into the ocean through their giant pipes 18 ft. in diameter (normal flow rate is a million gallons/ minute). Many do not realize that these emissions continue even after the reactors were shut down in January of 2012. In 2012 (after shutdown), there were 335.1 hours of liquid effluent releases. The longest one went on continuously for 28 hours and discharged 1.031 billion gallons into the ocean. Those who enjoyed the ocean that day will never know because discharge days are kept secret".

"It is pretty clear why Edison and the NRC keep harping on their PR mantra that safety is their number one priority. What else can you do when all your plans are really risky? But actions speak louder than words. The push by the nuclear industry to block cancer research demonstrates their true colors. The plan to store tons of high-level nuclear waste in a densely populated area vulnerable to earthquakes, tsunamis, and terrorist attacks makes a mockery out of the logo: "Protecting People and the Environment."

Because tritium is a radioactive radionuclide of hydrogen it is very difficult to contain efficiently and as a result, it escapes from nuclear reactors in huge amounts. The pipes, the concrete and other components of the reactors and buildings are literally saturated and radiate this radionuclide, especially in older reactors.

“The next 6 pages contain a brief description of tritium and it’s effects on people. Because of the tremendous amounts of tritium being released into the environment it is especially important to understand this radionuclide and how dangerous it is. The information I cite is all the work of Dr Ian Fairley, who’s tireless work on radiation contamination is so vital to this debate.

Dr Fairley describes himself this way,”I’m an independent consultant on radioactivity in the environment living in London UK. I’ve studied radiation and radioactivity at least since the Chernobyl accident in 1986. I’ve a degree in radiation biology from Bart’s Hospital in London and my doctoral studies at Imperial College in London and (briefly) Princeton University in the US concerned the radiological hazards of nuclear fuel reprocessing. I formerly worked as a civil servant on the regulation of radiation risks from nuclear power stations. From 2000 to 2004, I was head of the Secretariat of the UK Government’s CERRIE Committee on internal radiation risks. Since retiring from Government service, I have been a consultant on radiation matters to the European Parliament, local and regional governments, environmental NGOs, and private individuals. My areas of interest are the radiation doses and risks arising from the radioactive releases at nuclear facilities.”

Dr Fairley's comments begin with,"A report on tritium by the United Kingdom government's senior radiation committee,together with a flurry of other tritium reports, have revealed renewed interest in this radionuclide within the scientific community. This article, therefore, revisits tritium and reviews these reports, examining in particular their implications for radiation protection."

"Tritium (3H) is the radioactive isotope of hydrogen. It is a low-range beta emitter with a half life of 12.3 years and a maximum decay energy of 18.2 keV (average 5.7 keV). Tritium is formed naturally through cosmic ray interactions in the upper atmosphere, though anthropogenic tritium emission rates considerably exceed its natural production rate. Tritium most commonly occurs as tritiated water (3HOH), and in some industrial / military instances as elemental tritium gas (3HH), which is steadily oxidized to 3HOH in the environment. Therefore, in most instances, tritium can be accurately described as radioactive water. Tritium is created in most nuclear reactors by activation of hydrogen (1H) in their cooling water and moderator circuits and as a tertiary fission product in nuclear fuel. In heavy water reactors, larger amounts of tritium are created by the quicker activation of deuterium (2H) in the heavy water of their cooling and moderator circuits".

"Because of the low range of its β particles, radiation exposures from tritium only occur when it is inside the body – that is, tritium is considered an internal emitter. This does not mean that tritium outside the body is harmless, as tritiated water vapor readily

permeates the skin and, when inhaled, easily transfers across lung and buccal membranes"….

"Finally, tritium would be released in large quantities from any commercial fusion facilities in the future. In the case of fusion accidents or fires, it is estimated that extremely large quantities of tritium would be released. These estimates run contrary to the widespread, but erroneous, view that fusion energy is free from radioactivity; clearly, the opposite is the case"…

"Tritium is also the most studied radionuclide: since the 1950s several hundreds, perhaps thousands, of scientific articles have examined its biological effectiveness (that is, its hazard) and other properties. Yet it remains a misunderstood nuclide, as some radiation protection scientists still consider it a 'weak' nuclide, incorrectly thinking that, as its β particle has low energy, therefore its exposures are of little consequence and tritium outside the body is harmless."

"These are major misconceptions. In radiobiology, so-called 'weak' particles in fact have higher radiobiological effectiveness than more powerful emitters. Paradoxically, the lower their energy, the more effective they become. For example, β particles from tritium are actually two to three times more damaging than γ rays (explained later). Therefore to describe β particles from tritium as 'weak' is misleading: it is better to term them 'low range'".

“The reason for the greater effectiveness of low range particles has to do with the track structure of ionizing radiations. So-called ‘strong’ radiations (such as γ rays from cobalt-60) have very long tracks in tissue, but most of their energy is frittered away in small amounts over their long tracks. Damaging amounts of energy are deposited only at the ends of tracks. Low-range β emitters such as tritium effectively consist only of such track ends, and therefore are more damaging per disintegration than higher energy emitters.”

“Unfortunately, the International Commission on Radiological Protection (ICRP) still recommends that radiation from tritium is not particularly dangerous in comparison with other kinds of radiation. However, recent reports show a widening recognition that tritium is more hazardous than presently acknowledged by the ICRP; with the only question remaining being when the ICRP will acknowledge these reports?

Unfortunately, the ICRP continues to ignore the copious available scientific evidence on the added hazards of tritium”….

“In many respects, tritium has characteristics marking it out as an unusually hazardous radionuclide. These include its extreme mobility and cycling in the biosphere, its multiple pathways to man, its instantaneous ability to swap with H atoms in all other materials; its comparatively high relative biological effectiveness (RBE), it,s binding with cell constituents to form organically - bound tritium (OBT), and the heterogeneous distribution of OBT in humans”….

“Tritium emitted as water vapor or discharged as water from various facilities travels rapidly through multiple environmental pathways as water to reach humans, and cycles in the biosphere. Tritium atoms exchange very quickly with stable hydrogen atoms in the biosphere and hydrosphere downwind of a facility. This means that open water surfaces and biota downwind, including food growing in the area and food in open-air markets, and humans themselves would quickly become contaminated by tritiated air moisture up to ambient levels – that is, to the tritium concentration in water vapor in the air”.

“Humans can become tritiated not only by skin absorption but by inhalation of contaminated water vapor, and by ingestion of contaminated food and water. When tritium enters the body, it is readily taken up and used in metabolic reactions and in cellular growth: over 60% of the body’s atoms are hydrogen atoms and every day about 5% of these are engaged in metabolic reactions and cell proliferation. The result is that a proportion of the tritium taken in is fixed to proteins, lipids and carbohydrates, and most importantly to nucleoproteins such as DNA. This is called organically - bound tritium (OBT), which is non-uniformly distributed in the body and which is retained for longer periods than tritiated water (HTO). (All ICRP dosimetric models assume the opposite – that nuclides are homogeneously distributed in the body/tissue organ of interest). Doses from OBT are therefore higher than from HTO. The longer people are exposed to tritiated water, the higher their levels of OBT become until, in the case of very lengthy exposures lasting for years, equilibrium is established”.…

“This raises the question about how radiation protection authorities classify the potentially hazardous nature of radionuclides. The short answer is that they do not: there is no comprehensive hazard index for radionuclides as there is for chemicals. Many scientists consider there should be one because the properties of nuclides would be better recognized if such an index existed. After all, some nuclides are considered much more potent than others (polonium-210, for example, used recently allegedly to poison the Russian dissident, Alexander Litvinenko). It has been suggested that a number of characteristics should be included in a hazard index.”

- large releases to environment;
- widely used in society (industrial/military/research/medical uses);
- rapid nuclide transport, solubility and cycling in biosphere;
- global distribution and resulting large collective doses;
- many environmental pathways to humans;
- rapid molecular exchange rates (that is, fast uptake by humans);
- large uptake fractions to blood after intake;
- organic binding in biota;
- long biological half-life in humans;
- long radiological half-life;
- long nuclide decay chains with radiotoxic daughters;
- high radiotoxicity (the dose coefficient of the nuclide, that is, the radiation dose imparted from the disintegration of one atom of the nuclide in question).

“Tritium is unique in that it exhibits so many of these characteristics in fact, ten of the above twelve, with most other nuclides exhibiting two or perhaps three traits. Polonium-210 has four, carbon-14, iodine-129 and krypton-85 have six or seven out of the twelve traits. But, as stated above, no hazard index exists for radionuclides – at least at present. It is recommended that national radiation protection authorities should take steps to set up such a hazard index”.

“When a reactor is in operation, tritium is continuously formed and continuously released to the atmosphere in the form of radioactive water vapor. Contrary to what many people assume, few tritium air emissions are via a stack or chimney; most are via the continuous leakage of tritiated water vapor from machines, pumps, seals, pipes, reactor walls, etc. That is, tritiated water vapor literally oozes out of practically every surface, nook and cranny of the reactor building”….

From a second report on tritium that Dr Fairley produced for Greenpeace on the Canadian nuclear industry’s practices regarding tritium releases into the environment he wrote,“Canada Health has had a long history of adopting soft standards on radioactive pollutants compared to other pollutants, especially for tritium. For example, its former 1978 guidelines (Health and Welfare Canada, 1979) formerly recommended a very lax tritium limit of 40,000 becquerels per liter (Bq/L) for drinking water. Even then, it acknowledged that its limits for radionuclides were based on contested health risk estimates instead of the tighter concept of minimum detection levels used for most other pollutants….”

“In 1980, the Porter Commission (1980) on electric power in Ontario requested a Federal-Provincial Working Party to examine the question of radiological limits for drinking water. The Working Party recommended a chronic (lifetime) maximum concentration of 4,000 Bq/L. However, Canada Health and Welfare waited for another 14 years before it tightened the limit to 4,000 Bq/L in 1994”

“The current Canadian Federal limit for tritium in drinking water is 7,000 Bq//L, which is very lax compared with the limits set by the European Commission and the US EPA. The current US limit 7 is 740 Bq/L, based on a maximum dose to the public of 40 μSv per year from drinking water”.

“In the US, the state of Colorado has set a stricter standard 8 for tritium in surface water, of 18.5 Bq/L9. The US State of California uses a limit 10 of 15 Bq/L. Both are based on a one-in-a-million lifetime risk of a fatal cancer, which is the goal of cleanup under the US Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), more commonly known as the Superfund”.

“The current Canadian Federal limit for tritium corresponds to a risk of 350 excess fatal cancers per million people. On the other hand, the Canadian Federal drinking water objectives for chemicals are set at levels that provide a lifetime risk of 1–10 excess fatal cancers per million people. The primary reason for the difference is that the excess cancers predicted from radiation exposure are calculated by assuming one year’s

consumption of drinking water: the lifetime risk is calculated as if that year of consumption were the only consumption. With chemicals, the assumption is that people consume the affected drinking water for their whole lifetime—commonly set at a 70-year exposure. Why such a difference should exist is strange—it's another example of the apparently favored status of radiation in Canada".

In 2015 Dr. Fairley wrote an article for Counterpunch about a new study in Lancet Haemotology about the risks of low level radiation exposure in which he reported,"A powerful new study has been published in Lancet Haematology which adds to this evidence. However the study's findings are more important than the previous studies, for several reasons."

"First, it provides "strong evidence", as stated by the authors, of a "dose-response relationship between cumulative, external, chronic, low-dose, exposures to radiation and leukaemia".

"Second, it finds radiogenic risks of leukemia among nuclear workers to be more than double the risk found in a previous similar study in 2005. The excess relative risk of leukaemia mortality (excluding workers exposed to neutrons) was 4.19 per Gy."

"In 2005, a similar study among nuclear workers (also excluding those exposed to neutrons) in 15 countries by several of the same authors found an ERR of 1·93 per Sv.

In other words, the new study's risk estimates are 117% higher than the older study. The clincher is that the new study's estimated risks are much more precise than before."

"Third, it confirms risks even at very low doses (mean = 1·1 mGy per year). Unlike the Japanese bomb survivors' study, it observes risks at low dose rates rather than extrapolating them from high levels."

"Fourth, it finds risks do not depend on dose rate thus contradicting the ICRP's use of a Dose Rate Effectiveness Factor (DREF) which acts to reduce (by half) the ICRP's published radiation risks."

"Fifth, it finds radiogenic leukemia risks decline linearly with dose, contradicting earlier studies suggesting a lower, linear-quadratic relationship for leukemia. It strengthens the Linear No Threshold (LNT) model of radiogenic risks, as it now applies to leukemias as well as solid cancers."

"Sixth, the study finds no evidence of a threshold below which no effects are seen (apart from zero dose)."

"Seventh, the study uses 90% confidence intervals and one-sided p-values. In the past, 95% intervals and two-sided p-values were often incorrectly used which had made it harder to establish statistical significance."

Dr. Fairley wrote the following report on Childhood Leukemias Near Nuclear Power Stations,for his blog on June 25,2014,"In March 2014, my article on increased rates of childhood leukemias near nuclear power plants (NPPs) was published in the Journal of Environmental Radioactivity (JENR). A previous post discussed the making of the article and its high readership: this post describes its content in layman's terms."

"Before we start, some background is necessary to grasp the new report's significance. Many readers may be unaware that increased childhood leukemias near NPPs have been a contentious issue for several decades. For example, it was a huge issue in the UK in the 1980s and early 1990s leading to several TV programmes, Government Commissions, Government committees, a major international Conference, Government reports, at least two mammoth court cases and probably over a hundred scientific articles. It was refuelled in 1990 by the publication of the famous Gardner report (Gardner et al, 1990) which found a very large increase (7 fold) in child leukemias near the infamous Sellafield nuclear facility in Cumbria."

"The issue seems to have subsided in the UK, but it is still hotly debated in most other European countries, especially Germany."

"The core issue is that, world-wide, over 60 epidemiological studies have examined cancer incidences in children near nuclear power plants (NPPs): most (>70%) indicate leukemia increases. I can think of no other area of toxicology (eg asbestos, lead, smoking) with so many studies, and with such clear associations as those between

NPPs and child leukemias. Yet many nuclear Governments and the nuclear industry refute these findings and continue to resist their implications. It's similar to the situations with cigarette smoking in the 1960s and with man-made global warming nowadays."

"In early 2009, the debate was partly rekindled by the renowned KiKK study (Kaatsch et al, 2008) commissioned by the German Government which found a 60% increase in total cancers and 120% increase in leukemias among children under 5 yrs old living within 5 km of all German NPPs. As a result of these surprising findings, governments in France, Switzerland and the UK hurriedly set up studies near their own NPPs. All found leukemia increases but because their numbers were small the increases lacked "statistical significance". That is, you couldn't be 95% sure the findings weren't chance ones."

"In such situations, what you need to do is combine datasets in a meta-study to get larger numbers and thus reach higher levels of statistical significance. The four governments refrained from doing this because they knew what the answer would be, viz, statistically significant increases near almost all NPPs in the 4 countries. So Korblein and Fairlie helped them out by doing it for them (Korblein and Fairlie, 2012), and sure enough there were statistically significant increases near all the NPPs. Here are their findings-"

“Studies of observed (O) and expected (E) leukemia cases within 5 km of NPPs”

O	E	SIR=O/E	90%CI	P-VALUE
GERMANY	34	24.1	1.04-1.88	0.0328
GREAT BRITAIN	20	15.4	0.86-1.89	0.1464
SWITZERLAND	11	7.9A	0.78-2.31	0.1711
FRANCE B	14	10.2	0.83-2.15	0.1506
POOLED DATA	79	57.5	1.13-1.16	0.0042

“a derived from data in Spycher et al. (2011).”

“b acute leukemia cases”

“This table reveals a highly statistically significant 37% increase in childhood leukemias within 5 km of almost all NPPs in the UK, Germany, France and Switzerland. It’s perhaps not surprising that the latter 3 countries have announced nuclear phaseouts and withdrawals. It is only the UK government that remains in denial.”

“So the matter is now beyond question, ie there’s a very clear association between increased child leukemias and proximity to NPPs. The remaining question is its cause(s).”

“Most people worry about radioactive emissions and direct radiation from the NPPs, however any theory involving radiation has a major difficulty to overcome, and that is

how to account for the large (~10,000 fold) discrepancy between official dose estimates from NPP emissions and the clearly-observed increased risks."

"My explanation does involve radiation. It stems from KiKK's priniciple finding that the increased incidences of infant and child leukemias were closely associated with proximity to the NPP chimneys. It also stems from KiKK's observation that the increased solid cancers were mostly "embryonal", ie babies were born either with solid cancers or with pre-cancerous tissues which, after birth, developed into full-blown tumours: this actually happens with leukemia as well."

"My explanation has five main elements. First, the cancer increases may be due to radiation exposures from NPP emissions to air. Second, large annual spikes in NPP emissions may result in increased dose rates to populations within 5 km of NPPs. Third, the observed cancers may arise in utero in pregnant women. Fourth, both the doses and their risks to embryos and to fetuses may be greater than current estimates. And fifth, pre-natal blood-forming cells in bone marrow may be unusually radiosensitive. Together these five factors offer a possible explanation for the discrepancy between estimated radiation doses from NPP releases and the risks observed by the KIKK study. These factors are discussed in considerable detail in the full article."

"My article in fact shows that the current discrepancy can be explained. The leukemia increases observed by KiKK and by many other studies may arise in utero as a result of embryonal/fetal exposures to incorporated radionuclides from NPP radioactive

emissions. Very large emission spikes from NPPs might produce a pre-leukemic clone, and after birth a second radiation hit might transform a few of these clones into full-blown leukemia cells. The affected babies are born pre-leukemic (which is invisible) and the full leukemias are only diagnosed within the first few years after birth.To date, no letters to the editor have been received pointing out errors or omissions in this article."

In a report echoing Dr.Fairley's data ,Joseph J. Mangano concluded "Thyroid cancer incidence is increasing more rapidly than any other malignancy in the U.S.(along with liver cancer), rising nearly threefold from 1980 to 2006. Improved diagnosis has been proposed as the major reason for this change by some, while others contend that other factors also account for the increase. Among U.S.states, 2001-2005 age-adjusted thyroid cancer incidence rates vary from 5.4 to 12.8per 100,000. County-specific incidence data available for the first time document that most U.S.counties with the highest thyroid cancer incidence are in a contiguous area of eastern Pennsylvania, New Jersey, and southern New York. Exposure to radioactive iodine emissions from 16 nuclear power reactors within a 90 mile radius in this area as a potential etiological factor of thyroid cancer is explored; these emissions are likely a cause of rising incidence rates."

"From 1980 to 2006, annual U.S. thyroid cancer incidence rose nearly threefold, from 4.33 to 11.03 cases per 100,000 (age adjusted to the 2000 U.S. standard population).This increase has been steady, rising in 22 of 26 years, and has been most pronounced since the early 1990s . Along with liver/bile duct cancer, incidence of

thyroid cancer has experienced the greatest increase of any type of malignancy. Temporal trends during this period were consistent (between +137% and +181%) for males, females, blacks, and whites. Rates have risen markedly for all age groups except for children and the very old. The expected annual number of newly diagnosed U.S. thyroid cancer cases has reached 37,340. Improvements in treatment have raised survival rates; by 2006, the prevalence of U.S. thyroid cancer survivors was 410,404, and is increasing by more than 20,000 each year."

"This significant and largely unexpected rise in U.S. thyroid cancer incidence is consistent with reports of similar increases in many other developed nations, including Scotland, France, Italy, the Netherlands, Poland, the Czech Republic, Switzerland, Australia,England, Wales, and Canada."

Like every other part of this report , the problem has not been finding data supporting an anti-nuclear position,but selecting the most important information and leaving the rest out. This information on tritium contamination may be the most important part of this report because it is so wide spread.I recommend reading more of Dr Fairley's excellent work on his web page and learning as much as possible about this grave threat to our planet. No matter what country the industry is operating in it displays the same criminal disregard for the health and welfare of the people it profits from. The assault from dangerous radiation grows each year because of an ever more aggressive propaganda program, and like the tobacco and oil industries, the nuclear industrial complex's continued success depends on spreading misinformation and lies about its dangers.

Bad Business

On November 5, 2015 John LaForge of Counterpunch wrote an article where he highlighted the financial sectors grim assessment of the nuclear industry when he wrote, “On Feb. 11, 1985, the cover page of Forbes thundered, “The failure of the U.S. nuclear power program ranks as the largest managerial disaster in business history, a disaster on a monumental scale.…”

“Independent scientists, free of corporate blinders and the market imperative of short term profit, scoff at “green nuke” propaganda. Arjun Makhijani, President of Institute for Environmental and Energy Research, Amory Lovins, co-founder and Chief Scientist of the Rocky Mountain Institute, and Rifkin have all demonstrated how a nuclear “renaissance” — to replace the 400 old reactors now rattling apart worldwide and get to the total of 1,600 that Rifkin says are needed for a minimum impact on climate disruption — would require that we build three new reactors every 30 days for 40 years….”

“Reactors at Vermont Yankee, Kewaunee in Wis., and San Onofre in Calif. are all down to dismantlement long before their licenses expire. Last November, TXU, Inc., owners of the Comanche Peak station 40 miles southwest of Fort Worth announced the cancellation of their long-awaited expansion. TXU intended to double its poison footprint

and add two new reactors, but as Univ. of Texas engineering professor Ross Baldick told Dallas Morning News, “Currently, it’s just not competitive with gas. Nuclear’s capital costs are so high you can’t win on it.”

“Exelon Corp., the largest commercial reactor operator in the US with 22, announced last June that it would scrap plans to expand production at two sites. The firm said it was cancelling construction at the La Salle station in Illinois and its Limerick site in Pennsylvania.In August, Duke Energy Florida cancelled its two-reactor Levy County project after estimated costs had rocketed 400% about $5 billion each to $24 billion. “It turns out,” Time magazine reported, “that new [reactors] would be not just extremely expensive but spectacularly expensive.” Duke previously suspended plans for new reactors at Shearon Harris, NC”..

“Speaking in New York City Nov. 27, World Bank President Dr. Jim Yong Kim said, “The World Bank Group does not engage in providing support for nuclear power. … [O]ur focus is on finding ways of working in hydroelectric power, in geo-thermal, in solar, in wind. … and we don’t do nuclear energy.” A week earlier, Kim said governments weren’t doing enough to confront climate change, revealing that the WBG well knows that nuclear power is no answer.”….

“World Bank directors may have adopted the recommendation of the US Commission on the Prevention of Weapons of Mass Destruction Proliferation and Terrorism, which concluded in 2009 that governments can and should help stop nuclear weapons

proliferation by "… discouraging … the use of financial incentives in the promotion of civil nuclear power."…

"John Rowe, recently retired chairman and CEO of reactor-heavy Exelon Corp., said "unequivocally" in March 2012, "that new ones [reactors] don't make any sense right now…. It just isn't economic, and it's not economic within a foreseeable time frame".

"Germany's gas and electricity giant RWE Corp. announced in June 2012 that it would exit the nuclear power sector altogether and invest in solar power. As Germany's largest utility, RWE had been one of the most vehement defenders of nuclear power."

"Even the president of the Nuclear Energy Institute, Marvin Fertel, told Scientific American, "We won't build large numbers of new nuclear in the US in the near term … Today, you ought to build gas." Bill Johnson, CEO of Progress Energy, one of the utilities filing for a reactor construction license but with no plans to actually build, said in in the same issue, "Nuclear can't compete today."

"A year earlier, Siemens, the largest engineering conglomerate in Europe, fired a shot heard round the world, declaring that — following Germany's decision to close its reactors by 2022 — it would stop building new ones anywhere in the world. Siemens built all of Germany's 17 units. It was the first industry giant to announce such a departure. "The chapter for us is closed," said chief executive Peter Löscher"

“Calling new reactors “too expensive,” Jon Wellinghoff, the chairman of the US Federal Energy Regulatory Commission, said in 2009, “We may not need any, ever.” Wellinghoff directly countered the industry’s oft-heard complaint about meeting “base load” needs, saying that renewables “like wind, solar and biomass would be able to provide enough energy to meet base load capacity and future demand,” since the US can reduce energy usage by 50 percent."

“According to Jeffrey Immelt, CEO of the ubiquitous reactor engineering firm General Electric and one of nuclear power’s staunchest defenders, “If you were a utility CEO and looked at your world today, you would just do gas and wind. … You would never do nuclear. The economics are overwhelming.”

In 2015 GreenWorld wrote this article about a nuclear boondoggle in Georgia that has spiraled out of control, and the taxpayers are footing the bill, “Georgia is one state that you would think would be wary of nuclear power economics. The first two reactors at Georgia Power’s Vogtle site, which came online in the late 1980s, were a record 800% over budget”.

“That is a number that is almost impossible to grasp. Nothing goes 800% over budget– in the real world, projects get cancelled well before reaching that point”.
“When the project was announced, and when the utilities building the project first applied for taxpayer loans to help finance the project, Southern Company (Georgia

Power's parent) said the two reactors would cost about $14 billion and would be online in 2016 and 2017".

"That was back around 2008. Vogtle got its taxpayer loan promise in February 2010 and its construction permit in February 2012. Three and a half years later, Vogtle is more than three years behind schedule–39 months behind, in fact."

"And the cost of building Vogtle has, not surprisingly, gone up. Way up. Right now, it's somewhere around $16 billion and rising fast–the over-budget portion caused by the delays alone is $2 million per day. And as you can see from the photo at the top of the page, taken last Thursday, construction still has quite a long way to go."

"Because, as former PSC Commissioner Baker said, the total lifetime cost of Vogtle, including construction, is now estimated at $65 billion–a number too high for "staggering" to apply anymore".

"Two commenters to the article came up with two radically different estimates of what that means for the kilowatt/hour price for Vogtle's electricity. One says 6.1 cents, the other 15 cents. The real cost will depend on how well Vogtle runs once it's built; if, in fact, both units actually are completed. Assuming they are–at this point not a safe assumption–the real number probably would fall between those two guesses".
"Except that the $65 billion number doesn't include decommissioning and radioactive waste disposal costs, both of which will be added to ratepayers' bills–and probably the

rest of us taxpayers as well when the amount collected proves to be too small, as is the case with every other reactor in the country".

"Meanwhile, utilities across the country, including Georgia Power, are buying solar power for 5 cents kilowatt/hour and less. And, unlike Vogtle, where the costs keep rising, solar's price keeps falling".

BROTHER, CAN YOU SPARE A DIME?

With all of this bad press from the financial sector how does the industry stay in business? Nuclear advocates often fall back on the tired old arguments that the industry's dismal performance can be blamed on over regulation, when in fact the NRC has given its licensee a free hand in creating a consequence free business environment, where they can do almost anything they want. The second most over used excuse for the continued failure of nuclear to thrive is opposition from environmental activists who say mean and terrible things about it. Neither of these arguments have any truth to them, the reasons for the industry's current condition are its economic model and the truth how dangerous it is because of disasters like Chernobyl and Fukushima coming out.

The only reason that nuclear power still exists at all in the US is because American taxpayers subsidize it from the moment the uranium is taken out of the ground to the

1,000,000 year plan to store the hazardous waste it produces. The subsidies it receives are worth more than all the energy the industry produces, and could be much better spent on renewable energy. This corporate welfare has been going on for a very long time and the way it is structured helps to hide the staggering amount of money it involves, because the money is not paid to them directly, but through tax breaks and financial incentives. I don't want everyone's eyes to glaze over in this next section on subsidies, so I will only cover them in the simplest of terms and just highlight how expensive they are to everyone. All forms of energy get some subsidies but nuclear power hit the mother load ,(excuse the mixed energy metaphor) when it comes to them, even the billions that go to oil and gas pale in comparison. The business plan the industry uses is, SOCIALIZE THE LIABILITY AND COSTS, AND PRIVATIZE THE PROFITS. It is as simple as that. Get the public to finance an industry that the private financial sector wouldn't touch in a million years, guarantee the loans in a very risky and dangerous industry, give them freebees and incentives at taxpayer expense, then allow them to have a ridiculously low liability should an accident happen and let them keep all the profits.

In 2011 Doug Koplow teamed up with The Union of Concerned Scientists and produced the landmark study, NUCLEAR POWER: Still Not Viable Without Subsidies

Doug Koplow is the founder of Earth Track, Inc., and has worked on natural-resource subsidy issues for more than 20 years, mainly in the energy sector. He holds a B.A. in

economics from Wesleyan University and an M.B.A. from the Harvard Graduate School of Business Administration.

The Union of Concerned Scientists (UCS) is the leading science-based non-profit working for a healthy environment and a safer world. UCS combines independent scientific research and citizen action to develop innovative, practical solutions and to secure responsible changes in government policy, corporate practices, and consumer choices.

“This is the reports Executive Summary.”

“Nuclear Power: Still Not Viable without Subsidies Conspicuously absent from industry press releases and briefing memos touting nuclear power’s potential as a solution to global warming is any mention of the industry’s long and expensive history of taxpayer subsidies and excessive charges to utility ratepayers. These subsidies not only enabled the nation’s existing reactors to be built in the first place, but have also supported their operation for decades.”

“The industry and its allies are now pressuring all levels of government for large new subsidies to support the construction and operation of a new generation of reactors and fuel-cycle facilities. The substantial political support the industry has attracted thus far rests largely on an uncritical acceptance of the industry’s economic claims and an

incomplete understanding of the subsidies that made—and continue to make—the existing nuclear fleet possible."

"Such blind acceptance is an unwarranted, expensive leap of faith that could set back more cost-effective efforts to combat climate change. A fair comparison of the available options for reducing heat-trapping carbon emissions while generating electricity requires consideration not only of the private costs of building plants and their associated infrastructure but also of the public subsidies given to the industry. Moreover, nuclear power brings with it important economic, waste disposal, safety, and security risks unique among low-carbon energy sources. Shifting these risks and their associated costs onto the public is the major goal of the new subsidies sought by the industry (just as it was in the past), and by not incorporating these costs into its estimates, the industry presents a skewed economic picture of nuclear power's value compared with other low-carbon power sources.

- "SUBSIDIES OFTEN EXCEED THE VALUE OF THE ENERGY PRODUCED"

"This report catalogues in one place and for the first time the full range of subsidies that benefit the nuclear power sector. The findings are striking: since its inception more than 50 years ago, the nuclear power industry has benefited—and continues to benefit—from a vast array of preferential government subsidies. Indeed, subsidies to the nuclear fuel cycle have often exceeded the value of the power produced. This means that buying power on the open market and giving it away for free would have been less costly than

subsidizing the construction and operation of nuclear power plants. Subsidies to new reactors are on a similar path."

"Throughout its history, the industry has argued that subsidies were only temporary, a short-term stimulus so the industry could work through early technical hurdles that prevented economical reactor operation. A 1954 advertisement from General Electric stated that, "In five years—certainly within ten," civilian reactors would be "privately financed, built without government subsidy." That day never arrived and, despite industry claims to the contrary, remains as elusive as ever."

"The most important subsidies to the industry do not involve cash payments. Rather, they shift construction cost and operating risks from investors to taxpayers and ratepayers, burdening taxpayers with an array of risks ranging from cost overruns and defaults to accidents and nuclear waste management. This approach, which has remained remarkably consistent throughout the industry's history, distorts market choices that would otherwise favor less risky investments. Although it may not involve direct cash payments, such favored treatment is nevertheless a subsidy, with a profound effect on the bottom line for the industry and taxpayers alike."

"Reactor owners, therefore, have never been economically responsible for the full costs and risks of their operations. Instead, the public faces the prospect of severe losses in the event of any number of potential adverse scenarios, while private investors reap the

rewards if nuclear plants are economically successful. For all practical purposes, nuclear power's economic gains are privatized, while its risks are socialized."

"Recent experiences in the housing and financial markets amply demonstrate the folly of arrangements that separate investor risk from reward. Indeed, massive new subsidies to nuclear power could encourage utilities to make similarly speculative, expensive investments in nuclear plants—investments that would never be tolerated if the actual risks were properly accounted for and allocated."

"While the purpose of this report is to quantify the extent of past and existing subsidies, we are not blind to the context: the industry is calling for even more support from Congress. Though the value of these new subsidies is not quantified in this report, it is clear that they would only further increase the taxpayers' tab for nuclear power while shifting even more of the risks onto the public."

- "LOW-COST CLAIMS FOR EXISTING REACTORS IGNORE HISTORICAL SUBSIDIES "

"The nuclear industry is only able to portray itself as a low-cost power supplier today because of past government subsidies and write-offs. First, the industry received massive subsidies at its inception, reducing both the capital costs it needed to recover from ratepayers (the "legacy" subsidies that underwrote reactor construction through the 1980s) and its operating costs (through ongoing subsidies to inputs, waste

management, and accident risks). Second, the industry wrote down tens of billions of dollars in capital costs after its first generation of reactors experienced large cost overruns, cancellations, and plant abandonments, further reducing the industry's capital-recovery requirements. Finally, when industry restructuring revealed that nuclear power costs were still too high to be competitive, so-called stranded costs were shifted to utility ratepayers, allowing the reactors to continue operating."

"These legacy subsidies are estimated to exceed seven cents per kilowatt-hour (¢/kWh) —an amount equal to about 140 percent of the average wholesale price of power from 1960 to 2008, making the subsidies more valuable than the power produced by nuclear plants over that period. Without these subsidies, the industry would have faced a very different market reality—one in which many reactors would never have been built, and utilities that did build reactors would have been forced to charge consumers even higher rates."

- "ONGOING SUBSIDIES CONTRIBUTE TO NUCLEAR POWER'S PERCEIVED COST ADVANTAGE "

"In addition to legacy subsidies, the industry continues to benefit from subsidies that offset the costs of uranium, insurance and liability, plant security, cooling water, waste disposal, and plant decommissioning. The value of these subsidies is harder to pin down with specificity, with estimates ranging from a low of 13 percent of the value of the power produced to a high of 98 percent. The breadth of this range largely reflects three

main factors: uncertainty over the dollar value of accident liability caps; the value to publicly owned utilities (POUs) of ongoing subsidies such as tax breaks and low return-on-investment requirements; and generous capital subsidies to investor-owned utilities (IOUs) that have declined as the aging, installed capacity base is fully written off."

"Our low-end estimate for subsidies to existing reactors (in this case, investor-owned facilities) is 0.7 ¢/kWh, a figure that may seem relatively small at only 13 percent of the value of the power produced. However, it represents more than 35 percent of the nuclear production costs (operation and maintenance costs plus fuel costs, without capital recovery) often cited by the industry's main trade association as a core indicator of nuclear power's competitiveness; it also represents nearly 80 percent of the production-cost advantage of nuclear relative to coal. With ongoing subsidies to POUs nearly double those to IOUs, the impact on competitive viability is proportionally higher for publicly owned plants. "

- "SUBSIDIES TO NEW REACTORS REPEAT PAST PATTERNS"

"Legacy and ongoing subsidies to existing reactors may be important factors in keeping facilities operating, but they are not sufficient to attract new investment in nuclear infrastructure. Thus an array of new subsidies was rolled out during the past decade, targeting not only reactors but also other fuel-cycle facilities. Despite the profoundly poor investment experience with taxpayer subsidies to nuclear plants over the past 50 years, the objectives of these new subsidies are precisely the same as the earlier

subsidies: to reduce the private cost of capital for new nuclear reactors and to shift the long-term, often multi-generational risks of the nuclear fuel cycle away from investors. And once again, these subsidies to new reactors—whether publicly or privately owned—could end up exceeding the value of the power produced (4.2 to 11.4 ¢/kWh, or 70 to 200 percent of the projected value of the power)."

"It should be noted that certain subsidies to new reactors are currently capped at a specific dollar amount, limited to a specific number of reactors, or available only in specific states or localities. Therefore, although all the subsidies may not be available to each new reactor, are reasonably representative of the subsidies that will be available to the first new plants to be built. Furthermore, it is far from clear whether existing caps will be binding. Recent legislative initiatives would expand eligibility for these subsidies to even more reactors and extend the period of eligibility during which these subsidies."

- "KEY SUBSIDY FINDINGS"

"Government subsidies have been directed to every part of the nuclear fuel cycle. The most significant forms of support have had four main goals: reducing the cost of capital, labor, and land (i.e., factors of production), masking the true costs of producing nuclear energy("intermediate inputs"), shifting security and accident risks to the public, and shifting long-term operating risks (decommissioning and waste management) to the public. A new category of subsidy, "output-linked support," is directed at reducing the

price of power produced.-ing and new reactors. The subsequent sections discuss each type of subsidy in more detail."

- "Reducing the Cost of Capital, Labor, and Land (Factors of Production)"

"Nuclear power is a capital-intensive industry with long and often uncertain build times that exacerbate both the cost of financing during construction and the market risks of misjudging demand. Historically, investment tax credits, accelerated depreciation, and other capital subsidies have been the dominant type of government support for the industry, while subsidies associated with labor and land costs have provided lesser (though still relevant) support."

"Legacy subsidies that reduced the costs of these inputs were high, estimated at 7.2 ¢/kWh.

Ongoing subsidies to existing reactors are much lower but still significant, ranging from 0.06 to 1.94 ¢/kWh depending on ownership structure. For new reactors, accelerated depreciation has been supplemented with a variety of other capital subsidies to bring plant costs down by shifting a large portion of the capital risk from investors to taxpayers. The total value of subsidies available to new reactors in this category is significant for both POUs and IOUs, ranging from 3.51 to 6.58 ¢/kWh. These include:

“Federal loan guarantees. Authorized under Title 17 of the Energy Policy Act (EPACT) of 2005, federal loan guarantees are the largest construction subsidy for new, investor-owned reactors, effectively shifting the costs and risks of financing and building a nuclear plant from investors to taxpayers. The industry’s own estimates,which we have used despite large subsequent increases in expected plant costs, place the value of this program between 2.5 and 3.7 ¢/kWh. Total loan guarantees are currently limited to $22.5 billion for new plants and enrichment facilities, but the industry has been lobbying for much higher levels.”

‘Loan guarantees not only allow firms to obtain lower-cost debt, but enable them to use much more of it—up to 80 percent of the project’s cost. For a single 1,600-megawatt (MW) reactor, the loan guarantee alone would generate subsidies of $495 million per year, or roughly $15 billion over the 30-year life of the guarantee.”

•” Accelerated depreciation. Allowing utilities to depreciate new reactors over 15 years instead of their typical asset life (between 40 and 60 years) will provide the typical plant with a tax break of approximately $40 million to $80 million per year at current construction cost estimates. Rising plant costs, longer service lives, and lower capacity factors would all increase the value of current accelerated depreciation rules to IOUs. This subsidy is not available to POUs because they pay no taxes.”
•” Subsidized borrowing costs to POUs. The most significant subsidy available to new publicly owned reactors is the reduced cost of borrowing made possible by municipal bonds and new Build America Bonds, which could be worth more than 3 ¢/kWh.”

•” Construction work in progress. Many states allow utilities to charge ratepayers for construction work in progress (CWIP) by adding a surcharge to customers’ bills. This shifts financing and construction risks (including the risk of cost escalations and/or plants being abandoned during construction) from investors to customers. CWIP benefits both POUs and IOUs and is estimated to be worth between 0.41 and 0.97 ¢/kWh for new reactors.”

- “Property-tax abatements. Support for new plants is also available through state and local governments, which provide a variety of plant-specific subsidies that vary by project.”

- “ Masking the True Costs of Producing Nuclear Energy (Intermediate Inputs)”

“A variety of subsidies masks the costs of the inputs used to produce nuclear power. Uranium fuel costs, for example, are not a major element in nuclear economics, but subsidies to mining and enrichment operations contribute to the perception of nuclear power as a low-cost energy source. In addition, the under-pricing of water used in bulk by nuclear reactors has significant cost implications. The value of such legacy subsidies to existing reactors is estimated between 0.10 and 0.24 ¢/kWh, and the value of ongoing subsidies is estimated between 0.16 and 0.51 ¢/kWh. The value of such subsidies to new reactors is estimated between 0.21 and 0.42 ¢/kWh. Subsidized inputs include:”

- “Fuel. The industry continues to receive a special depletion allowance for uranium mining equal to 22 percent of the ore’s market value, and its deductions are allowed to exceed the gross investment in a given mine. In addition, uranium mining on public lands is governed by the antiquated Mining Law of 1872, which allows valuable ore to be taken with no royalties paid to taxpayers. Although no relevant data have been collected on the approximately 4,000 mines from which uranium has been extracted in the past, environmental remedition costs at some U.S. uranium milling sites actually exceeded the market value of the ore extracted.”

- “Uranium enrichment. Uranium enrichment, which turns mined ore into reactor fuel, has benefited from substantial legacy subsidies. New plants that add enrichment capacity will receive subsidies as well, in the form of federal loan guarantees. Congress has already authorized $2 billion in loan guarantees for a new U.S. enrichment facility, and the Department of Energy has allocated an additional $2 billion for this purpose. While we could not estimate the per-kilowatt-hour cost of this subsidy because it depends on how much enrichment capacity is built, the $4 billion represents a significant new subsidy to this stage of the fuel cycle.”

- “Cooling water. Under-priced cooling water is an often-ignored subsidy to nuclear power, which is the most water-intensive large-scale thermal energy technology in use. Even when the water is returned to its source, the large withdrawals alter stream flow and thermal patterns, causing environmental damage. Available data suggest that reactor owners pay little or nothing for the water consumed, and are often given

priority access to water resources—including exemption from drought restrictions that affect other users. While we provide a low estimate of water subsidies (between $600 million and $700 million per year for existing reactors), more work is needed to accurately quantify this subsidy—particularly as water resources become more constrained in a warming climate."

"Reducing the Price of Power Produced (Output-Linked Support)"

"Until recently, subsidies linked to plant output were not a factor for nuclear power. That changed with the passage of EPACT in 2005, which granted new reactors an important subsidy in the form of:"

- "Production tax credits (PTCs). A PTC will be granted for each kilowatt-hour generated during a new reactor's first eight years of operation; at present, this credit is available only to the first plants to be built, up to a combined total capacity of six gigawatts. While EPACT provides a nominal PTC of 1.8 ¢/kWh, payments are time-limited. Over the full life of the plant, the PTC is worth between 1.05 and 1.45 ¢/kWh. Under current law, PTCs are not available to POUs (since POUs do not pay taxes), but there have been legislative efforts to enable POUs to capture the value of the tax credits by selling or transferring them to other project investors that do pay taxes."

“Shifting Security and Accident Risks to the Public (Security and Risk Management)”

“Subsidies that shift long-term risks to the public have been in place for many years. The Price-Anderson Act, which caps the nuclear industry’s liability for third-party damage to people and property, has been a central subsidy to the industry for more than half a century. Plant security concerns have increased significantly since 9/11, and proliferation risks will increase in proportion to any expansion of the civilian nuclear sector (both in the United States and abroad). The complexity and lack of data in these areas made it impossible to quantify the magnitude of security subsidies for this analysis. But it is clear that as the magnitude of the threat increases,taxpayers will be forced to bear a greater share of the risk. Subsidies that shift these risks are associated with:”

“The Price-Anderson Act. This law requires utilities to carry a pre-set amount of insurance for off-site damages caused by a nuclear plant accident, and to contribute to an additional pool of funds meant to cover a pre-set portion of the damages. However, the law limits total industry liability to a level much lower than would be needed in a variety of plausible accident scenarios. This constitutes a subsidy when compared with other energy sources that are required to carry full private liability insurance, and benefits both existing and new reactors. Only a few analysts have attempted to determine the value of this subsidy over its existence, with widely divergent results: between 0.1 and 2.5 ¢/kWh. More work is therefore needed to determine how the

liability cap affects plant economics, risk-control decisions, and risks to the adjacent population."

"Plant security. Reactor operators must provide security against terrorist attacks or other threats of a certain magnitude, referred to as the "design basis threat." For threats of a greater magnitude (a larger number of attackers, for example), the government assumes all financial responsibility, which constitutes another type of subsidy. It is difficult to quantify the value of this taxpayer-provided benefit because competing forms of energy do not carry similar risks. But it is important that plant security costs be reflected in the cost of power delivered to consumers, rather than supported by taxpayers in general."

"Proliferation. The link between an expanded civilian nuclear sector and proliferation of nuclear weapons or weapons technology is fairly widely accepted. It is also consistently ignored when assessing plant costs—much as investors in coal plants ignored the cost of carbon controls until recently. Though quantifying proliferation costs may be difficult, assuming they are zero is clearly wrong. These ancillary impacts should be fully assessed and integrated into the cost of nuclear power going forward."

- "Shifting Long-Term Operating Risks to the Public (Decommissioning and Waste Management)"

“The nuclear fuel cycle is unique in the types of long-term liabilities it creates. Reactors and fuel-cycle facilities have significant end-of-life liabilities associated with the proper closure, decommissioning, and decontamination of facilities, as well as the safe management of nuclear waste over thousands of years. The industry has little operational experience with such large and complex undertakings, greatly increasing the likelihood of dramatic cost overruns. In total, the subsidies that shift these long-term operating risks to the public amount to between 0.29 and 1.09 ¢/kWh for existing reactors and between 0.13 and 0.54 ¢/kWh for new reactors. The specific subsidies that do the shifting are associated with: “

“Nuclear waste management. The federal Nuclear Waste Repository for spent fuel is expected to cost nearly $100 billion over its projected operating life, 80 percent of which is attributed to the power sector. A congressionally mandated fee on nuclear power consumers, earmarked for the repository, has collected roughly $31 billion in waste-disposal fees through 2009. There is no mechanism other than investment returns on collections to fully fund the repository once reactors close.”

“The repository confers a variety of subsidies to the nuclear sector. First, despite its complexity and sizable investment, the repository is structured to operate on a break-even basis at best, with no required return on investment. Second, utilities do not have to pay any fee to secure repository capacity; in fact, they are allowed to defer payments for waste generated prior to the repository program’s creation, at interest rates well below their cost of capital. Third, the significant risk of delays and cost overruns will be borne by taxpayers rather than the program’s beneficiaries. Delays in the repository’s

opening have already triggered a rash of lawsuits and taxpayer-funded waste storage at reactor sites, at a cost between $12 billion and $50 billion."

"Plant decommissioning. While funds are collected during plant operation for decommissioning once the plant's life span has ended, reduced tax rates on nuclear decommissioning trust funds provide an annual subsidy to existing reactors of between $450 million and $1.1 billion per year. Meanwhile, concerns persist about whether the funds accrued will be sufficient to cover the costs; in 2009, the Nuclear Regulatory Commission (NRC) notified the operators of roughly one-quarter of the nation's reactor fleet about the potential for insufficient funding. We did not quantify the cost of this potential shortfall."

Before moving on to a different topic, I will briefly highlight a glaring problem that the subsidies create, specifically the absurdly low amount of liability coverage the industry has to have in the case of a nuclear meltdown. Should there be a disaster, the amount of coverage provided by the Price-Anderson Act to pay for all of the health problems and damage to property is less than the amount paid out due to natural disasters which have already occurred,namely Hurricane Katrina and Super Storm Sandy. In a hypothetical situation, Koplow explains the coverage like this:

"A simple evaluation of coverage per person, should an accident occur at a reactor located close to a population center, helps to illustrate this point. Table 21 uses as an example a reactor at Calvert Cliffs, located near Washington, DC, and Baltimore, MD.

Available coverage,including pooled premiums from all other reactors (as stipulated under Price-Anderson), barely tops$1,100 per person in the Baltimore/Washington combined statistical area. This small amount would need to cover not only loss of property from an accident but also morbidity or mortality. The portion paid by Calvert Cliffs to cover the off-site accident risk from its own operations (Tier 1 coverage plus its share of Tier 2) would be a mere $60 per person affected. While the extent of the injuries would vary with the specifics of an accident, the weather at the time, and patterns of local settlement and construction, for a metropolitan area of this size it is clear that the coverage provided by Price-Anderson is not large."…

PLANT SECURITY AND TERRORISM

"In his January 2002 State of the Union speech, President Bush said that U.S. forces "found diagrams of American nuclear power plants" in al-Qaeda materials in Afghanistan. An al-Qaeda training manual lists nuclear plants as among the best targets for spreading fear in the United States. The government is taking the threat seriously: in February 2002, the Nuclear Regulatory Commission (NRC) issued an advisory to the nation's 103 nuclear power plants that terrorists might try to fly hijacked planes into some of them. And eight governors have independently ordered the National Guard to protect nuclear reactors in their states." This is what the Council on Foreign Relations reported on January !,2006."

Nuclear power plants are required by the NRC to be able to withstand an attack which is definedas a “Design Basis Threat”, which specifies the maximum severity of potential attacks that a nuclear plant’s security force is capable of repelling. Until a few years ago that threat included an attacking force of no more than three people with small semi-automatic weapons and with the help of only one plant insider. The weapons used in the attack do not include rocket propelled grenades, mortars or heavy automatic weapons, which are very commonly used by terrorists.

A 9-11 style attack is outside of the DBT scenario, and the NRC has chosen not to upgrade the plants from this kind of threat, but future reactor designs will include more protection from a 747 sized airplane loaded with fuel.
In an excellent report John P. Holdren wrote, “The possibility that civil nuclear-energy facilities might become targets for terrorists has been recognized since long before the attacks of September 11, 2001, on the World Trade Center and the Pentagon. The principal attraction of civil nuclear-energy facilities as terrorist targets lies in the potential for creating a release of radioactivity large enough to produce significant casualties and land contamination. Destruction of an important piece of energy-supply infrastructure in the targeted country and the possibility that a successful attack would lead to the wholesale shutdown of nuclear-energy facilities around the world might be seen as collateral “benefits” by terrorists….”

“The probability side of the risk from attacks on nuclear facilities is influenced by the motivation of terrorists to pursue this route as well as by their capabilities in relation to

the challenges of the task. The motivation presumably resides above all in that an attack on nuclear facilities has the very considerable potential for doing damage. A successful attack on a nuclear power reactor, for example, could destroy the facility itself, worth hundreds of millions to billions of dollars; produce tens to hundreds or even thousands of early fatalities and tens of thousands of delayed cancer deaths; and severely contaminate hundreds to thousands of square miles of land, requiring removal of much of it from habitation, commerce, and agriculture for periods ranging from months to many decades."

"Such an attack would also cause terror and distress among far more than just the people physically harmed (amplified by the public's particular fear of radiation), deprive the affected region of an important component of its electricity supply, and probably lead to prolonged or even permanent shutdown of other nuclear power plants around the world, with serious economic consequences."

Daniel Hirsch, David Lochbaum and Edwin Lyman wrote in a report for the Committee to Bridge the Gap,"…….. the NRC has taken no action to protect against the ultimate September 11-type threat, a jet aircraft attack, other than to initiate long-term technical studies to evaluate the consequences of air attacks and to require plant operators to plan for events that could "result in damage to large areas of their plants from impacts, explosions, or fires." The commission refuses to consider adding structural features to reactor sites that might prevent a successful aircraft attack."

“The NRC has also rejected calls by the public and policy-makers to consider the feasibility of directly protecting nuclear plants from air attack by imposing no-fly zones or deploying portable anti-aircraft systems, citing the command-and-control problems inherent in such an approach, the impact on the commercial airline industry, and the risk of accident or collateral damage. These considerations are important, but they must be weighed against the catastrophic consequences of a meltdown and large radiological release, especially at the many nuclear plants in densely populated urban areas–like the controversial Indian Point plant, near New York City. (None of the objections to these defensive measures appear to have prevented them from being taken to protect other buildings; the Pentagon ordered the deployment of heat-seeking anti-aircraft missiles around Washington, D.C. during the recent “code orange” terror alerts.)”
“Right now the industry is lobbying hard to significantly weaken any revised DBT. Little wonder that a recent report by the NRC’s inspector general found that commission staff believed “that NRC is becoming influenced by private industry and its power to regulate is diminishing….”

“The NEI has also waged a campaign to convince the public that it has nothing to fear, even if a nuclear plant were attacked by a jet plane fully loaded with fuel. It recently released a summary of a report it commissioned from the Electric Power Research Institute (EPRI), claiming to show that “structures housing reactor fuel at U.S. nuclear power plants would protect against a release of radiation even if struck by a large commercial jetliner…..”

“NEI refused to release the entire report, citing “security considerations,” but it was clear from the summary that it had chosen certain assumptions to produce the results it wanted, including a presumed containment wall thickness of four feet–thicker than typical reactor containment walls and domes. EPRI arbitrarily chose an impact speed of 350 miles per hour–well below the nearly 600 miles per hour at which the 767 struck the World Trade Center South Tower. And EPRI ignored the damage that an aircraft could cause to targets outside the containment, like the auxiliary feedwater pumps and the diesel generators.”

“The insider threat:”

“An individual drives to a nuclear power plant in the United States, obtains an access badge at the security gate, and walks freely through the facility. He takes a rubber hose from an equipment locker and cross-connects the hydrogen gas supply system to the air system. He opens a valve allowing hydrogen gas to flow inside the air system throughout the plant, and within a few minutes, produces combustible levels of hydrogen within the containment building, the auxiliary building, and the turbine building. Using matches, he ignites the explosions and fires that disable the emergency systems needed to cool the reactor core and the systems needed to limit radioactivity releases from the damaged core to the environment.”

“Sound impossible? Perhaps. But it nearly happened on January 7, 1989, at the H. B. Robinson nuclear plant in South Carolina. An individual made a mistake conducting a

test. Luckily, his error was discovered and the buildings were vented of the flammable gas mixture before disaster struck. But what prevents workers from accomplishing by intent that which nearly happened by mistake–sabotage from the inside?"

"Better security at sensitive facilities is needed more than ever, but the NRC and the nuclear industry have spent most of their time arguing against improvements. Some of those arguments have been extraordinary–for example, that Chernobyl wasn't so bad. Recent commentaries by a group of prominent nuclear industry figures made that assertion and even went so far as to claim that the release of radiation would be good for the public: "Data show detrimental health effects and biological functions when organisms are 'protected' from radiation."

"But imagine if the public were told that more than 100 massive radiological weapons–"dirty bombs" on an incomprehensible scale–had been pre-emplaced in the United States, each capable of rendering an area the size of Pennsylvania uninhabitable for decades. Imagine further that the public learned that despite all the hype about homeland security, a powerful industry and its captured regulatory agency had succeeded in blocking security measures that would prevent those weapons from being used against the U.S. population. But one needn't imagine–it's the NRC's latest dirty little secret."

Writing for IEEE Spectrum, Charles O. Choi wrote in 2015 about the threat of cyber attack facing the industry and the damage it has already done,"The 2010 Stuxnet

worm's infiltration of Iran's nuclear program was the most dramatic cyberattack the nuclear sector has ever seen. But it was not the only one. In one case in 2003, the Slammer worm infected the Davis-Besse nuclear power plant in Ohio, leaving reactor core safety data unavailable for nearly five hours. In another example from 2014, hackers stole blueprints of at least two nuclear reactors and other sensitive data from Korea Hydro and Nuclear Power Co., then demanded money from the company in exchange for not releasing potentially important files".

"Although the 2011 nuclear disaster at Fukushima was not the result of a cyberattack, that catastrophe nevertheless underscored what the grave consequences of disrupting a nuclear power plant can be. To shed light on what risks the nuclear industry now faces from cyber-threats, researchers at Chatham House, part of the the Royal Institute of International Affairs in London, conducted in-depth interviews of 30 nuclear industry experts and convened three expert roundtables on nuclear cyber-security over the course of 18 months."

"The results, detailed on 5 Oct., were alarming, says study lead author Caroline Baylon, a research associate at Chatham House. "I didn't expect to find as many vulnerabilities as I did," she says. "The nuclear industry is not mature at all when it comes to cyber-security—it's barely starting to deal with the issue."

"A cyberattack that takes two or three nuclear power plants offline could definitely cause major blackouts in the United States," says Baylon. "And if you look at a country like

France, where 60 to 70 “ percent of its power comes from nuclear, a cyberattack could be even more serious.”

“For instance, the researchers found that the conventional belief that all nuclear facilities are “air-gapped,” or isolated from the public Internet, is a myth. In recent years, many nuclear facilities have developed some form of Internet connectivity so nuclear plants can transmit data to, say, the head offices of those nuclear facilities, or to government regulatory agencies. The 2003 infection of the Davis-Besse nuclear plant with the Slammer worm happened when the malware spread over virtual private networks (VPN) connecting the nuclear plant with the home laptop of an engineer working for a subcontractor.”

“Even when nuclear facilities are air-gapped, this safeguard can be overcome with nothing more than a flash drive. This was the most likely route by which the Stuxnet worm infected the Iranian nuclear program.”

“In addition, nuclear plant personnel typically do not understand cyber-security procedures, often because the procedures are not clearly written. Furthermore, nuclear plant personnel often do not regularly practice cyber-security procedures in drills.”

“The researchers note that the nuclear industry adopted digital systems relatively late. One reason involved regulatory restrictions; another involved the very high costs of running nuclear plants, which meant that equipment in nuclear facilities is often kept in

service for decades instead of replaced regularly. Baylon and her colleagues suggest the nuclear industry's delay in adopting digital systems resulted in a lower level of cybersecurity experience than is the case in other industries. They also suggest the nuclear industry's longstanding focus on physical safety and protection may have contributed to less attention to cybersecurity. "

"In light of these findings, the researchers propose a number of recommendations to improve nuclear cybersecurity. For example, they suggest that governments can establish computer emergency response teams specialized in defending industrial control systems. Nuclear facilities can also anonymously share reports of cyberattacks against them in order to raise awareness of threats while protecting their reputations. The researchers also suggest that nuclear facilities promote "good IT hygiene," including practices such as changing the factory default passwords on equipment, and making certain that there are manual backups for critical systems in the event of a failure."

"The worst-case scenario the researchers analyzed—a cyberattack that triggered the release of radioactive material—may not be an immediate threat. "Such an attack is on the level of states against states, such as the U.S. and Russia and the U.K, which have a sort of gentleman's agreement to not attack each others' nuclear power plants," Baylon says. "Almost no state wants to open that can of worms right now, although with rogue states like North Korea, no one ever knows what they might do."

“For me, the really scary scenario is when a well-financed terrorist group like ISIS meets a hacker-for-hire company like the kind seen in Russia that may be extremely sophisticated and not have a lot of ethics,” Baylon says. "We need to address the cyber-security vulnerabilities in the nuclear sector immediately.”

DONT TURN OUT THE LIGHT AND GO HOME

With the economic outlook for nuclear power being so unprofitable, utilities are closing down plants long before they planned to, and since some countries are moving away from it totally a lot of plants are being shuttered. Around the world there are 148 reactors are waiting to be decommissioned and only 16 have been completely dismantled and the site decontaminated. The process of decommissioning a plant is no simple task and in the US the industry can still collect taxpayer subsidies even though the plant is no longer producing energy. There are regulations on the books that require utilities to pay into accounts set aside to cover decommissioning costs, but many have failed to contribute to them and as a result the accounts have been historically underfunded. The amount of the underfunding was estimated to be $1.6 billion dollars in 2008.

Decommissioning is a relatively new process for the industry and not completely understood. The cost of doing it is much more expensive than it was estimated to be, and the length of time it takes to do it is much longer than previously assumed. As long as a site has nuclear waste stored there the process isn’t over because it must be

secured and maintained safely until a safe repository is created for it. Many plants that have been shut down for many years still store very large amounts of highly radioactive waste because no safe, permanent solution has been found for waste.

The decommissioning process can be put on hold for as long as 60 years , doing only the minimum to protect the radioactive waste from theft or accidents, while the industry continues to collect their taxpayer subsidies and invest them in the stock market.

Beyond Nuclear wrote about the difficulties surrounding the international and local decommissioning process is encountering on April 27, 2016, ”It has never been more apparent that the skyrocketing costs to dismantle closed nuclear power stations are alarmingly similar to the unpredictable and now prohibitively high cost to build atomic plants. Of more concern, the decommissioning funds needed to clean up radioactive reactor sites are steadily shrinking each year.”

“Decommissioning cost estimates have outpaced inflation fourfold since 1988. Permanent reactor closures are anticipated to continue because of increasingly poor performance of nuclear economics and mounting safety concerns. The next nuclear accident will accelerate closures even faster widening the gap between what's on hand and what is really needed to "de-license" these radiological hulks.”

“How and when these mounting nuclear decommissioning costs get paid for and by whom was the subject of an international symposium of the Organization of Economic

Development and Cooperation's Nuclear Energy Agency (NEA) in Paris, France on April 22, 2016. Beyond Nuclear's Paul Gunter was invited by NEA to participate as a panelist with industry and regulators to present some of civil societies' growing concerns on failing decommissioning finances. The next day, Paul was also invited to speak at an anti-nuclear demonstration in western France's controversial decommissioning site of the Brennilis nuclear power station for the 30th commemoration of the Chernobyl catastrophe. The 70 MWe Brennilis nuclear power plant was permanently shutdown in 1985. After spending 480 million Euros ($542.5 million), Brennilis still sits in decommissioning limbo and is not scheduled to complete dismantlement until 2035 at even greater cost. Currenty 146 other closed reactors around the world remain on a decommissioning waiting list with only 16 reactors to date completing the dismantlement process. However, indeterminate nuclear waste storage continues on many of these sites".

"The Beyond Nuclear message at both events was the same. There is a growing consensus among civil society that the "polluter must pay" by providing adequate decommissioning funds at the time of reactor closure for prompt dismantlement, not prolonged delay sixty years into the future as the current regulatory options provide. The real cost of decommissioning radioactive reactors and cleaning up contaminated sites is emerging as a huge and long hidden subsidy in avoided cost that has artifically priced atomic generated electricity." "Limited Liabiity Company (LLC) restructuring must now be viewed as the prelude to corporate malfeasance to shift the burden of decommissioning cost shortfalls from the parent company and their shareholders to the

public. In order to ensure that decommissioning and its financing is a transparent process in the best interest of public health and safety, civil society must have meaningful participation in a regulatory approval process that includes a detailed site-specific decommissioning plan and a supplemental environmental review. The decommissioning plan needs to be informed with cost specificity at all of its phases."

"Even then, decommissioning is likely to remain a financial iceberg where much more cost remains below the surface literally in ground and water contamination cleanup costs. As the States of Vermont, Connecticut, Massachusetts and New York have already identified by historical experiece, the corporate parent should be required to secure a financial guarantee on 200% of these best decommissioning cost estimates. Given that no nuclear power plant decommissioning process is complete as long as radioactive waste remains on-site, licensees and parent companies need to be held accountable for the cost of transfer of highly radioactive spent fuel currently in vulnerable tightly-packed wet storage pools into qualified dry casks in hardened on-site storage (HOSS) as the 5-year minimum cooling time period for irradiated fuel permits."

ALL DRESSED UP AND NOWHERE TO GO

There is no more vexing problem created by to the nuclear industrial complex than the problem of what to do with all of the radioactive waste it produces. The Nuclear Energy Institute's report explains how much nuclear waste is produced in the US,

“Used Nuclear Fuel and High-Level Radioactive Waste”

“A typical nuclear power plant in a year generates 20 metric tons of used nuclear fuel. The nuclear industry generates a total of about 2,000 - 2,300 metric tons of used fuel per year”.
“Over the past four decades, the entire industry has produced 76,430 metric tons of used nuclear fuel. If used fuel assemblies were stacked end-to-end and side-by-side, this would cover a football field about eight yards deep.”

“High-level radioactive waste is the byproduct of recycling used nuclear fuel, which in its final form will be disposed of in a permanent disposal facility. NEI supports the recycling of used nuclear fuel as part of its integrated fuel management strategy, which includes 1) interim storage 2) research, development and demonstration to recycle nuclear fuel, and 3) development of a permanent disposal facility suitable for the final waste form.”

Low-Level Radioactive Waste

“Low-level radioactive waste (LLRW) consists of items that have come in contact with radioactive materials, such as gloves, personal protective clothing, tools, water purification filters and resins, plant hardware, and wastes from reactor cooling-water cleanup systems. It generally has levels of radioactivity that decay to background radioactivity levels in less than 500 years. About 95 percent decays to background levels within 100 years or less.”

“The NRC has adopted a waste classification system for low-level radioactive waste based on its potential hazards, and has specified disposal and waste form requirements for each of the general classes of waste: Class A, Class B and Class C waste. Although the classification of waste can be complex, Class A waste generally contains lower concentrations of long half-lived radioactive material than Class B and C wastes. For more information see the Nuclear Regulatory Commission.”

Active low-level waste licensed disposal facilities include the following:

- “Barnwell, located in Barnwell, SC. Previously, Barnwell accepted waste from all U.S. generators. As of July 2008, Barnwell only accepts waste from the Atlantic Compact States (Connecticut, New Jersey, and South Carolina). Barnwell is licensed by the State of South Carolina to receive all classes of LLRW.”

- “Compact Waste Facility, located in Andrews County, TX. Waste Control Specialists
- LLC operates the Compact Waste Facility site. The site is owned and licensed by the state of Texas and is able to receive all classes of LLRW.”

- “Energy Solutions, located in Clive, UT. Energy Solutions accepts waste from all regions of the United States. It is licensed by the State of Utah for Class A waste only.”

- “Hanford, located in Hanford, WA. Hanford accepts waste from the Northwest and Rocky Mountain compacts. Hanford is licensed by the State of Washington to receive all classes of LLRW.”

In addition to these dedicated sites, radioactive waste is also kept at the nuclear facilities around the country, mostly in “spent fuel ponds”, and a lesser amount in safer, more costly “dry cask containment”.

The Union of Concerned Scientists explains how the storage methods each work:

“What are spent fuel pools?”

“When fuel rods in a nuclear reactor are “spent,” or no longer usable, they are removed from the reactor core and replaced with fresh fuel rods. The spent fuel rods are still highly radioactive and continue to generate significant heat for decades. The fuel assemblies, which consist of dozens to hundreds of fuel rods each, are moved to pools of water to cool. They are kept on racks in the pool, submerged in more than twenty feet of water, and water is continuously circulated to draw heat away from the rods and keep them at a safe temperature.”

“Because no permanent repository for spent fuel exists in the United States, reactor owners have kept spent fuel at the reactor sites. As the amount of spent fuel has increased, the Nuclear Regulatory Commission has authorized many power plant

owners to increase the amount in their storage pools to as much as five times what they were designed to hold. As a result, virtually all U.S. spent fuel pools have been “re-racked” to hold spent fuel assemblies at densities that approach those in reactor cores.In order to prevent the spent fuel from going critical, the spent fuel assemblies are placed in metal boxes whose walls contain neutron-absorbing boron.”

“What are the risks and vulnerabilities?”

“If a malfunction, a natural disaster, or a terrorist attack causes the water to leak from the pool or the cooling system to stop working, the rods will begin to heat the remaining water in the pool, eventually causing it to boil and evaporate. If the water that leaks or boils away cannot be replenished quickly enough, the water level will drop, exposing the fuel rods.”

“Once the fuel is uncovered, it could become hot enough to cause the metal cladding encasing the uranium fuel to rupture and catch fire, which in turn could further heat up the fuel until it suffers damage. Such an event could release large amounts of radioactive substances, such as cesium-137, into the environment. This would start in more recently discharged spent fuel, which is hotter than fuel that has been in the pool for a longer time. A typical spent fuel pool in the United States holds several hundred tons of fuel, so if a fire were to propagate from the hotter to the colder fuel a radioactive release could be very large.”

“The spent fuel pools in boiling-water reactors are located only within the secondary containment of the reactor—the reactor building—and not within the more robust primary containment that is designed to keep radiation released from the reactor vessel during an emergency event from escaping into the environment. Thus, any radiation released from a spent fuel pool is more likely to reach the outside environment than is radiation released from the reactor core. Moreover, because it is outside the primary containment, the spent fuel pool is more vulnerable than the reactor core to certain terrorist attacks like deliberate aircraft crashes.”

“Continuing to add spent fuel to these pools compounds this problem by increasing the amount of radioactive material that could be released into the environment. A large radiation release from a spent fuel pool could release more cesium-137 than the Chernobyl disaster, resulting in thousands of cancer deaths and hundreds of billions of dollars in decontamination costs and economic damage.”

“Advantages of dry cask storage”

“The risks from spent fuel in storage pools can be reduced by moving some of it to dry casks. Typical dry casks are made of steel and concrete, with the concrete providing radiation shielding , and are stored at U.S. reactors outdoors on concrete pads. To become cool enough to be placed in the dry casks currently licensed and used in the United States, the spent fuel must first spend five years in a spent fuel pool. By then it is

cool enough that further cooling can be accomplished by natural convection—air flow driven by the decay heat of the spent fuel itself."

"By transferring fuel from spent fuel pools to dry casks, plants can lower the risk from spent fuel in several ways:"

- "With less spent fuel remaining in the pools, workers will have more time to cope with a loss of cooling or loss of water from the pool, because the amount of heat released by the spent
- fuel is lower. With less heat, it takes longer for the water to heat up and boil away."
- "If there is less fuel in the pool, it can be spread out more, making it easier for the fuel to be cooled by water, or even air if the pool is rapidly drained after an accident."
- "Because there is less fuel in the pool, if workers are unable to prevent an accident, the amount of radioactive material emitted from the pool will be much lower than it would be otherwise".

"After the 9/11 attacks, the NRC imposed new requirements on reactor owners to reduce the risks of aircraft attacks on both reactors and spent fuel pools. In particular, it required that hotter spent fuel should be dispersed throughout the pool instead of being concentrated in one spot. It also required the development of strategies for providing backup water supplies to the pools in the event of an aircraft attack. However, these measures do not go far enough to ensure the safety of the pools under a wide range of accident and attack scenarios."

“The combination of reducing the likelihood of an event and reducing the consequences of an event significantly reduces the risk from a spent-fuel accident. In contrast to spent fuel pools, dry casks are not vulnerable to loss of coolant because their cooling is passive.”

“While dry casks are still vulnerable to safety and security hazards, those risks are reduced. In contrast to the large amount of fuel in a single spent fuel pool, each dry cask only holds 10 to 15 tons of spent fuel, or only a few percent of a typical spent fuel pool. Thus, it would require safety failures at many dry casks to produce the scale of radiological release that could result from a safety failure at one spent fuel pool. Likewise, terrorists would have to break open many dry casks to release as much radioactivity as a single spent fuel pool could release. Therefore, an attack on a dry cask storage area would, in most circumstances, result in a much smaller release of radioactivity than an attack on a storage pool.”

“UCS recommendations”

- “All spent fuel should be transferred from wet to dry storage within five years of discharge from the reactor core. This can be achieved with existing technologies.”
- “The NRC should upgrade existing regulations to require that dry cask storage sites be made more secure against a terrorist attack.”

YUCCA MOUNTAIN

Besides Three Mile Island, this site is perhaps the one that is most identified with nuclear power. Wikipedia describes the controversial mountain like this,"The Yucca Mountain Nuclear Waste Repository, as designated by the Nuclear Waste Policy Act amendments of 1987, was to be a deep geological repository storage facility for spent nuclear fuel and other high level radioactive waste. The site is located on federal land adjacent to the Nevada Test Site in Nye County, Nevada, about 80 mi (130 km) northwest of the Las Vegas Valley."

"The project was approved in 2002 by the United States Congress, but Federal funding for the site ended in 2011 under the Obama Administration via amendment to the Department of Defense and Full-Year Continuing Appropriations Act, passed on April 14, 2011. The project has had many difficulties and was highly contested by the general public and many politicians. The Government Accountability Office stated that the closure was for political, not technical or safety reasons…."

"The DOE began studying Yucca Mountain in 1978 to determine whether it would be suitable for the nation's first long-term geologic repository for over 70,000 metric tons (69,000 long tons; 77,000 short tons) (150 million pounds) of spent nuclear fuel and high-level radioactive waste as of 2015 stored at 121 sites around the nation. An estimated 10,000 metric tons (9,800 long tons; 11,000 short tons) of the waste would be from America's military nuclear programs. On December 19, 1984, the DOE selected

ten locations in six states for consideration as potential repository sites, based on data collected for nearly ten years. The ten sites were studied and results of these preliminary studies were reported in 1985. Based on these reports, President Ronald Reagan approved three sites for intensive scientific study called site characterization. The three sites were Hanford, Washington; Deaf Smith County, Texas; and Yucca Mountain. In 1987, Congress amended the Nuclear Waste Policy Act and directed DOE to study only Yucca Mountain, which is located within a former nuclear test site. The Act provided that if during site characterization the Yucca Mountain location was found unsuitable, studies would be stopped immediately. This option expired when the site was actually recommended by the President. On July 23, 2002, President George W. Bush signed House Joint Resolution 87, (Pub.L. 107–200) allowing the DOE to take the next step in establishing a safe repository in which to store the country's nuclear waste. The DOE was to begin accepting spent fuel at the Yucca Mountain Repository by January 31, 1998 but did not do so because of a series of delays due to legal challenges, concerns over how to transport nuclear waste to the facility, and political pressures resulting in underfunding of the construction…."

"The purpose of the Yucca Mountain project is to comply with the Nuclear Waste Policy Act of 1982 and develop a national site for spent nuclear fuel and high-level radioactive waste storage. The management and operating contractor as of April 1, 2009 for the project is USA Repository Services, a consortium of government contractors, URS Corporation, Shaw Corporation and Areva Federal Services LLC. After the layoff of 800 employees on March 31, 2009, about 100 employees remained on the project until all

technical staff were laid off by the end of FY 2010 due to zero funding in the 2011 budget for the Office of Civilian Radioactive Waste Management.[20] Sandia National Laboratories had the responsibility for post closure analysis and ensuring compliance with the NWPA. The main tunnel of the Exploratory Studies Facility is U-shaped, 5 mi (8.0 km) long and 25 ft (7.6 m) wide. There are also several cathedral-like alcoves that branch from the main tunnel. It is in these alcoves that most of the scientific experiments were conducted. The emplacement drifts (smaller diameter tunnels branching off the main tunnel) where waste would have been stored were not constructed since they required a construction authorization by the Nuclear Regulatory Commission. The repository has a statutory limit of 77,000 metric tons (85,000 short tons). To store this amount of waste would have required 40 miles (64 km) of tunnels. The Nuclear Waste Policy Act further limits the capacity of the repository to 63,000 metric tons (62,000 long tons; 69,000 short tons) of initial heavy metal in commercial spent fuel. The 104 U.S. commercial reactors currently operating will produce this quantity of spent fuel by 2014, assuming that the spent fuel rods are not reprocessed. Currently, the US has no civil reprocessing plant…."

"The project is widely opposed in Nevada and is a hotly debated national topic. A two-thirds majority of Nevadans feel it is unfair for their state to have to store nuclear waste when there are no nuclear power plants in Nevada. Many Nevadans' opposition stemmed from the so-called "Screw Nevada Bill," the 1987 legislation halting study of Hanford and Texas as potential sites for the waste before conclusions could be made.

[The local county in which the proposed facility is located, Nye County, supports the development of the repository as do six adjoining counties…."

'The United States Environmental Protection Agency (EPA) established its Yucca Mountain standards in June 2001. The storage standard set a dose limit of 15 millirem per year for the public outside the Yucca Mountain site. The disposal standards consisted of three components: an individual dose standard, a standard evaluating the impacts of human intrusion into the repository, and a groundwater protection standard. The individual-protection and human intrusion standards set a limit of 15 millirem per year to a reasonably maximally exposed individual, who would be among the most highly exposed members of the public. The groundwater protection standard is consistent with EPA's Safe Drinking Water Act standards, which the Agency applies in many situations as a pollution prevention measure. The disposal standards were to apply for a period of 10,000 years after the facility is closed. Dose assessments were to continue beyond 10,000 years and be placed in DOE's Environmental Impact Statement, but were not subject to a compliance standard. The 10,000 year period for compliance assessment is consistent with EPA's generally applicable standards developed under the Nuclear Waste Policy Act. It also reflects international guidance regarding the level of confidence that can be placed in numerical projections over very long periods of time.

Inconsistent standards….."

“Shortly after the EPA first established these standards in 2001, the nuclear industry, several environmental and public interest groups, and the State of Nevada challenged the standards in court. In July 2004, the Court of Appeals for the District of Columbia Circuit found in favor of the Agency on all counts except one: the 10,000 year regulatory time frame. The court ruled that EPA’s 10,000-year compliance period for isolation of radioactive waste was not consistent with National Academy of Sciences (NAS) recommendations and was too short. The NAS report had recommended standards be set for the time of peak risk, which might approach a period of one million years. By limiting the compliance time to 10,000 years, EPA did not respect a statutory requirement that it develop standards consistent with NAS recommendations”.…

“EPA published in the Federal Register a final rule in 2009. The new rule limits radiation doses from Yucca Mountain for up to 1,000,000 years after it closes. Within that regulatory time frame, the EPA has two dose standards that would apply based on the number of years from the time the facility is closed….”

“For the first 10,000 years, the EPA would retain the 2001 final rule’s dose limit of 15 millirem per year. This is protection at the level of the most stringent radiation regulations in the U.S. today. From 10,000 to one million years, EPA established a dose limit of 100 millirem per year. EPA's rule requires the Department of Energy to show that Yucca Mountain can safely contain wastes, considering the effects of earthquakes, volcanic activity, climate change, and container corrosion, over one million years. The

current analysis indicates that the repository will cause less than 1 mrem/year public dose through 1,000,000 years…."

"During his 2008 presidential campaign, Barack Obama promised to abandon the Yucca Mountain project. As a result, Senator Reid moved the Nevada primary to help Obama's campaign. After his election, the Nuclear Regulatory Commission told Obama he did not have the ability to do so. On April 23, 2009, Lindsey Graham (R-South Carolina) and eight other senators introduced legislation to provide "rebates" from a $30 billion federally managed fund into which nuclear power plants had been paying, so as to refund all collected funds if the project was in fact cancelled by Congress…."

"In November 2013, in response to a lawsuit filed by the National Association of Regulatory Utility Commissioners and the Nuclear Energy Institute, the US court of appeals ruled that nuclear utilities may stop paying into the nuclear waste recovery fund until either the DOE follows the Nuclear Waste Policy Act, which designates Yucca Mountain as the repository, or Congress changes the law. The fee ended May 16, 2014."

HANFORD

Wikipedia details Hanford's history and the unfathomable amount of radioactive waste stored there this way,"The Hanford Site is a mostly decommissioned nuclear production

complex operated by the United States federal government on the Columbia River in the U.S. state of Washington. The site has been known by many names, including: Hanford Project, Hanford Works, Hanford Engineer Works and Hanford Nuclear Reservation. Established in 1943 as part of the Manhattan Project in Hanford, south-central Washington, the site was home to the B Reactor, the first full-scale plutonium production reactor in the world. Plutonium manufactured at the site was used in the first nuclear bomb, tested at the Trinity site, and in Fat Man, the bomb detonated over Nagasaki, Japan."

"During the Cold War, the project expanded to include nine nuclear reactors and five large plutonium processing complexes, which produced plutonium for most of the more than 60,000 weapons in the U.S. nuclear arsenal. Nuclear technology developed rapidly during this period, and Hanford scientists produced major technological achievements. Many early safety procedures and waste disposal practices were inadequate, and government documents have confirmed that Hanford's operations released significant amounts of radioactive materials into the air and the Columbia River".

"The weapons production reactors were decommissioned at the end of the Cold War, and decades of manufacturing left behind 53 million US gallons (200,000 m3) of high-level radioactive waste[4] stored within 177 storage tanks, an additional 25 million cubic feet (710,000 m3) of solid radioactive waste, and 200 square miles (520 km2) of contaminated groundwater beneath the site.[5] In 2011, DOE emptied 149 single-shell tanks by pumping nearly all of the liquid waste out into 28 newer double-shell tanks.

DOE later found water intruding into at least 14 single-shell tanks and that one of them had been leaking about 640 US gallons (2,400 l; 530 imp gal) per year into the ground since about 2010. In 2012, DOE discovered a leak also from a double-shell tank caused by construction flaws and corrosion in the bottom, and that 12 double-shell tanks have similar construction flaws. Since then, DOE changed to monitoring single-shell tanks monthly and double-shell tanks every 3 years, and also changed monitoring methods. In March 2014, DOE announced further delays in the construction of the Waste Treatment Plant, which will affect the schedule for removing waste from the tanks. Intermittent discoveries of undocumented contamination have slowed the pace and raised the cost of cleanup."

"In 2007, the Hanford site represented two-thirds of the nation's high-level radioactive waste by volume. Hanford is currently the most contaminated nuclear site in the United States and is the focus of the nation's largest environmental cleanup. Besides the cleanup project, Hanford also hosts a commercial nuclear power plant, the Columbia Generating Station, and various centers for scientific research and development, such as the Pacific Northwest National Laboratory and the LIGO Hanford Observatory."

Nuclear News reported on June 8, 2016 about unhealthy working conditions at the site, "After a 33 year career at Hanford working in the tank farms, Abe Garza of Richland is off the job and he'll never work again. He has permanent lung damage and brain damage from exposure to toxic chemical vapors at the jobsite. On some days the gasping for air and coughing is so violent he passes out."

“It feels like an elephant is sitting on my chest,” said Garza.”

“The damage to his brain has left him unable to drive and remember simple tasks. Once an avid reader of classic novels and books on mathematics, it’s now difficult for Garza to read any kind of material. According to his wife, the chemical exposures have turned their lives upside down”.

“(It’s) devastate our lives,” said Garza’s wife, Bertolla Bugarin.”

“Garza is one of an unknown number of current and former Hanford workers who suffer debilitating health effects because of a decades old problem of chemical vapors venting from underground nuclear waste tanks at the former plutonium production facility. Since April 28, 51 workers, a record number, have suspected they’ve been exposed to vapors. Some are still too sick to return to work, mostly due to breathing problems.”

“Despite findings by doctors that workers such as Abe Garza are sick as a direct result of exposure to chemical vapors, top managers from the U.S. Dept. of Energy, which owns Hanford, and its contractor in charge of the tank farms, Washington River Protection Solutions (WRPS), report their testing of the airspace after exposures always shows very small amounts of chemical concentrations”.

“Air samples taken yesterday in two areas where odors were reported indicated chemical concentrations well below regulatory standards,” said WRPS spokesperson

Rob Roxburgh in a statement on May 5, 2016 after nine people went to the onsite medical clinic due to suspected exposures in two separate locations".

"This has been the message from management to the workforce for decades at Hanford. In his 33 year career, Garza said he was consistently reassured in trainings that chemical vapors were in control at the site and always measured at acceptable levels. He said the chemical hazard trainers never mentioned readings of chemical concentrations measured at unsafe levels".

"I've never heard anybody say anything about that," said Garza. "When they tell you what's safe you would think that that's (the truth)."

The Nuclear News reported in May 2016 about the situation at Hanford and stated, "26 workers have now been affected by the radioactive fumes leaking from the Hanford nuclear site in the US state of Washington since April 17, 2016. After several years of radioactive waste leaking, the amount grew dramatically that day when 13 000 liters (3 500 gallons) of new waste was reported. The six affected workers sought medical attention, after being exposed to the odors about a week ago, according to media reports."

"The Hanford nuclear site on the Columbia River, in the state of Washington, stores 56 million gallons of radioactive waste left over from the plutonium processing, used in the

US nuclear weapons project since the Manhattan Project, in underground tanks. About two-thirds of the radioactive waste is estimated to have been stored in the tanks built in the period between the 1940's and 1970's."

"According to Gerry Pollet, the State Representative, these tanks were not meant to last over ten to twenty years, and an explosion was already reported from some of them in the 1950s: "They [tanks] were not supposed to last more than ten to twenty years, twenty years was a dream in the first place. Some of them didn't last twenty years, and we had a small explosion in the 1950s where hot waste boiled, created a steam explosion under the tank, and we were lucky we didn't have half of Eastern Washington permanently evacuated."

"The massive leak in question occurred at the double-shell storage AY-102, which was already leaking small amounts of nuclear waste since 2011. According to experts' estimates, approximately 265 liters (70 gallons) of waste has leaked during the last couple of years."

"The sickening odors, reported by the affected workers, are associated with the vapors coming from the chemical waste and have likely resulted from the transfer of waste. The "The sickening odors, reported by the affected workers, are associated with the vapors coming from the chemical waste and have likely resulted from the transfer of waste. The transfer has stopped until the new equipment gets installed. All 26 of the workers have

now returned to work. However, their health issues may be not only temporary but could also suffer some long-term consequences."

"Hanford created the largest inventory of high-level nuclear waste in the nation, and unhappily that waste is currently stored in leaking underground nuclear waste tanks. Now we are starting to see those failing. It is an environmental disaster. At some point, the river becomes so contaminated that you can't use the river," stated ecologist Tom Carpenter."

"To ensure the safety of workers, Bob Ferguson, Washington's Attorney General has engaged in a lawsuit against the Department of Energy and the Hanford tank farm contractor in Septemeber 2015 and is now exploring other legal options, according to the statement on April 3. He hopes that President Barack Obama and US Energy Secretary Ernest Moniz will personally engage in this issue."

"What's happening at Hanford isn't right, and I am exploring further legal options to keep our workers safe," Ferguson stated."

PSR / BUS RIDE TO AUGUSTA

Physicians for Social Responsibility provided this testimony before the NRC in Augusta,"What to do with the 67,000 tons of irradiated fuel we have created in the U.S. is a major concern to reactor communities all across this country, as well as those

communities who know that they are being considered for some kind of nuclear waste disposal site. The failure of Yucca Mountain has brought into sharp relief the problems of isolating long lived radioactive materials from the biosphere. Radioactive materials seeping into water tables over time should be a major concern to this body. Every conceivable step must be taken to see that these long lived, highly carcinogenic materials do not enter our present or future water supply and food chain."

"Why would we or any state allow another DOE project to create more radioactive waste when there's already such a legacy of failed solutions and broken promises?"

"The 36 million gallons of high level waste (HLW) still awaiting disposition at Savannah River Site are significant and problematic after decades of attempts to clean them up. Some of the High Level Waste in those tanks that was originally going to be removed from our state was "re-classified" by a last minute, non-debated amendment to the 2004 Defense Authorization Bill, allowing what was previously considered High Level Waste to be re-named "Waste Incidental to Reprocessing (WIR), thereby allowing millions of curies to be orphaned at the Savannah River Site, a high water table location, sitting atop the Tuscaloosa aquifer, distinctly unsuited and dangerous for long term storage of long lived radioactive nuclides. The current method of WIR disposition is simply to mix the waste with grout, pour it into concrete vaults, cover it with earth and leave it forever. Waste left at the bottom of the corroded tanks is also grouted and left in place."

“Around the world, reprocessing has created a worldwide stockpile of 215 metric tons of weapons- usable plutonium. Our start-up of reprocessing would signal to the rest of the world the acceptance of this dangerous technology as a solution to the waste problem, when it simply heightens the risk of proliferation activities.”

“Military reprocessing in the U.S., at Hanford, Washington, The Idaho National Laboratory, and The Savannah River Site have left behind radioactive wastes that will cost hundreds of billions of dollars over time to deal with, while risking major water bodies and aquifers. The six year experiment of reprocessing commercial irradiated fuel a West Valley New York, resulted in continuing radioactive contamination of the surrounding soils and waters that now threatens Lakes Erie and Ontario downstream, and is costing tax payers billions for clean up. In France, The La Hague reprocessing facility discharges hundreds of millions of liters per year of radioactively contaminated liquid waste into the English Channel via an underwater pipeline.

Similar environmental assaults have taken place a Britain’s Sellafield reprocessing facility, where 1,000 pounds of ultra-hazardous plutonium have been dumped into the Irish Sea, traces of which have been found in children’s teeth hundreds of miles away. The Russian reprocessing site at Mayak is the most contaminated geographical location in Russia. The Japanese reprocessing plant at Rokkushu has topped $20 billion and still isn’t working .Japan Nuclear Fuel Ltd. Announced in October that they will delay full scale start up by two more years. This is the 18th postponement of the project, and will leave it 15 years behind schedule….”

DEPLETED URANIUM

Wikipedia described depleted uranium and it's toxic properties this way,"Depleted uranium (DU; also referred to in the past as Q-metal, depletalloy or D-38) is uranium with a lower content of the fissile isotope U-235 than natural uranium.[2] (Natural uranium contains about 0.72% of its fissile isotope U-235, while the DU used by the U.S. Department of Defense contain 0.3% U-235 or less). Uses of DU take advantage of its very high density of 19.1 g/cm3 (68.4% denser than lead). Civilian uses include counterweights in aircraft, radiation shielding in medical radiation therapy and industrial radiography equipment, and containers for transporting radioactive materials. Military uses include armor plating and armor-piercing projectiles".

"Most depleted uranium arises as a by-product of the production of enriched uranium for use as fuel in nuclear reactors and in the manufacture of nuclear weapons. Enrichment processes generate uranium with a higher-than-natural concentration of lower-mass-number uranium isotopes (in particular U-235, which is the uranium isotope supporting the fission chain reaction) with the bulk of the feed ending up as depleted uranium, in some cases with mass fractions of U-235 and U-234 less than a third of those in natural uranium. Since U-238 has a much longer half-life than the lighter isotopes, DU emits less alpha radiation than natural uranium. DU from nuclear reprocessing has different isotopic ratios from enrichment–by-product DU, from which it can be distinguished by the presence of U-236."

“DU used in US munitions has 60% of the radioactivity of natural uranium.Trace transuranics (another indicator of the use of reprocessed material) have been reported to be present in some US tank armor.”

“The use of DU in munitions is controversial because of concerns about potential long-term health effects. Normal functioning of the kidney, brain, liver, heart, and numerous other systems can be affected by exposure to uranium, a toxic metal. It is only weakly radioactive because of its long radioactive half-life (4.468 billion years for uranium-238, 700 million years for uranium-235; or 1 part per million every 6446 and 1010 years, respectively). The biological half-life (the average time it takes for the human body to eliminate half the amount in the body) for uranium is about 15 days. The aerosol or spallation frangible powder produced by impact and combustion of depleted uranium munitions can potentially contaminate wide areas around the impact sites, leading to possible inhalation by human beings.”

“The actual level of acute and chronic toxicity of DU is also controversial. Several studies using cultured cells and laboratory rodents suggest the possibility of leukemogenic, genetic, reproductive, and neurological effects from chronic exposure. A 2005 epidemiology review concluded: "In aggregate the human epidemiological evidence is consistent with increased risk of birth defects in offspring of persons exposed to DU.”

Global Research wrote this scathing article on the illegal use of DU, “Depleted Uranium or DU encased bombs that have been used since 1991 by US and NATO forces knowing well that the use of DU weapons is illegal being weapons of mass destruction [WMD] and amounts to War Crimes. These weapons were used in Gulf War 1 against Iraq, then in the Balkans and later, after 9/11 events, in Afghanistan, Iraq, North Africa, Libya and now being used in Drone bombings in Pakistan…..

“Depleted Uranium’ has nothing depleted about it: when this potent hard metal hits a solid surface like concrete or a battle tank, the temperature at the point of impact reaches over 40000C and turns the projectile into uranium oxide gas. These gases are picked up by the wind and carried all over the world creating vast areas of secondary contamination. Based on the population within the contamination map, over 35% of India’s population received a heavy dosing of DU aerosolized uranium nano particles within months of the start of Afghan and Iraq wars. “

“The total estimated population within the two circles is nearly a billion. ‘The capitals of 19 countries are within 1000 mile radius and include New Delhi (621 miles), Islamabad (232), Bishkek (651), Beirut (515), Cairo (806), Ankara (785), Jerusalem (546), Damascus (468), Kuwait City (347), Nicosia (643), Teheran (429), Abu Dhabi (856), Amman (503), Riyadh (615), Ashgabat (645) and so on.’ Countries like India, Pakistan, Nepal, Afghanistan, Iraq, and some Central Asian States do not even have well established, dependable cancer screening facilities, let alone determining whether the illness is due to depleted uranium contamination…..

“The total land area of earth is about 57.3 million square mile, which implies that roughly 8% of total land area is now contaminated. Add another 6-8% of the landmass within 1000 mile radius of Bosnia, Kosovo, Libya, and Sudan and you can guess that the entire West, Central and South Asia, half of Northern Africa and almost entire Europe is contaminated with DU aerosolized nano particles. Even the Indian armed forces are using these lethal weapons and they won’t even know why they died in peacetime. According to one report DU weapons have been sold to 27 countries and India is one of them”.

“According to Admiral Vishnu Bhagwat: “The long-term effects from over a decade of DU exposures are emerging in Southern Iraq. They are devastating. The increased quantities of radio-active material (including non-depleted uranium), used in Afghanistan are 3 to 5 times greater than Iraq 1991. In Iraq 2003 they are already estimated to be 6 to 10 times 1991 and will travel through a larger area and affect many more people, babies and unborn. Countries within a 1000 mile radius of Baghdad and Kabul are being affected by radiation poisoning that includes the Capital, New Delhi..”…”
“Each time southwesterly air currents rise up over North Africa and West Asia, they pick up radioactive nano particles and blow right across India. These winds also blow across the Himalayas where these particles are rained out or snowed out. These particles are carried by the perennial Himalayan Rivers irrigate the agriculture lands that feed 1.6 billion Asians. I know these parts”.

“Nine days after the start of the American president’s 2003 ‘shock and awe’ uranium bombing campaign in Baghdad, an invisible radioactive uranium oxide gas cloud swept through Britain’s towns and countryside and throughout Europe.” Scientists like Dr. Chris Busby and Saoirse Morgan, shocked Europe in a Sunday Times of London article on Feb. 19, 2006 that Aldermaston radiation monitoring centre which Dr. Busby oversaw, had shown high level of radiation. By tracking airflow pattern from West Asia to Europe during the time period, they came to a conclusion that the radiation level was high from the bombing raids over Iraq..

“Bob Nichols says, “The deadly uranium oxide gas measured about 48,000 radioactive particles per square meter. The average radioactive dose, according to official government index based calculations, was about 23 million radioactive particles for the average adult male in Britain and Europe.” That is sufficient dosing to turn the entire population sterile….”

“In so far as India, South Asia, and the Himalayas are concerned, the airflow patterns from West Asia are regularly reported in major national dailies. What they don’t report is that these air currents carry depleted uranium particles at low, medium, and high altitude, from West Asia, North Africa, Afghanistan and Pakistan across India, the Himalayas into China. This typical airflow pattern continues across Asia, and is carried around the world mixing with the global atmosphere within weeks…..

“Uranium isotope U238 is a natural substance and all life forms have trace amounts from ingesting food and water. Another isotope of uranium U235 is also naturally occurring substance. The ratio of naturally occurring U238 to U235 is 137.88. Human body can cope with this ratio. However, the use of depleted uranium, the primary waste product of the uranium enrichment process, in weapons upsets this ratio. Enriched and depleted uranium are both mutagenic materials; they attack DNA structure and alter it. Exposure to radiation from nuclear explosions and to the subsequent dust cloud is serious enough. The insidious aspect of the nano-particles of U235 dust is that they are very easily ingested, and being so tiny, they find their way into individual cells in the body, wreaking havoc from their constant radiation, and as a highly toxic heavy metal.”

“It means that the use of depleted uranium weapons can compromise the future quality of human population and all life forms. Responsible scientists had warned that DU weapons are WMD and must not be used. Yet DU weapons are being extensively used in Afghanistan particularly in the eastern parts, including the heavily populated Kabul and Jalalabad. Studies conducted by Uranium Medical Research Centre (UMRC) showed a ratio of 237 times in returning Gulf War I British soldiers, which ‘indicated the presence of 30-50% of DU mixed with natural uranium.”.

“During 2002 the UMRC research team conducted a series of field tests in Afghanistan. In Jalalabad it found concentrations of 400 to 2000% above normal level. At Nangarhar, the concentration was 100 to 400 times; every person donating urine sample was contaminated. Doug Westerman met the research team and this is what he reports: ‘In

Afghanistan, unlike Iraq, UMRC lab results indicated high concentrations of NON-DEPLETED URANIUM, with the concentrations being much higher than in DU victims from Iraq. Afghanistan was used as a testing ground for a new generation of “bunker buster” bombs containing high concentrations of other uranium alloys.”

“Discussions and email exchanges with UMRC team clearly showed that they were shocked by the public health impact of the use of these weapons. Dr Miraki says that every bombsite that he has visited and investigated, he finds that people are ill. The civilian population presents symptoms consistent with internal contamination by uranium.” “Asaf Durakovic, UMRC’s president and a former US army adviser, believes that exposure to DU weapons may have brought a rise in birth defects as well as “symptoms of muscular-skeletal pains, immune system disorders, lung disease, and eventually cancer.

The International Coalition to Ban Uranium Weapons campaigns to stop the use of DU, and wrote about their legal / moral repercussions:

“Are DU weapons illegal under current international law?”
“Using DU runs counter to the basic rules and principles enshrined in written and customary International Humanitarian Law. This relates among other things to:”

- “The general principle on the protection of civilian populations from the effects of hostilities.”

- “The principle that the right of the parties to an armed conflict to choose their methods or means of warfare is not unlimited.”

- “The principle that the employment in armed conflicts of weapons, projectiles, and material and methods of warfare of a nature to cause superfluous injury or unnecessary suffering is forbidden.”

- “The prohibition of the use of poisonous weapons according to Art. 23 para.1 of the Hague Regulations and the rules of the Poison Gas Protocol.”

- “The prohibition of widespread damage to the natural environment and unjustified destruction according to the Hague Regulations and the First Additional Protocol to the Geneva Conventions.”

- “The principle of ‘humanitarian proportionality’, which is contained in the St. Petersburg Declaration.”
- “Additionally both Humanitarian Law and Environmental Law are based on the principle of precaution and proportionality, which at the very least, states should adhere to. Two resolutions of the Sub-Commission to the UN Commission on

Human Rights (1996/16 and 1997/36) state that the use of uranium ammunition is not in conformity with existing International and Human Rights Law."

- "Why are we trying to explicitly ban DU weapons?"

- "Even though the use of DU weapons should already be illegal under International Humanitarian, Human rights and Environmental Laws, as has been seen with chemical and biological weapons and landmines an explicit treaty has proved the best solution for confirming their illegality and banning their production, and all other processes related to DU weapons."

- "Such a treaty would not only outlaw the use of DU weapons, but would include the prohibition of their production, the destruction of DU stockpiles, the decontamination of battlefields and rules on compensation for victims."

A DARK ENVIRONMENTAL LEGACY

Wikipedia had a detailed report on uranium mining, from which this was extracted,”Uranium mining is the process of extraction of uranium ore from the ground. The worldwide production of uranium in 2012 amounted to 58,394 tonnes. Kazakhstan, Canada, and Australia are the top three producers and together account for 64% of world uranium production. Other important uranium producing countries in excess of 1,000 tons per year are Niger, Namibia, Russia, Uzbekistan, the United States, China, and Malawi.”

“Uranium ores are normally processed by grinding the ore materials to a uniform particle size and then treating the ore to extract the uranium by chemical leaching. The milling process commonly yields dry powder-form material consisting of natural uranium, "yellowcake," which is sold on the uranium market as U3O8.

“Uranium from mining is used almost entirely as fuel for nuclear power plants. As of July 2014, the price of uranium concentrate remained near a five-year low, the uranium price having fallen more than 50% from the peak spot price in January 2011, reflecting the loss of Japanese demand following the 2011 Fukushima nuclear disaster. As a result of continued low prices, in February 2014 mining company Cameco deferred plans to expand production from existing Canadian mines, although it continued work to open a new mine at Cigar Lake. Also in February 2014, Paladin energy suspended operations

at its mine in Malawi, saying that the high-cost operation was losing money at current prices."

"Mining techniques.As with other types of hard rock mining there are several methods of extraction. The main methods of mining are box cut mining, open pit mining and In-situ leaching (ISL)."

""Open pit Rössing open pit uranium mine, Namibia
"In open pit mining, overburden is removed by drilling and blasting to expose the ore body, which is then mined by blasting and excavation using loaders and dump trucks. Workers spend much time in enclosed cabins thus limiting exposure to radiation. Water is extensively used to suppress airborne dust levels."

"Underground uranium mining"
"If the uranium is too far below the surface for open pit mining, an underground mine might be used with tunnels and shafts dug to access and remove uranium ore. There is less waste material removed from underground mines than open pit mines, however this type of mining exposes underground workers to the highest levels of radon gas."

"Underground uranium mining is in principle no different from any other hard rock mining and other ores are often mined in association (e.g., copper, gold, silver). Once the ore body has been identified a shaft is sunk in the vicinity of the ore veins, and

crosscuts are driven horizontally to the veins at various levels, usually every 100 to 150 metres. Similar tunnels, known as drifts, are driven along the ore veins from the crosscut. To extract the ore, the next step is to drive tunnels, known as raises when driven upwards and winzes when driven downwards through the deposit from level to level. Raises are subsequently used to develop the stopes where the ore is mined from the veins."

"The stope, which is the workshop of the mine, is the excavation from which the ore is extracted. Two methods of stope mining are commonly used. In the "cut and fill" or open stoping method, the space remaining following removal of ore after blasting is filled with waste rock and cement. In the "shrinkage" method, only sufficient broken ore is removed via the chutes below to allow miners working from the top of the pile to drill and blast the next layer to be broken off, eventually leaving a large hole. Another method, known as room and pillar, is used for thinner, flatter ore bodies. In this method the ore body is first divided into blocks by intersecting drives, removing ore while so doing, and then systematically removing the blocks, leaving enough ore for roof support."

"The health effects discovered from radon exposure in unventilated uranium mining prompted the switch away from uranium mining via tunnel underground mining towards open cut and In-situ leaching technology, a method of extraction that does not produce the same occupational hazards, or mine tailings, as conventional mining."

“Heap leaching”

“Heap leaching is an extraction process by which chemicals (usually sulfuric acid) are used to extract the economic element from ore which has been mined and placed in piles on the surface. Heap leaching is generally economically feasible only for oxide ore deposits. Oxidation of sulfide deposits occurs during the geological process called weathering. Therefore, oxide ore deposits are typically found close to the surface. If there are no other economic elements within the ore a mine might choose to extract the uranium using a leaching agent, usually a low molar sulfuric acid.”

“If the economic and geological conditions are right, the mining company will level large areas of land with a small gradient, layering it with thick plastic (usually HDPE or LLDPE), sometimes with clay, silt or sand beneath the plastic liner. The extracted ore will typically be run through a crusher and placed in heaps atop the plastic. The leaching agent will then be sprayed on the ore for 30–90 days. As the leaching agent filters through the heap the uranium will break its bonds with the oxide rock and enter the solution. The solution will then filter along the gradient into collecting pools which will then be pumped to on-site plants for further processing. Only some of the uranium (commonly about 70%) is actually extracted.”

“The uranium concentrations within the solution are very important for the efficient separation of pure uranium from the acid. As different heaps will yield different concentrations the solution is pumped to a mixing plant that is carefully monitored. The

properly balanced solution is then pumped into a processing plant where the Uranium is separated from the sulfuric acid."

"Heap leach is significantly cheaper than traditional milling processes. The low costs allow for lower grade ore to be economically feasible (given that it is the right type of ore body). Environmental law requires that the surrounding ground water is continually monitored for possible contamination. The mine will also have to have continued monitoring even after the shutdown of the mine. In the past mining companies would sometimes go bankrupt, leaving the responsibility of mine reclamation to the public. Recent additions to the mining law require that companies set aside the money for reclamation before the beginning of the project. The money will be held by the public to insure adherence to environmental standards if the company were to ever go bankrupt."

"Another very similar mining technique is called in situ, or in place mining where the ore doesn't even need extracting.In-situ leachingTrial well field for in-situ recovery at Honeymoon, South Australia"

"In-situ leaching (ISL), also known as solution mining, or in-situ recovery (ISR) in North America, involves leaving the ore where it is in the ground, and recovering the minerals from it by dissolving them and pumping the pregnant solution to the surface where the minerals can be recovered. Consequently, there is little surface disturbance and no tailings or waste rock generated. However, the orebody needs to be permeable to the

liquids used, and located so that they do not contaminate ground water away from the orebody."

"Uranium ISL uses the native groundwater in the orebody which is fortified with a complexing agent and in most cases an oxidant. It is then pumped through the underground orebody to recover the minerals in it by leaching. Once the pregnant solution is returned to the surface, the uranium is recovered in much the same way as in any other uranium plant (mill)."

"In Australian ISL mines (Beverley, Four Mile and Honeymoon Mine) the oxidant used is hydrogen peroxide and the complexing agent sulfuric acid. Kazakh ISL mines generally do not employ an oxidant but use much higher acid concentrations in the circulating solutions. ISL mines in the USA use an alkali leach due to the presence of significant quantities of acid-consuming minerals such as gypsum and limestone in the host aquifers. Any more than a few percent carbonate minerals means that alkali leach must be used in preference to the more efficient acid leach."

The Australian government has published a best practice guide for in situ leach mining of uranium, which is being revised to take account of international differences

On April 10, 2016, NPR filed the following report on how uranium mining affected the Navajo,"The federal government is cleaning up a long legacy of uranium mining within the Navajo Nation- some 27,000 square miles spread across Utah, New Mexico and Arizona that is home to more than 250,000 people."

“Many Navajo people have died of kidney failure and cancer, conditions linked to uranium contamination. And new research from the CDC shows uranium in babies born now.”

“Mining companies blasted 4 million tons of uranium out of Navajo land between 1944 and 1986. The federal government purchased the ore to make atomic weapons. As the Cold War threat petered out the companies left, abandoning more than 500 mines.”

“On a recent day in Flagstaff, Ariz., she asks a mother about feeding practices for her baby. Forty percent of the tribe lacks running water. Welch learns that the mother mixes baby formula with tap water.”

“One of the study's findings: 27 percent of the participants have high levels of uranium in their urine, compared to 5 percent of the U.S. population as a whole.”

“Welch, who is Navajo, got involved in the study because of her own family's exposure to uranium. Both of her parents grew up next to mines, even playing in contaminated water.”

"When they did the mining, there would be these pools that would fill up," she says. "And all of the kids swam in them. And my dad did, too."

“Many Navajo unwittingly let their livestock drink from those pools, and their children play in mine debris piles. Some even built their homes out of uranium.”

“All four of Welch's grandparents have died, and she worries about her parents' health and now her daughter's. Cancer rates doubled in the Navajo Nation from the 1970s to the 1990s.”

"Why isn't there more of an outrage? Why isn't there more of a community sense of what the heck is going on? How did this happen? Why is this still occurring? Why hasn't anything been done?" she asks.”

“George McGraw, a human rights advocate working on the Navajo Nation, has one answer.”

"Problems like this really disproportionately affect low-income communities of color," says McGraw, whose organization DIGDEEP is raising money to dig wells on the reservation.”

"Flint (Michigan) might feel really far away from the Navajo Nation in rural Arizona. But when you look at the demographics of it, it really isn't," he says. "This is a community that has found themselves voiceless.”

“The U.S. Justice Department has recently gone after some of the mining companies. Since 2008, the Environmental Protection Agency has hauled away thousands of cubic yards of mine waste and has rebuilt nearly 50 contaminated homes, says EPA Regional Administrator Jared Blumenfeld. But there's still much more to be done.”

"We're spending a lot of time making sure that the polluters pay, so it isn't the federal taxpayer," he says."

"One company, Anadarko Petroleum, and its subsidiary Kerr-McGee recently paid $1 billion to the Navajo Nation for cleanup and as compensation to people living with the effects of uranium contamination.

But one-third of the mining companies have shut down or have run out of money. The federal government knew about some of the dangers decades ago, but only started the cleanup in recent years."

"We understand that there's frustration," Blumenfeld says. "We share that frustration that some of this takes a long time."

"And the uranium issue on the Navajo Nation is part of a much bigger problem. Across the western United States there are more than 160,000 abandoned hardrock mines — thousands of which continue to pollute."

Uranium mines all over the world have polluted the environment and poisoned the people who worked in them for decades. India, Africa, Australia and Canada have thousands of abandoned mines that leech radioactivity and dangerous chemicals into the water table, and cause genetic abnormalities—disease and birth defects are

rampant. Every part of the nuclear fuel cycle spreads death and disease, and threatens the survival of life as we know it on this planet.