

Is nuclear waste sustainable?

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The idea of sustainability is an alluring one which, outside of the natural world, is in some respects a contradiction. Every system ever devised by man has, in reality, proved to be unsustainable if viewed over a long enough period of time. Systems break down, processes fall into disrepair and horizons are often limited by everything from cash and politics to fashion. In general terms a definition of sustainability is simply the endurance of systems and processes. However, more often than not, the word sustainable is followed by the term development. The idea is for economic growth and development to happen without having an adverse impact on the environment. Energy, obviously, is a large part of that equation. My essay, therefore, intends to look at one aspect of energy generation and its sustainability.

Nuclear Energy is one of the cleanest, most efficient, and most available sources of power so far devised by man. To generate one kilowatt hour of energy, nuclear power plants only emit 12 grams of carbon dioxide. In comparison, an average coal fired plant which produces the same amount of energy will emit 820 grams of CO₂ - more than 68 times greater. If you take the environmental cost of production into consideration, nuclear energy is cleaner than hydroelectric power, geothermal power, solar generation, and pretty much any other energy source except wind. Nevertheless, that does not mean that nuclear power is a long-term solution for an energy hungry world.

Britain was once the world leader in the production of nuclear energy. The Queen officially opened the first nuclear power station in the world in 1956 at Calder Hall in Cumberland, early on in her reign. Today, however, the UK is no longer the world leader in this once cutting edge industry while neighbouring Germany is phasing out its nuclear power generation industry all together. In the decades since the first nuclear power plant opened, the industry's allure has waned as the pitfalls

associated with production have become more evident. That is because the waste created through the generation of nuclear energy is probably the most poisonous substance on earth. This essay, therefore, will explore and discuss the sustainability of nuclear power and the radioactive waste it produces.

Despite the worldwide use of such energy nuclear power plants have only twice leaked significant and worrying amounts of radiation. The most notorious was in 1986 in the town of Chernobyl, in the Ukraine, in what was then the Soviet Union. The accident at the plant killed 31 people but at least another 4,000 were expected to contract early lethal cancer due to the radiation. The fall-out at the time was so widespread that sheep farmers from north Wales to Cumbria were banned from selling their stock until as recently as 2012, because radioactive rain had contaminated their grazing grounds. The second accident happened in 2011, at Fukushima, in Japan, as a result of a Tsunami caused by an earthquake. Fukushima was better contained and resulted in only two deaths, both of which were unrelated to radiation. In comparison with Chernobyl, only 130 early cancer deaths are expected as a result of the accident. But additionally, each site today still has massive exclusion zones where people simply cannot live due to radiation contamination. Hundreds of thousands of people were collectively displaced from their homes as a result of the two accidents, and will never be allowed to return. The economic damage of Chernobyl is estimated at nearly \$250 billion dollars, significantly more than the country's GDP at the time. The Fukushima disaster happened in a much more populated and developed area of Japan and is estimated to have cost the country \$500 billion dollars - 10% of the country's GDP. However, nuclear energy production is also limited by the relative shortage of uranium - the most common element used in nuclear reactors. Using present-day extraction methods, it is estimated that there is only enough uranium left for the next 230 years. As a result, many people would say nuclear energy production is not sustainable and represents only a short-term solution to reducing carbon emissions until something better is developed.

By far the biggest problem with nuclear energy, however, is not the risk of meltdown, or the limited supply of uranium, but what to do with the nuclear waste generated as a by-product of the process.

All current commercial nuclear power plants work through a process called nuclear fission. Energy is released through splitting uranium atoms. This energy is used to heat water. The heated water turns into steam and the steam produced is used to operate a turbine to generate electricity. Because nuclear power plants do not burn fuel they do not produce green house gases. The plants themselves are basically giant kettles used for heating large quantities of water. Uranium fuel rods used in nuclear fission have a life of between six to eight years, after which they are no longer useful in nuclear reactors. Although they continue to emit minimal amounts of energy in the form of radiation. This radiation can go on being emitted in lethal doses for tens or hundreds of thousands of years after removal. So the problem is what do you do with the radioactive waste? In some ways the answer is simple. Put the waste somewhere isolated and protected where it can remain undisturbed until no longer harmful. The problem is that keeping nuclear waste in storage over such long periods of time is currently almost impossible. In fact, no nuclear waste anywhere in the world is currently kept in what is considered long-term storage. Every iota of nuclear waste material in the world is currently kept in temporary storage facilities, used until longer term facilities exist.

Most of that nuclear waste is stored in holes filled with water. These pools of water are an efficient and inexpensive way of shielding radiation. Most nuclear power plants have water pools within their confines so that when spent fuel is removed it can be transferred directly into the water and left there. The radioactive material, since it's still emitting energy, continues to heat up the water, but cooling systems and pumps keep the water below boiling point. But to do that a nuclear plant needs power. If for any reason the main power fails and all emergency backup generation also fails, the pumps and cooling systems stop working. In that scenario vital water used to shield the radiation heats up and boils off. As it is simply water that is blocking the radiation, once the water is no longer present the radiation escapes directly into the environment. That is essentially what happened with Fukushima.

While such catastrophes are extremely rare they have at least happened in facilities where experts with a full understanding of the hazards are present. Once the nuclear waste in the storage pools has cooled it is usually encased in concrete

and steel casks that block the radiation. This is the point at which the radioactive waste is moved to a secure location. However, even this solution is far from permanent. It does not consider earthquakes, it cannot withstand tsunamis, and it would not work without people and the infrastructure they bring. Essentially, these casks require security and maintenance without which they could easily be damaged or breached over time releasing radiation into the environment.

What experts have decided is that any secure facility built to contain such waste, should assume that people will eventually no longer be around to maintain it. When looked at from an historical perspective, human beings in their present form have only been around for about 200,000 years. Civilisation as we know it is only about 6,000 years old, and industrialisation only really got underway in the 1800s. While progress has changed the world beyond recognition, nobody can say whether human civilisation or the human species will exist in the distant future. What is certain is that most toxic nuclear waste will continue to emit radiation. What is more, nobody can assume that the most advanced countries that have nuclear technology today will continue to exist for thousands of years. The Roman Empire was once the most powerful human civilisation in the world.

Some historians argue that it was the most powerful civilisation ever to have existed, superior to anything which exists even in modern times. But even the Roman Empire fell, and despite all appearances to the contrary, eventually the super powers of today will too. This means that the storage of poisonous nuclear waste long-term needs to last longer than even the most seemingly permanent political structures. It needs to exist in a situation where it can operate without people to supervise it - permanently.

Finland is building just such a facility, on Ikiluoto island, in the country's remote and sparsely populated western region. The island has been identified as being at very low risk of natural disasters. The region itself is not prone to earthquakes, does not suffer tsunamis, and there are few natural phenomena that could damage such a nuclear waste storage-site. That is even more true of the current site which is being readied 1,500 feet underground. When finished it will be the world's first permanent repository for spent nuclear fuel.

The facility is called Onkalo, (which means "cavity" in Finnish).

The Finns are currently finishing their dig with a scheduled completion date of 2020. Once the basic facility is finished long tunnels will be dug, and small holes created in them, into which will be placed casks of nuclear waste. The tunnels will then be backfilled with clay to be left for all eternity. With this system, there is a near zero risk of nuclear material leaking out into the surrounding groundwater and, once it is full, it can be left, forever. Because the waste material will be so deeply buried, and so difficult to get to, no human management will be necessary. There will be no need for security and no need for maintenance, which means it should be truly, sustainably, secure. However, before withdrawing, the experts have identified a final risk they need to guard against - human nature.

Human curiosity has brought the world to the height of technological progress we enjoy today. But the urge to discover, or rediscover, the world could pose a grave danger to any distant civilisation. If the long forgotten Onkalo facility is rediscovered thousands of years in the future, it would be quite natural to want to open it up. We did just that, essentially, with the pyramids in Egypt. Huge tombs built as the final, permanent, resting places for the elite rulers of Egypt, were eventually reopened by another civilisation, curious to discover what lay hidden inside. In some far flung future, curiosity might well be the justification for opening a mysterious and forgotten nuclear storage facility - and releasing poisonous radiation into the atmosphere. To prevent that happening the builders of today have to leave a vital message inside each storage facility, warning people to keep away. With this in mind, the US Department of Energy commissioned a study on how to communicate this forgotten danger into the far future. The key is to create a message that conveys how uninteresting, how unimportant, and how dangerous nuclear waste is. They settled on the following text:

"Sending this message was important to us. We considered ourselves to be a powerful culture. This place is not a place of honor... no highly esteemed deed is commemorated here... nothing valued is here. What is here was dangerous and repulsive to us. This message is a warning about danger. The danger is in a particular location... it increases toward a center... the center of danger is here... of a

particular size and shape, and below us. The danger is still present, in your time, as it was in ours. The danger is to the body, and it can kill. The form of the danger is an emanation of energy. The danger is unleashed only if you substantially disturb this place physically. This place is best shunned and left uninhabited". The idea would be to translate the message into every United Nations language, from Arabic and Chinese to English, French, Russian and Spanish. Experts have reasoned the dominant languages of today will still be around, in one form or another, for at least the next couple of thousand years. But over much longer periods of hundreds of thousands of years, there is little expectation that even these languages will survive. Experts believe that even the human species is unlikely to survive over such long periods. This means these nuclear waste storage facilities will also need to carry a message aimed at a non-human civilisation of the future. The contents of the written message will need to be conveyed without language. What the US study suggests is that the overall thrust of the message should be reinforced by building a landscape that conveys danger. The landscape itself could be a scene of thorns, or spikes, or forbidding blocks. To satisfy the curiosity of the facility's future discoverer, it has also been suggested monoliths are added to explain the site's history using pictographs. Also included would be images engraved in stone, conveying that the substance has danger, that will be passed onto humans, or anything else, if touched. The difficulty of this is that it very well might not be humans exploring earth 100,000 years from now. It could be a species that doesn't recognise the likeness of what might be a long-extinct species. What some have suggested is to just let the site be forgotten, to not mark it at all, to just seal it up, and leave, but having something that significant disappear isn't simple. The site in Finland is designed to work without security or oversight, but its current location is very well documented in a potentially irreversible way. With books and the internet, records of the site might exist until at least the end of human civilisation.

The final conclusion is that for such a site to be truly forgotten, and be left as part of nature, humans themselves must be forgotten first.

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