Too Cheap to Meter

Frances Cowell

Nuclear energy is the ideal complement to wind and power – until you consider its costs and risks.

When internal combustion began to replace horses, bullocks and mules a century or so ago, it was hailed as a safe, clean and affordable form of locomotion – no more panicking horses to calm, piles of dung to clean up or expensive stables to maintain. It is now becoming clear that fossil fuels are not as safe, clean or cheap as once thought. The big challenge now is to replace filthy fossil fuels with a safe, clean and affordable power source.

Where will that "clean" power come from? Wind and solar-generated electricity have surprised even enthusiastic promotors, but they are hostage to the weather, so will almost certainly need some complement, at least in the medium term. Natural gas is one least-bad option, but the war in Ukraine has exposed its limitations, especially in Europe.

Many look to nuclear as a clean and economical solution, but in light of fossil fuel experience, a comprehensive cost-benefit analysis seems warranted before ramping up production.

Two reports, from the International Atomic Energy Agency (IEAE), the UN nuclear watchdog, and Focus Europe, a collaboration of independent scientists in Europe and the USA, shed some light on nuclear operations.

The IEAE report is titled Status and Trends in Spent Fuel and Radioactive Waste Management. Dated January 2022, it draws on information up to December 2016 about all nuclear-related activities, except military, in all 138 participating countries. The World Nuclear Waste Report 2019 from Focus Europe centers on waste, especially high-level waste from electricity generation, mainly in Europe.

What is nuclear technology used for?
The IAEA cites medicine, some industrial processes, electricity generation, military applications and nuclear research. All produce radioactive waste, but some, such as medicine, produce relatively little waste, albeit of the most harmful, high-level, kind, yet are valued more highly by society than others, and not all nuclear applications have known, non-nuclear substitutes.

A small, but visibly growing number of countries use nuclear technology for military purposes. This is not reported to the IAEA, so we don't know how much there is. Its benefits depend on your perspective, of course, but in geo-political terms, there is no realistic substitute. Military applications generate high level and lower-level waste.

By contrast, there are plenty of non-nuclear ways to generate electricity. Yet, globally, this is the most widespread use of nuclear technology.

Nuclear reactors for electricity generation are typically big, cost a lot, take a long time to build and produce electricity for abut 40 years before they must be decommissioned, which usually takes another 20 years or so. Like most coal-fired facilities, they need to operate at full capacity to realise their economic promise, and generally viable only with significant government subsidies or guarantees.

How much nuclear waste is there?
The short answer is that we don't really know because quantities are not reported rigorously. Both reports agree that extracting and milling uranium ore, transporting it to refining facilities, enriching and refining it all release waste, much of it dangerous enough to need special treatment and isolation from the biosphere, often for many years. We know that in 2016, 448 reactors operated in 30 countries, generating about 10% of global electricity. Another 28 states use nuclear technology for things like research, isotope production, and nuclear-powered ships/submarines. We also know that, in 2018, 154 nuclear reactors worldwide awaited, or were in various stages of decommissioning. But the IAEA also notes that information about spent fuel and radioactive waste inventories is not available for all countries, partly because not all reported waste conforms to a common classification system. Focus Europe adds that information about quantities of decommissioning waste is hard to find.

In any case, absolute volumes can be misleading for a number of reasons. To begin with, not all nuclear waste is equally toxic. The IAEA defines six categories of nuclear waste, from Exempt (EW), which does not need regulatory oversight, to high level waste (HLW), which demands extensive heat reduction and other treatment before eventual disposal. In between are: very short-lived waste, very low-level waste (VLLW), low level waste (LLW) and intermediate level waste (ILW), each demanding regulatory control, isolation and containment and sophisticated disposal facilities.

Both reports agree that LLW or VLLW account for most nuclear waste by volume, yet they produce only a small proportion of radioactivity, mainly because of short half-lives, often a few days or weeks. Nearly all waste-related radiation is from the relatively small volume of HLW, nearly all of which comes from electricity generation and military applications, and has half lives in the tens of thousands of years or longer.

What counts as waste in one country can count in another as an asset to be reprocessed to generate more fuel. Some countries return their spent research reactor fuel to where it came from, or to third countries for reprocessing. The waste generated by reprocessing is, according to Focus Europe, even more radioactive and difficult to manage, requiring cooling periods of over a century or at least three times more space in a final repository.

Some governments, notably Germany, have put a stop to nuclear power. But existing waste still needs to be managed for a very long time yet. And because what in the past was best practice may not meet current standards, disposed waste from older facilities may need to be retrieved, re-treated, re-stored, and eventually re-disposed, all of which produces yet more nuclear waste.

Are small modular reactors (SMRs) the alternative to conventional reactors they appear to be? Boasting quick and low-cost deployment, with flexibility to adjust output to local demand, they seem ideal for remote regions with less developed grids and as a "transition" fuel. The IAEA says that they produce the same amount of waste as regular reactors, yet research from Stanford and the University of British Columbia, published in May 31, 2022 in the Proceedings of the National Academy of Sciences, suggests they actually generate two to thirty times more.

What happens to it?
Each category of waste is treated differently at each stage of the nuclear cycle, although, as the IEAE stresses, actual practices vary widely between countries. While most VLLW and LLW has been disposed of using well known solutions, that is not true for HLW from spent fuel rods and old reactors.

By contrast, all HLW needs sophisticated treatment, mainly to reduce the heat it still produces, and storage before it is disposed of "permanently". Interim storage is mostly "wet", although experts favour "dry" storage. Wet storage entails, among other things, energy-intensive cooling systems, without which fuel assemblies would ignite. Constant monitoring and replenishment is essential to avoid pools evaporating or otherwise being emptied, by accident or arson. And this intensive management must be sustained for decades or perhaps centuries until suitable disposal sites become available.

Permanent disposal is, of course, the aim, but is turning out to be harder than was once thought. Successive attempts to dispose of HLW "permanently" have all proved unsatisfactory, usually because the highly corrosive waste breaches its containers and contaminates the surrounds.

It is telling that, as the IAEA mentions, most current and proposed research into nuclear waste is about what happens after fuel rods have been spent and reactors stop reacting. Collaborative work aims for better technical equipment for repository construction and operation, ageing management, predisposal management and other processes.

Current best practice is to bury it in a Deep Geological Repository, or DGR, which can be a kilometre or so below the surface, in non-permeable rock. While the IAEA seems satisfied that the search for suitable sites has begun, DGRs are in practice proving hard to locate. Focus Europe points out that, so far, only one, in Finland, is actually under construction, although France, Sweden and Switzerland have identified sites and expect them to be receiving waste in the 2050s or 2060s. Even then, spent fuel will remain hot for hundreds of thousands of years. Meanwhile, HLW continues to be produced – in ever increasing quantities - while interim storage facilities fill up.

How much does nuclear cost and who pays?
The costs of any project can be estimated only after the end of its life. Yet the very long life of nuclear waste makes that estimation virtually impossible because the eventual costs cannot be known. That, in turn tends to lead to those costs being under-estimated, with new reactors approved on the basis of unrealistic

assumptions. It also means that governments' claims to make polluters pay are wildly misleading. For example, Posiva, the operator of the DGR in Finland, cannot know when it will have been filled by spent fuel rods and finally sealed "forever", or whether its containers actually resist corrosion. Yet even when the DGR has been filled, we cannot know the final cost of nuclear power. "Permanent" disposal is not all that permanent: it is the point that the firm hands responsibility for monitoring and managing to the Finnish government – and future generations.

Conclusions

The mess made by horses was generally not cleaned up by those who owned or used the transport they provided: streets were instead cleaned by municipal workers and other service employees. The damage to our atmosphere and environment caused by fossil fuel emissions similarly tends to be borne by everyone and everything living, or yet to live on the planet, not by fuel producers or users of the transport and electricity it fuelled. Much the same can be said of nuclear power. The big difference is the time frames. If not cleaned up, horse dung hangs around for a few days until flies and other scavengers take care of it. Carbon dioxide and other nasties linger in the atmosphere for up to a couple of hundred years. The most dangerous nuclear waste will blight the planet for thousands, even millions of years to come, or until we find a way to neutralise it. Nobody, even the most enthusiastic promoters of nuclear energy, and nobody pretends that we're even close to doing that.

When nuclear electricity generation was first promoted, it was said to be "too cheap even to meter". Certainly, once operational, nuclear power generators can be very cheap to run, but when any sensible estimate of the long-term cost – and risks - of waste disposal are taken into account, nuclear looks much less competitive.

Nuclear, or some, as yet nascent technology may yet prove its worth, but until it does, we should know by now to proceed with extreme caution.

This article was first published on TheEuropeanNetwork.eu in July, 2022