**Germany’s elephant in the room.**

* **Co2 in Germany since nuclear switched off**
* **CO2 per kWh of different energy sources**
* **UK biggest absolute reduction in Co2** <http://www.world-nuclear-news.org/EE-Anti-nuclear-Germany-is-Europes-biggest-GHG-emitter-13111701.html>
* **ElectricityMap.org**
* **Grid watch (UK and France)**

Beware the headlines. That’s nothing new, of course. You may have heard that Germany is in the midst of a great *Energiewende*, or energy transition. The highly-publicised plan would have Germany reduce greenhouse gas emissions by 80-95% of 1990 levels and produce 60% of its electricity from renewable energy sources by the year 2050 [1]. An honourable ambition! I hear you cry. Honourable indeed, but behind the glossy PR there lurks a dirty secret.

*[Disclaimer: I work in the nuclear industry! But fear not, in this article I am going to do something incredible: try to rely on data rather than my opinions.]*

Let your mind slip back to 2011. There was this *huge* earthquake off the coast of Japan [2]. Like, really huge. Likely, you’ll remember it as being the “Fukushima” earthquake, because of the damage to the Fukushima Daiichi Nuclear Power Plant (<https://en.wikipedia.org/wiki/Fukushima_Daiichi_nuclear_disaster>), and the media-coverage frenzy that followed. In Japan, the event is known as the 2011 Tōhoku (TOH-ho-ku) earthquake. It was the most powerful ever recorded in Japan, and the fourth most powerful earthquake in the world since modern record-keeping began in 1900 [3]. Sounds strong but, if you’re like me, you’ll prefer an absolute over a relative number. I recommend reading the first few sections of the Wikipedia entry (https://en.wikipedia.org/wiki/2011\_T%C5%8Dhoku\_earthquake\_and\_tsunami) yourself (yeah, I use Wikipedia, and so should you – more on that in a future blog post!), but here I have reproduced some of the most interesting figures, with the caveat that many of them are from “media” sources, rather than scientific journals or official government statistics:

The force of the earthquake *moved* Honshu, the main island of Japan, 2.4m to the east [4]. The tsunami waves were 40.5m high [5], that’s the same as a thirteen story building. In places the waves travelled 10km inland, or the distance from Canary Wharf to Hyde Park (if you’re familiar with London) [6]. Not impressed? Well, the effects of the earthquake were not limited to Japan. It is estimated that the earthquake *shifted the Earth on its axis by 10 to 25cm* [7]. Yep, you read that right. And if the Tōhoku earthquake seems to you like it happened only yesterday, maybe that’s because the quake might have *increased the Earth’s rotational speed by 1.8µs per day* [8]!

Whilst I cannot vouch for the accuracy of the above numbers, sadly we do know that the tremors and ensuing tsunami killed at least 15,984 [9] people, with many more missing, presumed dead. Over a *million* buildings were damaged or destroyed [10]. The World Bank estimated the cost of recovery and reconstruction to be US$235 billion, making it the *costliest natural disaster in history* [11][12].

I’m sorry if it feels like I’m labouring the point – and there is one coming, I promise – but it’s important to remember just how powerful the 2011 Tōhoku earthquake was before we get to what happened at the Fukushima Daiichi plant.

I’m not going to give the blow-by-blow Fukushima story – you can read the Diet (parliament) of Japan’s produced an official report here (<http://large.stanford.edu/courses/2013/ph241/mori1/docs/NAIIC_report_hi_res10.pdf>). The International Atomic Energy Agency (IAEA) report is probably the most authoritative and informative, and anything I discuss below related to the accident is taken from their work. If you don’t have hours to burn, the Encyclopaedia Britannica (yes, they do still exist) summarised the incident succinctly here (<https://www.britannica.com/event/Fukushima-accident>).

Contrary to what you may assume, there is no evidence of damage to the main safety systems of the Fukushima Daiichi plants (there were three reactors involved) from the earthquake itself (i.e. from ground vibrations). The problem lay in the plant operators’ underestimation of the likelihood of large tsunamis and the damage they might cause. Tsunami flooding caused the Fukushima plants to lose electricity supply to vital systems required to cool nuclear fuel that remains hot (due to radioactive decay products https://en.wikipedia.org/wiki/Decay\_heat) even after the reactor has been shut down.

TEPCO, the operator of the plants, made valiant efforts to cool the reactor cores as well as what are known as the Spent Fuel Pools (a kind of giant swimming pool where old fuel is stored until it has cooled down). They also made a series of well-documented mistakes, exacerbated by indecision and unclear division of responsibility between it, the nuclear regulator and the government. The result was a nuclear operator’s worst possible day at the office: some of the nuclear fuel got so hot it melted through its protective containment. You’ve probably heard of this event before, if only in Hollywood sci-fi: a core meltdown. Eventually, some fraction of this leaked fuel made it into the air and sea.

Bad. But *how* bad? Before we get to that, this is in no way intended as an apology for mistakes made by the Fukushimi Daiichi designers, operators or anyone else, nor do I wish to belittle the real human tragedy of mass evacuation of areas around the Fukushima plant following the accident. I only mean to highlight the real-world *data* from the accident. Quoting naked statistics may seem hard and cold for what is clearly an emotive topic, but I argue that it’s the only way for us to bring together points-of-view which seem irreconcilable on first impressions.

Back to that question: how bad was the Fukushima nuclear accident? By official measures, it was the second-worst accident after Chernobyl, rated 7 on the INES scale (http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-accident.aspx) (the most severe level). Despite that, no “early-induced health effects were observed among workers or members of the public” [14, pg13]: this means no one got ill from radiation in the immediate aftermath. And what about the long term effects, such as cancer risk? The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) reported to the United Nations General Assembly that: “no discernible increased incidence of radiation-related health effects are expected among exposed members of the public and their descendants” [14, pg13]:, i.e. we don’t think that there will be any additional cancers amongst those who lived in and around the Fukushima plants due to the accident. The IAEA did conclude that *plant workers* would have an increased risk in cancer, but that this increase would be so small that we won’t be able to confirm it even exists [14, pg13].

How can this be? you may ask. If you watched the news you might have convinced yourself that fish would be growing third eyes (this only happens on The Simpsons, by the way) and children would be born with abnormalities for years to come. Thankfully, this isn’t the case.

You see, the amount of radiation picked up by workers and the public were not so large when compared to other sources of radiation, both natural and man-made. The typical dose over two weeks for people within the Fukushima exclusion was 1 *millisievert*, or mSv. Don’t worry if you don’t know what that is, just know that the radiation most of us pick up *every year* from the rocks, soil, buildings and roads around us, from the food we eat and the air we breathe, and from medical scans such as x-rays, is around 4 mSv. One particular monitoring station close to Fukushima recorded higher doses of around 40 mSv. This 40 mSv value is still within the typically allowed dose for a person who works with radiation as part of their job such as a radiologist, nuclear plant worker, or, surprisingly, an airline pilot (see below) i.e. it’s a dose that will not lead to an increased risk of cancer. So, the radiation that leaked during the Fukushima accident was a risk to the public (and was preventable), but it didn’t (and probably won’t) make anyone ill. Now remember, this accident happened because of the *massive* Tohoku earthquake, it affected some of the oldest (i.e. least resilient) nuclear plants in the world, yet it didn’t lead to nuclear Armageddon. Understanding how low the doses were from the second-worst civil nuclear accident (let’s not get started on the outfall from the completely unrelated source of nuclear weapons testing), you can imagine how even living alongside a nuclear power plant for your whole life poses negligible risk to your health; visit a nuclear plant in the UK and you’ll find commercial farms right next-door, safely growing food for our consumption.

A brilliantly-visual tool to get your head around radiation doses is provided by the online nerd comic xkcd (<https://xkcd.com/radiation/>), including doses related to the Fukushima accident.

Again, without getting into the details of exactly how and why there was a mass evacuation of people from around the Fukushima area, nor why the evacuation lasted so long, it is worth considering some of the irrational behaviour witnessed during and following the accident: some people living *far* outside the zone of influence of any radioactive release, such as in Tokyo, took flights out of the country to escape the perceived risk of contamination. Every time you take a flight, you leave behind much of the protection our atmosphere affords you at sea level and expose yourself to radiation from space. As xkcd shows (<https://xkcd.com/radiation/>), someone on a flight out of Tokyo to escape perceived radiation risk might get a 40µSv dose, which is already almost as much as if you camped out at Fukushima town hall for the whole event (100µSv)! But not to worry: 40µSv is peanuts when it comes to radiation dose, but it does mean that airline pilots and crew must monitor their yearly dose to ensure they are within safe limits. Unfortunately, we are not generally very informed about how *natural* radiation is, how we’re subjected to it *constantly* and how small doses have no demonstrable link to illnesses such as cancer.

Surprisingly, it is the way in which the Fukushima evacuation was managed that caused the most damage: around 1000 premature deaths are thought to have occurred as a result of the extended evacuation due to factors such as fatigue, trauma, people’s fear that they’d received a fatal dose of radiation and restricted access to medical care at their evacuation shelter. 90% of the deaths were in persons over the age of 66 (<http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-accident.aspx>). It’s clear that the main tragedy in the whole Fukushima disaster was maintaining the evacuation beyond a few precautionary days. Put another way, the greatest damage came not from any radiation leak but from the misunderstanding of what the consequences of such a leak are for us human beings.

This is a common theme with nuclear energy: our fear of nuclear radiation is disproportionate to any real health risk. This is an idea that many find difficult to accept, that raises the hackles of many a Greenpeace employee and invites derision from the more sensational elements of the media. Even the usually balanced outlets such as the BBC seem to find it difficult to turn off their emotional brain and simply report the facts when it comes to nuclear. This probably isn’t helped by science-trained staff being outvoted by those trained in the arts and humanities who are less accustomed to handling statistics.

Unlike fossil fuels such as gas and coal, nuclear energy is a source of low-carbon energy in a world where rising CO2 levels threaten our ecosystems. Unlike other low-carbon sources such as solar and wind, nuclear energy is high-intensity (low land use) and high-availability (whatever the weather). In a world with a growing population and ever-shrinking wilderness, do we really want to convert vast tracts of farmland or nature reserves into sprawling solar farms? Perhaps it *is* the right thing to do, but I have not yet seen the arguments carefully thought out. With current (and this could change – look at what Tesla is doing <https://www.tesla.com/en_GB/utilities>) energy storage technology, an electricity grid supported entirely by wind and solar is also not feasible because the wind doesn’t always blow and the sun doesn’t always shine. The cost of nuclear new build compared to renewable new build is too complex to cover in this post, but existing nuclear plants are a cheap source of low-carbon electricity that should be kept online for as long as is safe. Great idea, you might say, so that’s what everyone is doing, right?

Wrong.

Read on for part two………….

Environmentalists who use their brains vs environmentalist who use their hearts.

We all “know” we should fear radiation. We shouldn’t

, and tsunami damaged We all know that stuff went wrong, and radioactive material was released to the environment

Websites such as fukuleaks (<http://www.fukuleaks.org/web/?p=13038>) have sprung up that are part pressure group, part conspiracy wackos. I’m all for holding governments and business to account, but why not do that by providing google-able information about the radiation dose to humans from the Fukushima accident, instead of wilfully omitting it (<http://www.fukuleaks.org/web/?page_id=13790>).

(PAHs) are known to be carcinogenic and toxic [13]

How many died from imposing the exclusion zone over those that would have died from cancer.

but there is an elephant in the room, and the elephant happens to spew out *massive* quantities of sooty, sulphurous, carcinogenic pollution.

[1] [*The Energy of the Future: Fourth "Energy Transition" Monitoring Report — Summary*](https://www.bmwi.de/Redaktion/EN/Publikationen/vierter-monitoring-bericht-energie-der-zukunft-kurzfassung.pdf) (PDF). Berlin, Germany: Federal Ministry for Economic Affairs and Energy (BMWi). November 2015. Retrieved 2017-11-18.

[2] <https://en.wikipedia.org/wiki/2011_T%C5%8Dhoku_earthquake_and_tsunami>

[3]

1. [*"New USGS number puts Japan quake at 4th largest"*](http://www.cbsnews.com/stories/2011/03/14/501364/main20043126.shtml). [*CBS News*](https://en.wikipedia.org/wiki/CBS_News). Associated Press. 14 March 2011. [*Archived*](https://www.webcitation.org/5xgjFTgf4?url=http://www.cbsnews.com/stories/2011/03/14/501364/main20043126.shtml) from the original on 4 April 2011*. Retrieved 15 March 2011*.
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[6] Roland Buerk (11 March 2011). ["Japan earthquake: Tsunami hits north-east"](http://www.bbc.co.uk/news/world-asia-pacific-12709598). BBC. [Archived](https://www.webcitation.org/5x7SSocBe?url=http://www.bbc.co.uk/news/world-asia-pacific-12709598) from the original on 12 March 2011. Retrieved 12 March 2011.

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<http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1710-ReportByTheDG-Web.pdf>