# Nuclear power

## Dead end for climate change mitigation

GREEN EUROPEAN FOUNDATION

FREDA
DIE GRÜNE ZUKUNFTS AKADEMIE

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## Dead end for climate change mitigation

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# Content

# Preface

by **Martin Litschauer**

My story in the anti-nuclear movement began in 2000 with the protests against the commissioning of the Temelin nuclear power plant. As a native from the region of Waldviertel in Austria, I wanted to stop the threat at the border. I organized demonstrations and border blockades, and also served as spokesman for the non-partisan platform Stop Temelin. Many hours in the cold and hundreds of hours of voluntary work strengthened awareness that we do not need high-risk nuclear power for our energy supply. This realization and the support of Eurosolar helped establish the organisation "Waldviertler Energiestammtisch", which has been working ever since to promote the transition to renewable energy.

What has happened since then, or more precisely: What did not happen? Neither the maximum credible accident at Fukushima, the numerous financial fiascos, the severe earthquakes near the Krsko NPP, the bankruptcies of NPP equipment suppliers, the unresolved nuclear waste issue, toxic uranium mines nor nuclear power plants as theatres of war have been sufficient grounds to change the minds of the pro-nuclear powers.

Quite the opposite. The nuclear power lobby is stronger today than ever. The lobbyists have succeeded in creating an enormous disparity in the perception of what to believe and reality. The post-Chernobyl generation is increasingly falling prey to the fairy tale of modern, safe, cheap and $CO_2$ neutral nuclear power. These arguments can be quickly refuted and often only serve to conceal the ulterior motive: to increase the stockpile of nuclear armaments.

Nuclear power will most definitely not save the environment. On the contrary: nuclear power plants are at risk from climate change, and new reactors are too late for the energy transition as they require decades of construction time.

If we want to protect ourselves and save the environment, we have to use solar, wind and geothermal energy, because these are the fastest and safest ways to achieve the energy transition. Besides, we have long since arrived in the era of renewable energy. In the electric power mix of the EU, renewables already outpace nuclear energy.

On clear days, I can see the Czech nuclear power plant Dukovany to the east and the Temelin nuclear power plant to the west. It is an oppressive feeling to be caught between high-risk reactors because radiation knows no boundaries. Same with the Slovenian power plant Krško in the south. And this is exactly why it is so important to work for a future without nuclear power plants in Europe, also in a nuclear-free country like Austria.

**Martin Litschauer**
Member of Austrian Parliament and Anti-nuclear Spokesman

# Preface

by **Dagmar Tutschek**

Insurance companies have designated 2021 the worst disaster year of the century to date. This “key decade” is likely to be dominated entirely by the climate crisis and the massive loss of biodiversity – and by the joint commitment of governments, the business sector and society to achieve fundamental changes.

Russia’s invasion of Ukraine in 2022 opened an ominous portal to a new dimension of multiple dependencies. Apart from the immeasurable suffering of the people in the war zone, the stubborn adherence to fossil fuels still has merciless consequences. Prices have been exploding worldwide, the war in Europe has become both a global energy supply crisis and a food security crisis.

And all of this has been happening before the backdrop of heightening political and economic volatility since 2010. Commodity prices and consumption rose during the pandemic, likewise energy prices – partly as a result of the urgently needed green transition.
The coronavirus had already had severe effects on the social fabric of society, but these were only a prelude compared to the situation we are facing at the time of writing of this brochure.

Now it is even easier for the proponents of backward-looking low-quality and high-risk technologies to promote their interests. Despite the accompanying irritation at times, the phasing out of coal seems to be on track. However, due to the absence of alternatives for some EU member states, nuclear power has been classified as CO2 neutral green energy in the most recent EU Taxonomy Regulation. This Regulation was originally designed to serve as a reference work for economic activities and as guidance for private investors on how to invest capital sustainability and to help prevent greenwashing. It entered into force in July 2020 and was supplemented in 2021 by a first Delegated Act on Climate Change Mitigation and Adaptation.

Therefore, the current greenwashing of nuclear power starkly contrasts with the original objective. The ultimate aim is to focus on potentially lucrative inflows into investment funds that could be marketed by the financial industry as ecologically sustainable financial products in the meaning of the EU Taxonomy. This trend is also viewed as problematic in some financial circles. The war in Europe and the undeniable connection to the enlargement of the nuclear arms arsenal are the other side of this inglorious coin.

Crises vastly intensify the longing for simple solutions. Nuclear power is currently viewed by many people as the lesser of two evils and this is also influencing a new generation with complete faith in the progress of new technologies that also believes in solutions to previously unsolved problems such as the disposal of nuclear waste.

However, it is not just a matter of differing opinions and generations – research also provides divergent expert opinions. This brochure contains a critical analysis of the main ten misconceptions about "green" nuclear power. It has been prepared in close cooperation with Martin Litschauer, Member of the Austrian Parliament and Anti-nuclear Spokesman of the Austrian Greens, and Maria Niedertscheider, Expert Assistant, Austrian Federal Environmental Agency. It has been drafted to serve as guidance for a broad European discussion and as a concise summary of the narrative on nuclear power as a supposedly bridge technology.

**Dagmar Tutschek**
FREDA.AT, Chairwoman (until 09/2022)
GEF.EU, Co-President


Photo: Monica Schreiber / pixabay

# Ten misconceptions set right

# Misconception 1:
# No energy transition without nuclear power

**We need electricity, lots of electricity.**
And in the future, we will need even more. The energy transition will not succeed without nuclear power. Sun and wind will not be enough. Besides, the sun doesn't always shine, and the wind doesn't always blow. Nuclear power, on the other hand, is available quickly and regardless of the weather.

Yes, phasing out fossil fuels requires enormous amounts of electric power, and the transition to carbon neutrality must happen quickly. In the EU by 2050, and in Austria we want to achieve this by 2040. There is not much time left. That alone is an argument against nuclear power. Why?

## 1) Not enough.
Currently, 33 countries worldwide operate 411 nuclear power plants (NPPs) (status as of July 1st, 2022). These generate just 10% of the world's electricity, and therefore, just under 2% of the world's energy needs.[1]

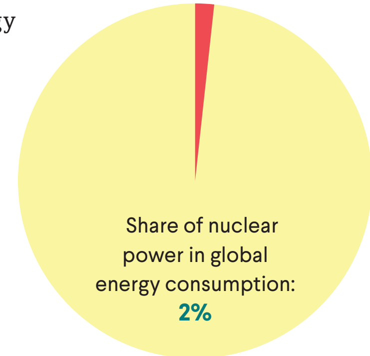
## 2) Too slow.
In Europe, it takes at least ten years to build a nuclear power plant. Considering the additional years needed for the permit procedures, it is clear that nuclear power is too late for climate change mitigation. Just to maintain current levels of nuclear power production, a new reactor would have to go live every month until 2030. This is not possible. On the contrary: in 2021, only six reactors were commissioned, and eight were shut down.[1]

## 3) Too unreliable.
Nuclear power plants are highly dependent on the weather, because nuclear power plants need water cooling. This is a massive problem, especially during peak periods in winter and summer when rivers carry little water. In the summer, rivers sometimes heat up to an extent that nuclear power plants have to be shut down. Therefore, when power is urgently needed, nuclear power plants are at a standstill.
Old nuclear reactors are also requiring more and more maintenance and are less reliable. In the winter of 2021/22, corrosion problems shut down almost half of French reactors. This was followed by the most extreme phase of dark doldrums in decades and horrific electricity prices.
On the other hand, sun and wind perfectly complement each other seasonally.

## 4) Too inflexible.

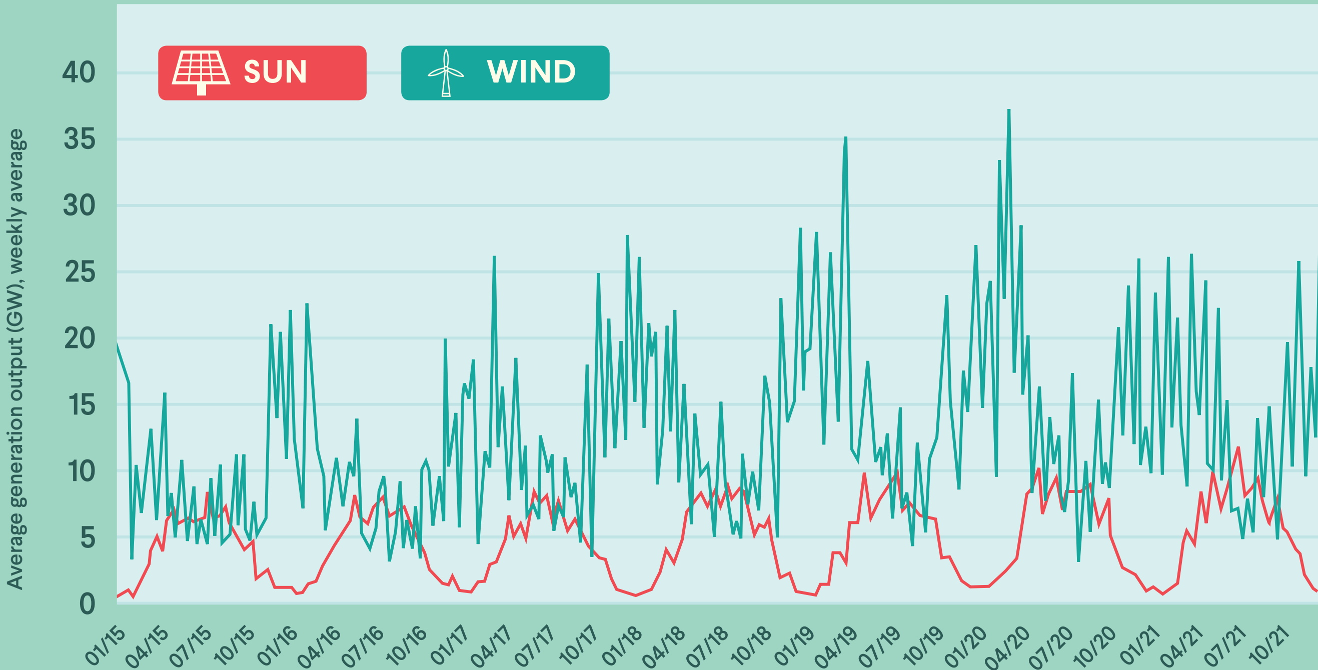
Nuclear power plants cannot be shut down quickly at the push of a button and then quickly restarted when needed. Both processes take time. This eliminates nuclear power plants as a reserve supply. They are actually designed for uniform capacity to cover basic loads. However, cutting back capacity increases production costs.

The example of Austria shows that the energy transition works without nuclear power. In 1978, Austria rejected the construction of a nuclear power plant in Zwentendorf. By now it would have meanwhile been hopelessly outdated and would have had to be decommissioned. However, Austria has adopted the Renewable Energy Expansion Act (Erneuerbaren Ausbau Gesetz, EAG) to ensure the expansion of electricity sourced from renewables to 100% by 2030. Innovative technologies ensure better availability and cheaper production. Renewable energy is cheaper than ever. By 2030, we will be able to produce eight times the amount of electricity using only sun, wind, water and biomass that Zwentendorf would have supplied in its prime times.[3]




It is very clear: nuclear power is preventing the energy transition. Every cent spent on nuclear power today will be lacking for the development of cheaper, environmentally-friendlier and safer energy sources. This is especially true in the European Union, which grants extensive privileges to nuclear research, with a total of EUR 5.8 billion having been spent for this purpose from 2014 to 2020. This is roughly the same amount spent for all other areas of the energy sector such as grids, storage, efficiency, and energy reducing measures.[4] The largest share of funding for nuclear power research flows into the ITER nuclear fusion project, which hardly has a realistic chance of being realized and most certainly will not contribute to climate change mitigation. If the same money were spent on promoting and researching efficiency and how to save energy, we would be much closer to the energy transition.

# AVERAGE WEEKLY PRODUCTION OUTPUT
## GERMANY + AUSTRIA




Source: Data for Germany and Austria; Österreichische Energieagentur (Austrian Energy Agency) based on Entso-E (https://www.entsoe.eu)

# Misconception 2: New technologies solve old problems

**The Bill Gates Reactor is ready to go.**
We, on the other hand, are sleeping through the nuclear transition because of old prejudices. Thorium as a fuel does not produce nuclear waste, liquid salt cooling makes nuclear disasters impossible, and fast breeder reactors generate their own fuel. Cheap, clean electricity for everyone.

The promises of the so-called Generation IV reactors are impressive. But are they ready for commercial use? Let us conduct a brief reality check of the three innovations currently being strongly promoted.

## Molten salt reactor

In molten salt reactors (MSR), molten salt is used for cooling instead of water. This makes reactors safer and more efficient.[5] In 2008, Bill Gates founded a dedicated company for this purpose: TerraPower.

MSRs could turn the US mountains of nuclear waste into fuel, with meltdowns practically eliminated. This is the promise. To date, hundreds of millions of taxpayer funds have been invested in the project, but there is still no functioning MS reactor. Öko-Institut Darmstadt investigated the current state of molten salt technology. Conclusion: The concept was tested as early as 1940s by the US military for aircraft engines, but to date it has not yet been successful for electricity production. The first commercial proto-type is not expected before 2060. Bill Gates would then be 105 years old and his posh winter home in Palm Beach, Florida will be submerged by the sea just like half of Bangladesh. Because the climate crisis is not waiting.

## Thorium fuel

Thorium instead of uranium as fuel. Various thorium lobbying groups are disseminating the fairy tale of the nuclear waste-free and safe thorium reactor.

Background: Thorium is four times more abundant in the earth's crust than uranium and is said to be unsuitable for building nuclear weapons. But what many people don't know is that the idea is as old as the nuclear industry. Safety issues, surging costs and technical difficulties scuttled the attempts of the 1950s to the 1980s. Experts doubt that thorium is safer, cleaner or cheaper than uranium. Going back to the 1950s will get us nowhere with the climate crisis.

## Fast breeder reactors

At the beginning of the nuclear era, uranium reserves were assumed to be very low. This resulted in the concept of fast breeder reactors, which use fast neutrons to breed their own fuel. Practical side effect: spent fuel rods can be reused for this purpose. However, of all 20 breeder reactors operated up to now only the Russian BN-800 has remained operational to this day. It would hardly be approved under EU standards. Similar reactors had to be shut down again due to major fires and surging costs. However, some countries also publicly oppose the construction of fast breeder reactors. Quickly converted, they produce large quantities of weapons-grade plutonium and pose a nuclear threat to world peace.[6]

## Conclusion

Generation IV concepts are old and have not progressed for decades. Unsolved technical problems and appalling high electricity prices have prevented their commercial use up to now. Who needs new reactors that generate expensive electricity and are extremely unreliable? No game changers in terms of safety and economic efficiency are expected in the next decades.


Photo: Michael Schmid

# Misconception 3:
# Small, safe and almost free – Small modular reactors ensure power supply in all world regions

**Produced cheaply in large numbers,** small reactors bring electricity, hydrogen and heat to the remotest parts of the world. Because they use little fuel, they are safe compared to today's reactors.

The only small modular reactor ever put into operation is floating in the East Siberian Sea. The "Akademik Lomonossow" reactor provides electricity for the Russian city of Pevek and will probably remain the last of its kind. The construction took more than 10 years and the enormous electricity costs dwarf even those of large reactors. Uranium is used as fuel, and it is cooled with water.

Real technological and economic breakthroughs look different.

More than 50 different SMR concepts are being pursued worldwide, some of which are struggling with the same problems as the so-called "new technologies" *(see Chapter 2)*. The only thing they have in common is their low output of a maximum of 300 megawatts. This is how experts from Ökoinstitut Darmstadt assess the novel SMRs in terms of time, costs and safety:[7]

## Time

Cheap and safe SMRs exist only on paper, and paper is patient. Even if the first prototype were to be built, years of waiting for permit applications to be process would follow. Widespread use is wishful thinking according to scientists.

Meanwhile, even prominent nuclear power like William Magwood who is Director General of the OECD Nuclear Energy Agency (NEA), views the grandiose announcements with skepticism: "If these technologies are not brought to market within roughly one decade, they may no longer be relevant for the energy transition."

## Costs

The claim is that large quantities and the modular construction helps lower production costs. In fact, economies of scale would only become effective as of 3,000 reactors. Before this threshold is reached, they tend to do more harm, because relative to output, SMRs consume more construction materials and energy, require more fuel, and create significantly more nuclear waste.[8] Development is stuck in the dilemma "what came first, the chicken or the egg". High costs check demand, and without demand there is no serial production.

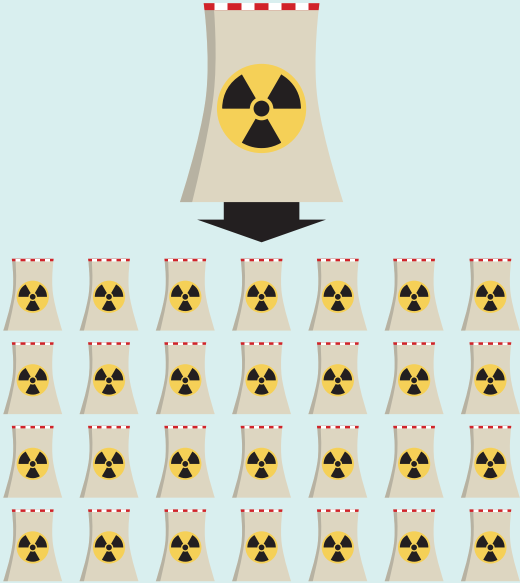
## Safety

A mini reactor naturally contains less fissile material. Thousands of mini-reactors all over the world repeat this volume-based argument ad absurdum. This type of reactor opens up endless possibilities for terrorists to obtain weapons-grade material. Fully proliferation-proof SMRs will not be available in the foreseeable future. It is probably no coincidence that especially nuclear powers such as France, the US, India and Russia are lobbying massively for SMRs. The civilian nuclear industry supplies fuel, know-how and manpower to the defence industry.[9] Therefore, giving SMRs a climate-friendly label is harmful to the global nuclear peace.

## Conclusion of the Darmstadt experts

"None of the technologies discussed are currently available on the market nor will they be in the foreseeable future. At the same time, they are being touted with promises similar to those made about nuclear reactors in the 1950s and 1960s of the last century." *(see Endnote 7)*

**28 SMRs would be needed to replace one pressurized water reactor commonly used today. For the entire fleet in use today, it would take thousands.**



The capacity of today's standard pressurized water reactors (1000 megawatts) compared to the capacity of the reactor "Akademik Lomonosov" (world's only SMR in operation as at June 2022, 35 megawatts).

# Misconception 4: Nuclear power is cheap

**The energy transition** will be expensive. Giving up inexpensive nuclear power now would be madness.

Inexpensive nuclear power has always been a fairy tale. Construction costs range in the billions, and the maintenance, interim and the final storage of nuclear waste make nuclear power the most expensive form of electricity today. Over the past 10 years, solar and wind energy have become 90% cheaper, while nuclear power costs have risen steadily. The generation of nuclear power is now about four times as expensive as photovoltaic and wind energy.

Once upon a time, nuclear reactors were supposed to revolutionize European electricity generation, but have now become a symbol of an ailing industry: the three new reactor projects of the French European pressurized reactors.[10]

### Example: Hinkleypoint C (UK)

Projected costs: EUR 20 billion. Actual costs: EUR 30 billion (May 2022). This is around EUR 9,000 for investment costs per kilowatt of installed capacity. The Fraunhofer Institute calculates EUR 1,500 to EUR 2,000 per kW for onshore wind turbines. Large-scale photovoltaic systems are even less expensive. Additionally, the completion of Hinkleypoint C has been delayed for a full decade.

### Example: Flamanville (FR)

The plan: “European Pressurized Water Reactor” (EPR) at the site of the French nuclear power plant Flamanville. Fixed price EUR 3.2 billion; construction time six years (2006 - 2012). The reality (status 2022): Date of completion 2024 at the earliest, costs around EUR 12.4 billion (manufacturer EDF) to EUR 19 billion (French Court of Audit). The addition of technical protection against a potential aircraft crash would raise the costs to around EUR 30 billion.

### Example Olkiluoto (FI)

The plan: construction time four years (2005 to 2009), costs EUR 3 billion. Reality: construction time 2005 to 2021. Costs at least EUR 8.5 billion. Right after the first trial operation in January 2022, the reactor had to be shut down repeatedly.[11] However, in 2015, the French government had to bail out the construction company AREVA with funding of EUR 7.5 billion. The Swiss organization Energiestiftung SES states rather soberly: “Without the constant massive government aid, France’s nuclear industry would already be bankrupt.”

However, even more expensive than the new construction of a plant are the costs of extending the life of a plant. France will have to invest a full EUR 100 billion in its outdated nuclear power plants by 2030 to maintain current electricity production levels.[12] However, it is doubtful how the semi state-owned power company EDF, which has some EUR 43 billion in debt, will be able to accomplish this. Conclusion: Nuclear power does not pay off. It is a business that survives on state subsidies and is fully dependent on public funding.[13] Major rating agencies and investment funds have long since recognized this. Standard and Poor's, for example, does see any point in nuclear investments in Europe or the United States. Lead times too long, new reactors too expensive to build, modern renewables too cheap.[14] Global investors have invested seventeen times as much money in renewables as in nuclear energy in the crisis year 2020 alone.[15]

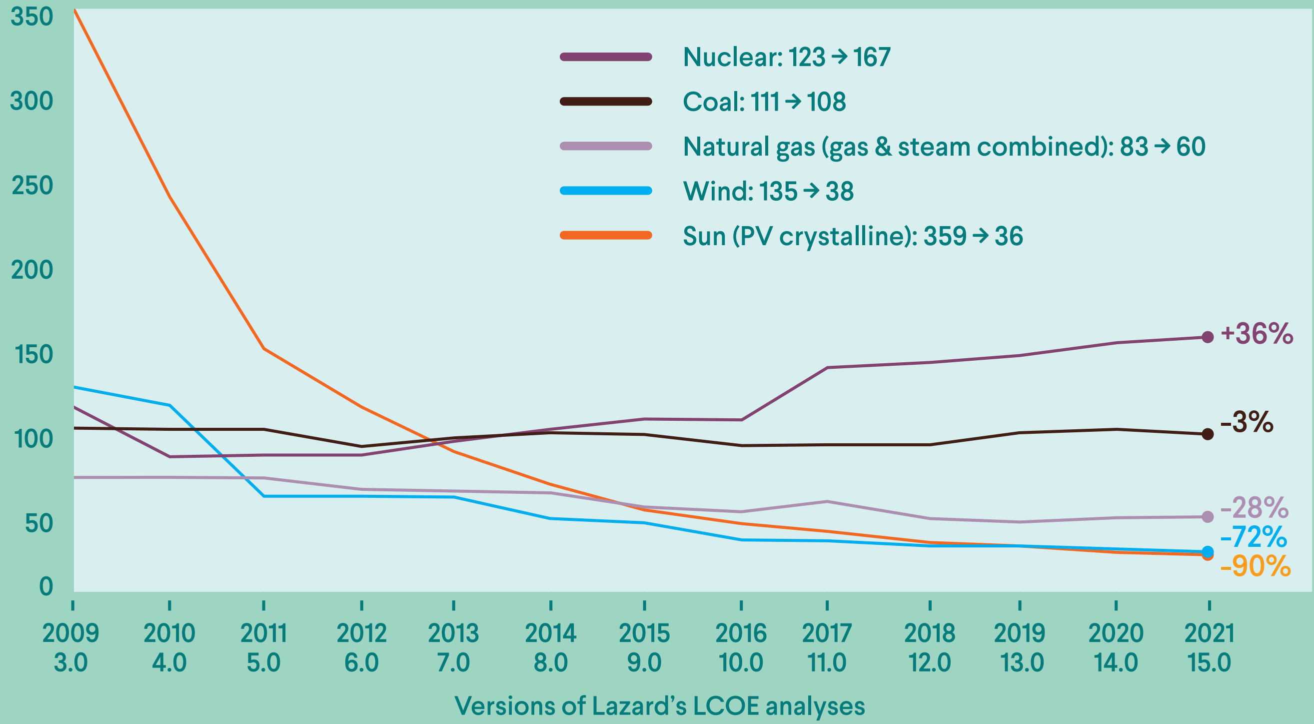
The dismantling of decommissioned reactors and the end storage of nuclear waste are not included in the calculation. As an example, the German Democratic Republic (GDR) nuclear power plant Greifswald-Lubmin: It supplied electricity for 16 years in the GDR, but the work of dismantling the plant has been work-in-progress for 30 years and there is no end in sight yet. EUR 6.6 billion have already been spent, with a rising tendency. The dismantling fund of German nuclear power plant operators is only endowed with EUR 24 billion for all German nuclear power plants. The coming generations will be paying the bill for a long time to come.[16]



Photo: distelAPPArath / pixabay

# ENERGY COSTS 2009 TO 2021

Average production costs in US$/megawatt hour*




* Corresponds to the mean decrease since Lazard's LCOE analysis of 2009 (version 3.0)

# Misconception 5: Nuclear power is carbon neutral

**The CO2 footprint** of nuclear power is zero; it can serve as emergency exit from fossil fuels

The energy transition needs lots of electricity and nuclear power is an indecent proposal to satisfy this need. One kilo of enriched uranium generates the enormous amount of heat of three million kilos of hard coal.[17] The radioactive decay heat is also completely carbon-free. However, bringing the heat into the power grids is extremely carbon-intensive. Just like the operation and dismantling of nuclear power plants and end storage. In concrete figures: one kilowatt hour of nuclear power releases some 104 grams of carbon emissions. This is significantly higher than the quantity released by wind energy or photovoltaic.[18] And the lower the ore content, the balance becomes even worse. If uranium demand continues to rise steeply, in a few decades we will have to cope with up to 500 grams of carbon emissions per kilowatt hour.[19]

But where does the wide range of carbon emissions come from? Uranium, the main fuel of the nuclear industry, is a non-renewable raw material that is mined and then processed. The $CO_2$ balance depends on the uranium content of the respective ores. The balance deteriorates as soon as ores with low uranium content are used. This is occurring more frequently because the high-yield deposits have been depleted. Extraction is thus becoming increasingly costly and environmentally harmful. Alone for this reason, a massive expansion of nuclear power would not improve the Earth's carbon emissions balance.

Currently, an average of just seven tonnes of fissile uranium-135 can be extracted from 10,000 tonnes of uranium ore. Huge radioactive mining shafts and massive pollution are the result.

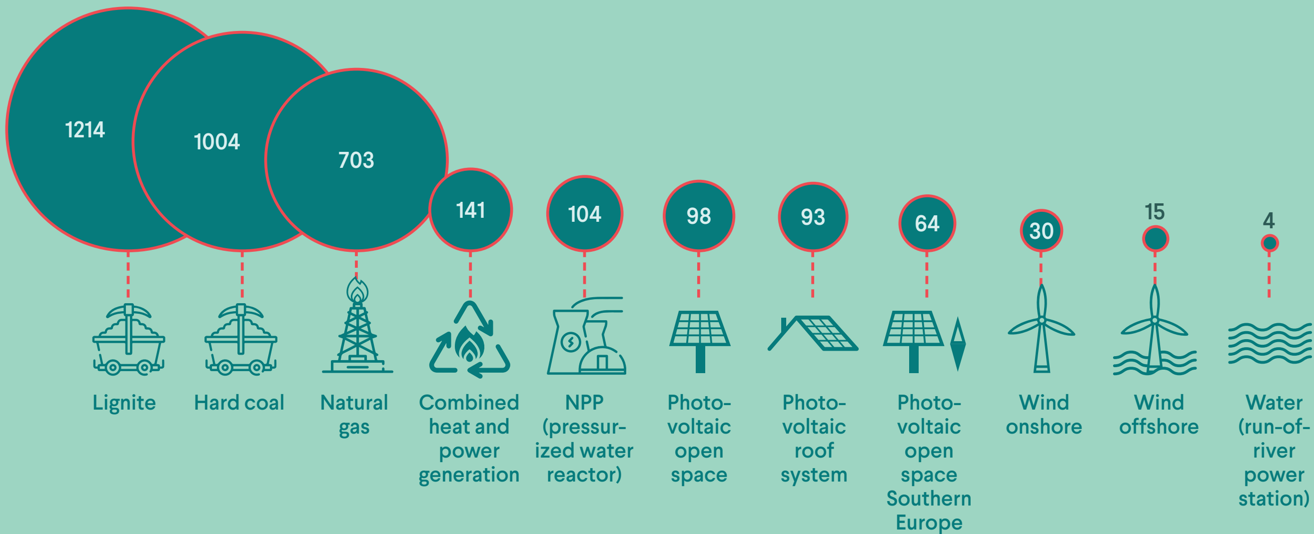
In the US, these massively contaminated areas are called "National Sacrifice Areas". They are located mostly in indigenous peoples' territories, where they endanger the health of the population.[20] However, even the highest estimates of the carbon footprint of nuclear power may be an understatement, because there is a great deal of uncertainty.

A volume of 390,000 tonnes of nuclear waste worldwide are waiting for functioning geological repositories. Their construction will involve huge volumes of emissions, because the repositories have to be leak-proof for one million years.

# ELECTRICITY IMPACT ON THE CLIMATE

## Carbon emissions of various energy sources in grams per kilowatt hour

Ökö-Institut has computed the climate emissions of our electricity for the “URANATLAS” (according to ecoinvent 3.5)



# Misconception 6: Nuclear power is safe

**Chernobyl and Fukushima** do not happen every day. Even solar and wind energy have claimed more lives than nuclear energy, not to mention coal.

More and more often, the web publishes disconcerting figures on the safety of nuclear power. For example, the nuclear disaster in Chernobyl in 1986 is said to have claimed only 60 lives.[21] But these are only the people who died as a result of direct radiation at the accident site. According to realistic estimates, up to 125,000 clean-up workers died up until 2005 alone, the so-called "liquidators". Some calculations even place the death toll at nearly 500,000 worldwide.[22]

The radioactive cloud that spread from Chernobyl over large parts of Europe continues to claim victims today. People are still dying from the late effects. In Austria, some 1,000 km away, tumour and cancer cases have increased significantly since the 1990s due to the Chernobyl disaster.[23]
More than 35 years after the disaster, every twelfth domestic chanterelle mushroom significantly exceeds the limits for radioactive cesium-137.[24]

Until 2011, the nuclear lobby liked to point out superior Western technology that virtually ruled out nuclear accidents like the one at Chernobyl. But then an earthquake surprised the Japanese at the Fukushima nuclear power plant. Earthquakes are not uncommon in the region. But an earthquake of this magnitude (9.1) had probably not been anticipated by the builders and most certainly not the subsequent fifteen-meter-high tsunami flood wave.

The Central Institute for Meteorology and Geodynamics stated: "The six-meter-high tsunami protection walls were designed far too low. The five-meter deep flooding of the reactor units and emergency power generators caused the cooling systems to fail. Within just a few days, three reactor blocks exploded, resulting in several meltdowns and fires, and the release of radioactive materials that contaminated workers and the surrounding population." [25]

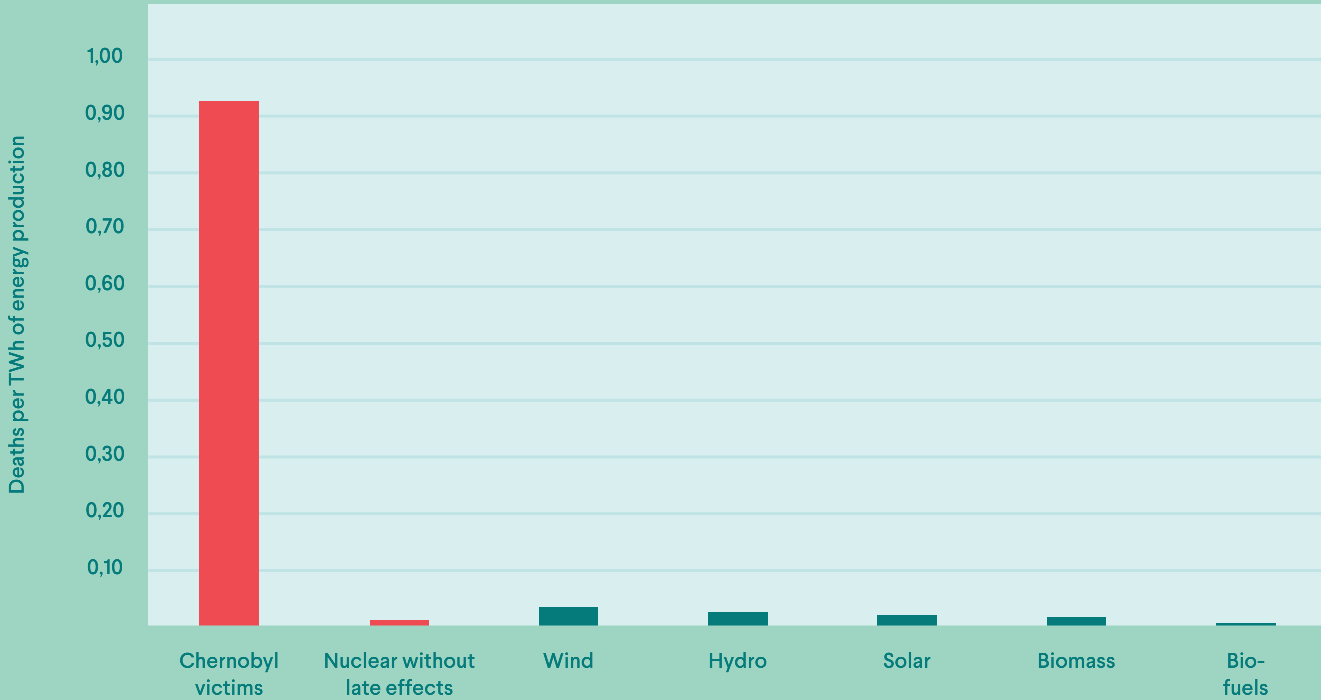
To this day, Japan officially denies any connection with cancer cases in the region, which are significantly higher than the national average, especially among children. Of the 160,000 refugees, more than a third never returned.

Assistance provided to the injured parties was modest. The nuclear power plant operator Tepco was rescued by government intervention and now wants to discharge 1.27 million tons of treated water, i.e. radioactive contaminated water into the sea.

Photo: Johannes Plenio / pexels

Nuclear power is never safe. Chernobyl and Fukushima were maximum credible accidents. Smaller and medium-sized incidents occur regularly. With all the negative consequences for nature and health. Many people probably know about the Three Mile Island meltdown in 1979. But who also knows that there was an INES 4 accident not far from Vienna at the Bohunice nuclear power plant in Slovakia as early as 1977? Who could have imagined nuclear power plants as theatres of war just a short time ago? *(See Chapter "Nuclear power plants are not bomb-proof – NPP in the event of war", p.56-57)*

# HOW DANGEROUS ARE LOW-CARBON FORMS OF ENERGY




Calculated based on IPPNW 2016 and Sovacool et al estimates. 2016.[26]

# Misconception 7: Outdated reactors are being modernized or shut down

**In such a risky industry,** no one take chances. Unsafe reactors are being shut down.

Cracks in materials, problems with power generators. Almost weekly, we receive reports of incidents at outdated nuclear power plants. With an average age of 31 years, many nuclear power plants are in dire need of an overhaul. One in five reactors worldwide is even older than 41 years. Reactors are usually designed to operate for 30 to 40 years. The materials become more brittle with each year of operation, cracks occur in the pressure vessel, which is the radioactive core of a reactor, making severe accidents more likely. Each shutdown and restart puts additional stress on the materials.

According to the Max Planck Institute, age-related deterioration is the reason why a super maximum credible accident is currently likely every 10 to 20 years. This means 200 times more often than previously assumed.[27] There are studies that conclude that a cracked pressure vessel cannot withstand the temperature difference of emergency cooling.[28]
An expert opinion of the Environment Agency Austria (Umweltbundesamt) on extending the operational life of a total of 32 French reactors of the 900-MW series beyond 40 years states that even with the most comprehensive modernization the reactors will not be able to achieve modern safety standards. The only thing left to do is to shut them down. But this creates new problems.

The nuclear power business is built on the principle of socializing losses and privatizing profits (with the help of state subsidies).

Although operating companies are required to set aside reserves for the event of severe accidents, these financial reserves are negligible. In France, for example, operators have to set aside a modest EUR 700 million for emergencies, while in the Czech Republic the figure is as low as EUR 74 million. That is a fraction of the estimated costs of a super maximum credible accident in the middle of Europe of EUR 100 to EUR 430 billion.[29] Even if operating companies wanted to, they cannot insure themselves against a severe accident. Not a single insurance company in the world is prepared to assume such a high risk.

Additionally, there is no incentive for nuclear power companies to pay closer attention to safety and shut down plants in the event of danger. Tepco, the operator of the Fukushima super maximum credible accident reactor kept decades of mishaps at its nuclear power plants secret, maintenance work was inadequate, and repair reports were falsified.[30] Every year of operation generates high returns for nuclear power companies.

Dismantling and disposal costs billions and takes many years without generating any income. From a business point of view, it is therefore best to let nuclear power plants run until a maximum credible accident occurs. These costs must then be borne by the state (see Fukushima).

Austria is surrounded by 11 active nuclear power plants, 10 of which are classified as high-risk plants.



Photo: Petar Avramoski / pexels


Neckarwestheim
Isar
Temelin
Dukovany
Bohunice
Mochovce
Leibstadt
Beznau
Gösgen
Paks
Krško

| NPP | Distance to border | Reason for high risk |
|---|---|---|
| **Krško** | 70 km | Earthquake area |
| **Paks** | 180 km | No containment |
| **Mochovce** | 100 km | No containment |
| **Bohunice** | 60 km | No containment |
| **Dukovany** | 40 km | No containment |
| **Isar** | 70 km | older than 30 years |
| **Neckarwestheim** | 160 km | Earthquake area |
| **Leibstadt** | 110 km | older than 30 years |
| **Beznau** | 110 km | older than 30 years |
| **Gösgen** | 130 km | older than 30 years |
| **Temelin** | 65 km | Not a high-risk reactor, but unresolved matters in the Brussels agreement |

Source: https://www.global2000.at/atomkraftwerke-um-oesterreich

# Misconception 8: Nuclear power is available at all times

**Nuclear power plants run** even when the sun isn't shining, and the wind isn't blowing. Without nuclear power we are at risk of blackouts.

When the French population was called on to save electricity at the beginning of April 2022 and the Carrefour supermarket chain dimmed the lights at 400 of its stores, the nuclear lobby suddenly fell silent. Overnight, nuclear power went from being an electricity miracle to the cause of a serious energy crisis.[31] At the time, 25 of the 56 nuclear reactors were out of operation, the capacity for electricity imports was almost at its limit, and electricity prices were rising to record levels.[32]

Severe safety problems caused by corrosion were identified at critical spots on several reactors and these problems possibly affect most reactors.

Therefore, France will have to restart old coal-fired power plants and import electricity again in 2022, when other EU countries are rapidly expanding their renewables capacity. The production forecasts for the years 2022 to 2023 for nuclear power plants had to be lowered significantly. This example illustrates the fundamental problem of an energy supply based on nuclear power as a basic source of energy. There is no fail-safe.

In France, each of the 56 reactors did not supply electricity for an average of 115.5 days in 2020.[33] Therefore, for one third of the year, outages had to be compensated most of which occurred completely unexpectedly and often concerned several reactors (at one time 24 simultaneously). In Belgium, the outage balance is even worse at 180 days and is due to the age of the reactors.

Once the maximum operating time is reached, costly and lengthy maintenance and modernization work become necessary. A large share of European nuclear power plants have now reached this stage. This increases the risk of failure.

At the same time, thousands of kilometres away in the Californian desert, a milestone project of the energy transition is being built on sand and dust.[34] The "Eland Solar & Storage Center" will soon supply 90,000 households in the metropolis of Los Angeles with electricity – day and night. Wind and solar power are the cheapest and most sustainable forms of energy and will be the foundation of the energy transition. Additionally, the projects show that wind power and photovoltaics complement each other well. Much more wind energy can be used in winter and more solar power in summer, resulting in an ideal combination *(see Misconception Number 1)*.

New battery storage technologies and green hydrogen will soon help close the gaps. Pumped storage power plants already fulfil this function – especially in Austria.

The nuclear industry persists in speaking of the all-time availability nuclear power. This talk includes repeated warnings of a blackout. Markets and investors, however, are already one step ahead and are placing their bets on solar, wind and geothermal energy with modern storage technologies that can fill the gaps in power generation. Lithium storage prices have dropped from EUR 1,060/MWh in 2010 to almost a tenth (just under EUR 100/MWh in 2021).[35] At the same time, the development of affordable, environmentally-friendly liquid batteries is progressing rapidly.[36] The future of electricity will be renewable and storable.



Photo: Der Weg / pixabay

# FRENCH REACTOR OUTAGES IN 2021

## Reactors without power generation.

On 338 days, which is 92% of the year, at least 10 reactors temporarily failed to generate electricity, and on 58 days or 16% of the year at least 20 reactors were non-operational.
The maximum number was 22 reactors (18.1 GW), the minimum was 7 (5.5 GW).

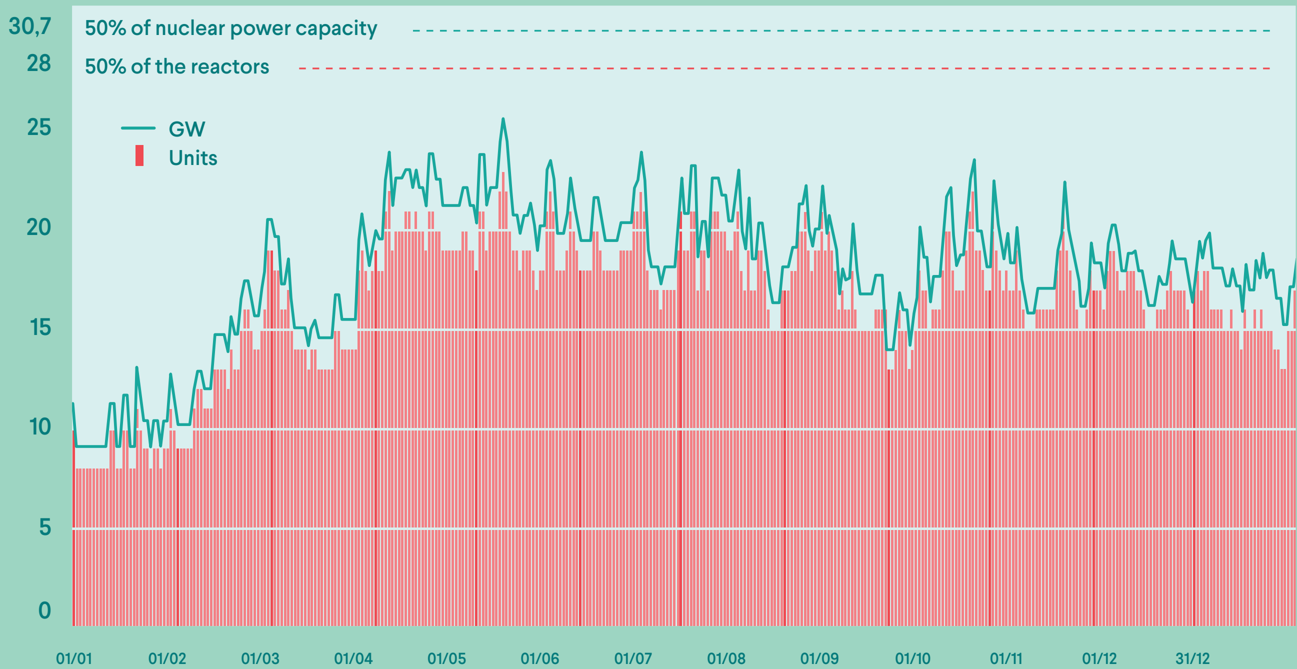


Photo: Michael Schmid

# Misconception 9: Fusion reactors will bring the sun to the earth

**Nuclear fission** is only an intermediate stage. With fusion reactors, unlimited energy will be available to us at no risk.

The idea is tempting. If we succeed in using nuclear fusion instead of atomic fission to generate energy, we will bring the sun to the earth. Unlimited energy without radioactive fissile material. It looks great in the computational model. Since 2007, work has been under way at the Cadarache nuclear research centre in southern France to build the world's first fusion reactor facility. In addition to the EU, seven other countries are involved in ITER (International Thermonuclear Experimental Reactor), the USA, Russia,

China, India, Korea, Japan and Switzerland. The facility is scheduled for completion by 2025, with the first nuclear fusions planned for 2036.[37]

There are great expectations and huge amounts of funds invested in the project in the hills of Provence northeast of Marseille. However, despite the current calculated investment of around EUR 30 billion and the broad international cooperation, it is highly uncertain or even unlikely that the dream of a power plant that produces unlimited and inexpensive electricity will ever become reality. Several major hurdles have to be overcome along the way. The European Greens have already named ITER the "chimera project" that diverts important resources from renewables. The originally estimated project costs of EUR 5 billion have now become EUR 15 billion with a rising tendency.[38]

## Plasma temperature

ITER is planned to generate plasma. Plasma refers to the fourth fundamental state of matter (apart from solid, liquid and gas). At a temperature of 150 million degrees Celsius (ten times hotter than the sun[39]), the atomic structure dissolves. Atomic nuclei and electrons are separated. The fusion takes place in the resulting plasma, which is held together by strong magnetic fields in a vacuum vessel. During the process, the hydrogen atom, deuterium, which contains an electron and a proton as well as a neutron, fuses with tritium, a hydrogen atom with two neutrons, to form a helium atom and a free neutron. The problem: To prevent the fusion process from breaking down, the vacuum vessel which contains the plasma is capable of withstanding enormous temperatures and an additional bombardment with neutrons.

At ITER, a period of around 7 to 8 minutes is planned for this process during the trial stage. Later during large-scale production it will not be enough. The material for the vessels for this process has not yet been found.

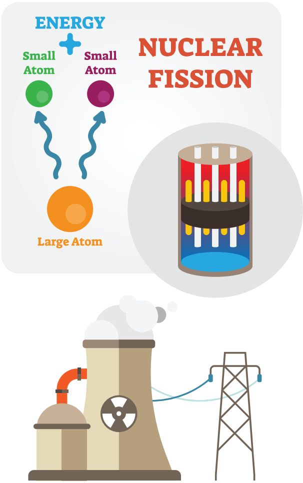
## Tritium

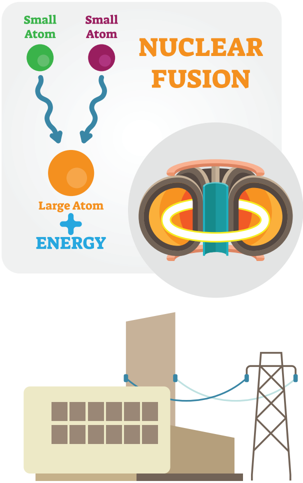
The fusion process needs deuterium and tritium. Deuterium can be easily extracted from seawater. Tritium, on the other hand, is a waste product from old heavy water reactors and extraction is costly. Therefore, fusion reactors would have to produce their own tritium.[40] This would put ITER in direct competition with the renewable energy transition, because large quantities of lithium are required for production. These would then be lacking for the production of batteries, for example. Tritium is also difficult to handle and causes radiation damage to the human organism.

## Efficiency

From ITER, it is known that during the comparatively short phases of fusion operation, the heat produced does not yield more than around one and a half times as much energy as goes into the process. This is a rather meagre output for such an expensive undertaking. Of course, it could be possible that in a large-scale facility, the 1:10 efficiency target defined by ITER would be attainable. However, it is highly uncertain at what point such a reactor would be able to supply electricity for everyone. Michael Dittmar, a physicist at ETH Zurich, states dryly: “ITER is only a prototype, at best interesting for basic research. Ultimately, it is about how to heat the plasma to 150 million degrees Celsius for a few seconds.”[41]

To recapitulate: ITER construction started in 2007, its commissioning is planned for 2025 and the first fusion for 2036. From 2007 to 2020 alone, the global temperature rose on average by around 0.4°C. The fusion reactor is certainly not an effective remedy for the climate crisis.



# Misconception 10: Myrrha solves the waste problem

**Who needs a final repository?**
New processes make high-level radioactive nuclear waste harmless.

In the small Belgian town of Mol, an international research team is working on a technology that promises nothing less than a solution to the global nuclear waste problem. Myrrha is the nice-sounding name of the project at the nuclear research centre (SCK-CEN), which includes co-funding by the EU.[42]

The concept sounds plausible and enticing. A particle accelerator fires fast neutrons at high-level radioactive waste. It decays, i.e. transmutes, into short-lived and stable isotopes. This simple procedure solves the nuclear waste problem. However, as with nuclear fusion and Generation IV reactors, there is still a wide disparity in the Myrrha project between what is wished for and reality. Based on an expert opinion of Bundesamt für nukleare Entsorgungssicherheit (BASE) (German Federal Office for Nuclear Safety), Germany, for example, decided against participating in the Myrrha project.[43]

The reasons are obvious.

## Myrrha does not solve the search for a final repository

Transmutation converts only a portion of the long-lived transuranic elements. It would require many process steps ranging from fuel reprocessing and transportation to irradiation. Alone for Germany's nuclear waste, this would take centuries under optimal conditions. After 300 years of transmutation, out of 150 tonnes there would still be 30 tonnes of transuranic elements left over.
Moreover, 40% of the high-level radioactive waste in Germany is vitrified and cannot be reprocessed.

Transmutation creates new fission products. These include high-level radioactive iodine-129 with a half-life of 15.7 million years, but also large quantities of low and intermediate-level nuclear waste, which also requires a secure storage facilities. Apart from this, fuel reprocessing also increases the risk of proliferation, i.e. the use for military purposes.

## No experience with the technology

New reactor concepts with a fast neutron spectrum, special reprocessing facilities, and fuels with a high transuranic content would have to be developed, built and become established on a large scale. Whether this can be achieved, and if yes, when, is uncertain. After seventy years of experience with the use of nuclear energy for electricity generation, it is clear that it will require decades of development work and construction time for these reprocessing facilities.

The funds used to finance the energy transition are not endless. We should therefore think carefully about which future technologies we want to invest in today.

With respect to Myrrha and transmutation, we currently see only enormous costs and a high risk of betting on the wrong horse.

# Facts & fiction

# Gone soon – Nuclear power is outdated

The only future nuclear power can promise is a legacy of decommissioned nuclear reactors and radioactive waste. These are the reasons.

How many new nuclear power plants has France – the number one nuclear power country – commissioned in the last ten years? Not a single one. Chivaux, France's newest nuclear power plant, has been producing electricity since 2002 and is already having operational problems. Over the past 20 years, only three reactors in the whole of Europe were connected to the grid: Temelin 1 and 2, and the Romanian Cernavoda 2. The golden age of nuclear power has been over for 40 years. In 1975, a record number of 44 new reactors were connected to the power grid.

In 2021, there were only six, three of them in China. The reason does not take long to find out.

Nuclear power is simply no longer competitive. Decades of construction time, construction delays and high costs deter investors. In 2020, they invested 17 times more funds into renewable energy than into nuclear energy.

This has not been without consequences. In the year 2020, growth in the renewable energy segment eclipsed nuclear power worldwide. Renewable energy produced 256 GW more electricity than in the preceding year. Nuclear energy by contrast increased only minimally by 0.4 GW.44 In the EU, electricity from renewable energy (excluding hydro-power) even exceeded the fossil fuel electricity share. Sun and wind have long since decided the race in their favour.[45]

In July 2021, 411 reactors were in operation worldwide with an average age of 31 years.[46]

Their contribution to the world's energy supply was around 2% in 2018, with a downwards tendency.

## Why nuclear energy's time is over

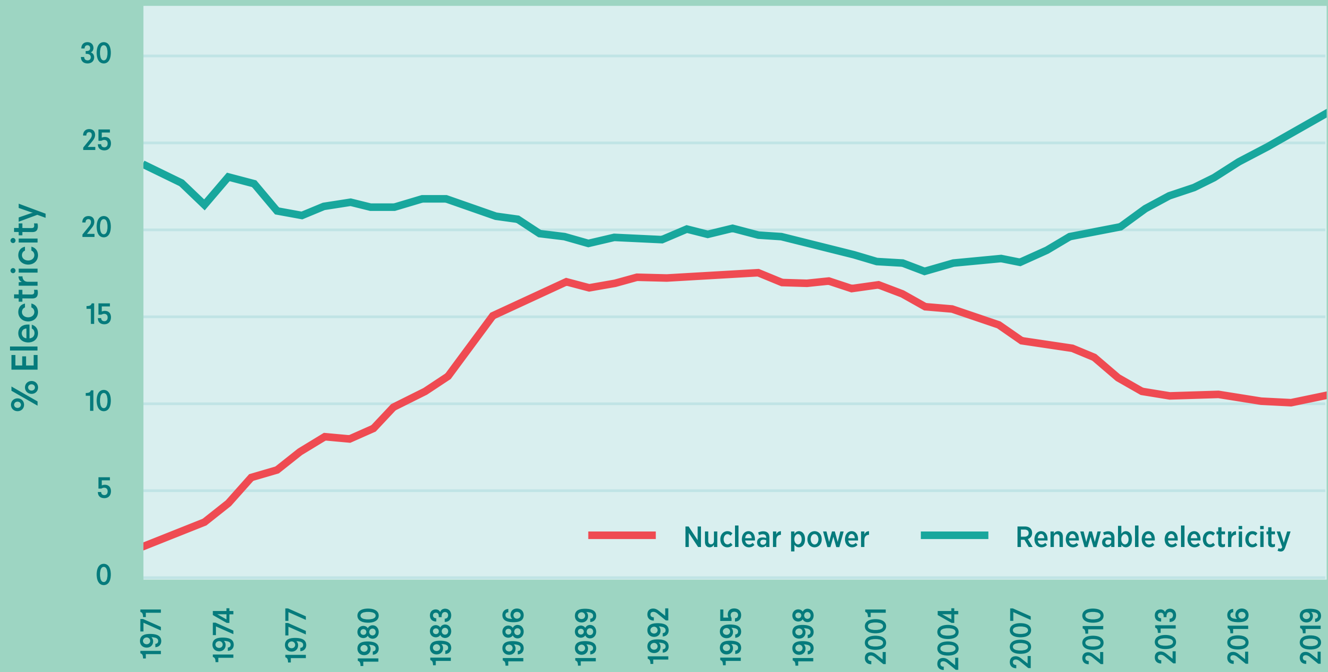
The old reactors are gradually being disconnected from the grid for safety reasons. Moreover, the need for maintenance and repair work increases significantly with the duration of operation. Breakdowns and outages are not only a safety hazard, but they also cost money and disrupt the power supply. France would have to invest EUR 100 billion in its outdated nuclear power plant fleet to maintain its nuclear power production at today's level.[47] The construction of new nuclear power plants is very time-consuming and costly *(see Misconception Number 4)*. By 2030, 178 reactors would have to be commissioned to retain today's level of nuclear power production. With construction times of 10 to 15 years,

Photo: Michael Schmid

a nuclear revolution in Europe can be completely ruled out. Only China is rapidly expanding its reactor fleet, but there, too, there will be resource problems.

However, the renewable energy sources of photovoltaic and wind power plants are experiencing a rapid decline in prices. Wind turbines and photovoltaic installations can be erected quickly, and are available and efficient also in smaller dimensions. With respect to the third major renewable energy source, hydropower, the potential for expansion is lower, but the old plants can be modernized at reasonable costs. Unlike nuclear reactors. All of these – including the ones currently under construction – will no longer be in operation by the middle of the century. The share of nuclear power in global electricity consumption is declining steadily.

# GLOBAL ELECTRICITY SHARES: NUCLEAR VERSUS RENEWABLE ENERGY




Source: IEA, World electricity generation mix by fuel, 1971 to 2019.

# No space for spent fuel rods

Although nuclear power plants have been in operation since the 1950s, there is still no final repository for spent fuel rods anywhere in the world. These will continue to be radioactive for hundreds of thousands of years to come.

The shrinking importance of nuclear energy contrasts with a growing mountain of nuclear waste. Around 390,000 tonnes of high-level radioactive waste has been produced since 1954.[48] One third have been reprocessed, the rest is being stored temporarily. This is done in provisional facilities in the immediate vicinity of nuclear power plants or on nuclear weapons bases. A highly questionable solution. However, all attempts to establish fixed disposal sites for radioactive waste have failed to date. In most cases, the sites considered ultimately failed to meet the strict safety criteria required for final disposal.

Often, the neighbouring communities put up fierce resistance. Not even in France, a country supportive of nuclear power, is there a safe nuclear waste repository for the approximately next one million years. While the construction and operation of nuclear power plants create jobs, at least for a while, a repository produces undesirable – because dangerous – delivery traffic. Only at the Olkiluoto site in Finland is the "Onkalo" geological deep repository being built at a depth of 450 meters, which will probably be completed in the next few years, but here too, there are unresolved technical problems.

Here are a few examples to better illustrate the temporal dimensions. The man from Hauslabjoch, better known as Ötzi, lived just over 5,000 years ago. The world-famous cave paintings of Altamira were created about 15,000 years ago. The Venus of Willendorf is some 30,000 years old. One million years ago, Earth was in the Late Pleistocene (Ice Age). At the time, the prehistoric mammoth was native to our latitudes. The first humans, however, did not appear in Central Europe until later.

But the high-level radioactive waste is only part of the problem. While it concentrates 95% of radioactivity of the world's nuclear waste, it accounts for only 5% of the volume. The remainder consists of medium to low-level radioactive nuclear waste from reactor components, protective clothing, and waste from medical, industrial and research uses. This nuclear waste is less radioactive, but still highly harmful to human health and must be safely stored in final repositories. In Austria, the national Waste Management Advisory Board (Entsorgungsbeirat) is responsible for the implementation of the national waste management strategy and the construction of a final storage facility, the location of which has yet to be determined.[49] Even if the nuclear era were to last until the mid-21st century, a modest energy contribution of about 2% for 100 years contrasts with the highly dangerous and expensive legacy of one million years.

**30 000 GENERATIONS**

will have to deal with the resultant risks and pass on the information

**1 MILLION YEARS**

is how long a repository must be sealed tight

**390 000 TONNES HIGH-LEVEL RADIOACTIVE WASTE**

have been waiting for decades for their safe final disposal

# Uranium mining – Death from the mine

People who think nuclear energy is clean, safe and creates energy self-sufficiency have forgotten about uranium. Uranium mining causes environmental destruction and death. The radioactive contamination in mining shafts, groundwater and soil will remain for millennia.

## History of radioactivity in the EU

Today, the EU imports almost all of its uranium as the number one fuel for its 110 reactors. The only active uranium mine in the EU, the Crucea mine in Romania, is used mainly for stockpiling. This was not always the case. Historically, Germany with the former GDR, for example, is the fifth largest mining country in the world. This was for military reasons: Hitler wanted the atomic bomb, and later on, German uranium from the ore mines of Saxony and Thuringia was used for the Soviet arsenal of weapons.

Although the mine has been closed since the fall of the Iron Curtain, not all shafts and tailings have been safely sealed to this day. Tailings are the toxic sludge left over after uranium mining.

## Dangerous dependence – also on Russia

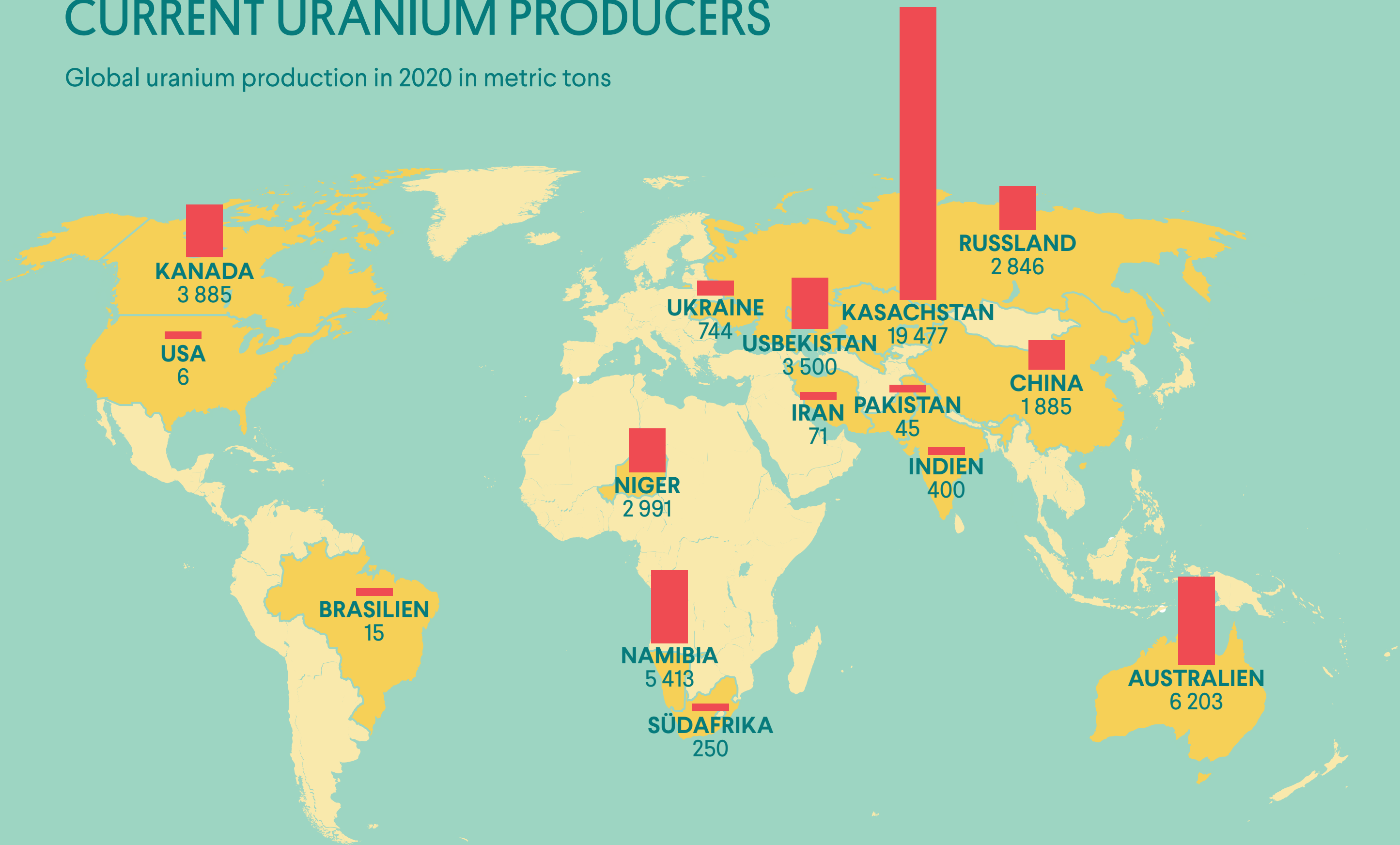
Can nuclear energy reduce the EU's dependence on Russia for gas, coal and oil? A look at the uranium trade reveals the opposite. Currently, the EU imports 20% of natural uranium from Russia and another 20% comes from Kazakhstan, a long-time ally of Russia. Russia is also heavily involved in fuel development, producing as much as 26% of enriched uranium. This will not, and cannot, change overnight. Technically, only Russian fuel rods can be used for the 18 Russian-designed EU reactors. Energy self-sufficiency in the EU is therefore only possible without nuclear power.

## Human suffering and environmental disasters

The medics of the Middle Ages called it "mountain sickness". A mysterious cluster of lung illnesses and deaths among miners. Today, the chemical causes are known. Mining in uranium-rich areas releases radon, a decay product of uranium, as well as radioactive isotopes and heavy metals that can cause malignant tumours, embryonic malformations, infertility and a host of other diseases. The German Bundesamt für Strahlenschutz (Federal Office for Radiation Protection) conducted an investigation of 59,000 former miners from GDR and found an increased risk of lung cancer of 50% to 70%. 7,000 of these miners (almost 12%) died prematurely due to radiation exposure.

# CURRENT URANIUM PRODUCERS

Global uranium production in 2020 in metric tons




Source: Nuclear Free Future Foundation/Hoffmann, CC BY 4.0, Uranium Atlas 2022

Nuclear companies in the EU have meanwhile completely outsourced uranium mining and its fatal consequences. A share of 70% of uranium is mined in areas populated by indigenous groups worldwide and have been causing humanitarian tragedies there for decades. Resistance to this is growing, in some cases with success. But the Cree in Canada, Diné in New Mexico, Aborigines in Australia, and miners in African mines are up against giants. In the US, only about one-third of the presumed 15,000 mine shafts are registered. The areas surrounding these mines remain contaminated, because the companies have left, and restoration work has been pending for decades.

Uranium mining has made large parts of the world uninhabitable. Cancer and tumours, however, do not carry a label of origin – lucky for many companies that earn money in the uranium business and then shirk their responsibility.

Photo: Recognize Productions / pexels

# Weather-sensitive and Climate-sensitive

Nuclear power plants are sensitive structures. It does not even take a severe freak weather event to throw them off kilter. A very warm summer or a particularly dry winter is quite enough.

An exceptionally violent storm swept across the southern Czech Republic in the night of 24 June 2021. The damage to roofs, houses and power lines was enormous. 10,000 households remained without electricity for days. And the reactor block 2 of the Temelin nuclear power plant was disconnected from the high-voltage grid and safe operation was no longer guaranteed. Three downed power poles were enough to shut down an entire reactor.

According to the Intergovernmental Panel on Climate Change (IPCC), the climate crisis is manifesting itself in storms, floods and droughts much earlier, stronger and more frequent than previously assumed.[50] Temelin is only a symptom of a far greater threat.

## Some don't like it hot

Nuclear power plants must be permanently cooled. For this reason, the reactors are usually located along rivers or near the sea. They need enormous amounts of cooling water. This water is returned to the rivers after cooling. It is not radioactive. But warm. More and more often too warm for the ecological balance of the rivers.[51] But without cooling water, no nuclear power plant operation. The otherwise so meticulous Swiss engineers therefore allow river water temperatures of up to 30°C in the vicinity of nuclear power plants in exceptional cases. This pleases the nuclear power industry. But not at all the domestic fish. Trout can hardly stand more than 18° C water temperature. Large catfish like it a bit warmer, namely 18° to 22° C. But if the water is warmer, it's the end of the catfish, too.

If maximum temperatures are exceeded, nuclear power plants must shut down or limit their capacity. This is not just theoretical, but has already happened. For example, in 2003, 2006 and 2015. In 2018, even Northern European power plants were affected for the first time (Northern Ireland, Finland, Sweden).

A similar problem is caused by longer dry periods in summer and winter. These are occurring more frequently as climate change progresses. If there is simply not enough cooling water in the river, the only option is to throttle or shut down the nuclear power plant. This happens more and more often when electricity consumption is high. In summer, when air conditioners are running at full blast; in winter, when the outside temperatures drop below zero. France, which a few years ago still obtained around 70% of its electricity from nuclear power plants, reached the limits of its production capacity several times in the recent past. All European nuclear power plants together evaporate four times the amount of water of Lake Neusiedl in a year.[52] When water becomes scarce, agriculture will be the main sector to need it, much more so than an industry that only covers 2% of global electricity demand.

## In hot water

Water shortage is very bad for nuclear power plants. But too much water is even more fatal. The Fukushima tsunami was impressive proof of this. Rising sea levels and the increasing risk of storm surges due to climate change pose a particular threat to coastal nuclear power plants, which in total account for 41% of all nuclear plants. This was ascertained by the British Nuclear Consulting Group in a report published in June 2021: "Due to ramping climate-induced sea-level rise, storm, storm surge, severe precipitation and raised river-flow, UK nuclear installations are set to flood – and much sooner than either the nuclear industry or regulators suggest." [53]

US colonels have a similar assessment of US nuclear power plants: Climate change puts 60% of reactors at risk from flooding or heavy storms, and the government is not prepared for such an event.[54] Not a good outlook.

But rivers are also overflowing their banks with increasing frequency, as the summer of 2021 in Germany and Belgium clearly demonstrated. When the Meuse River exceeded its former all-time high water mark of 1926 in July of 2021, the Tihange nuclear power plant was at risk. 2,140 cubic meters of water per second caused the safety buffer of the nuclear power plant to shrink to just 20%. The situation at the sites of the Swiss nuclear power plants Beznau and Gösgen is similarly problematic. Especially at Beznau, heavy flooding of the rivers Aare, Reuss and Limmat are causing increased soil erosion and thus weakening the ground on which the nuclear power plant is built.[55] Nuclear power companies will increasingly have to shut down reactors at short notice in response to extreme events. This poses safety risks, because the extreme temperature differences cause the reactor's material to become brittle. For example, a large number of disquieting cracks have been detected at the Belgian high-risk reactors Tihange 2 and Doel 3. The two reactors are scheduled to go offline by 2023.[56]

## Conclusion

Nuclear plant safety designs are based on past extreme weather events, but ignore the new challenges of climate change.[57] Up to now, nuclear companies have just sat by and watched. However, they should take action sooner rather than later, because even after a shutdown, the fuel rods have to continue to be cooled at the site for years.

# Atomic Bomb included

The world's plutonium stockpiles are sufficient to destroy all life on Earth several times over. The plans to build hundreds of new small nuclear power plants will make all those happy who want to finally get easy access to a nuclear bomb.

It is 100 seconds to midnight. Not even during the Cold War was the Doomsday Clock so close to the end of the world as in 2020. The American scientists of the Bulletin of the Atomic Scientist have raised the alarm. We are in a new nuclear arms race, and it has never been easier to get the bomb than it is today.[58] Little Boy, the first atomic bomb used in a military conflict, was not yet very sophisticated.

It contained 64 kilograms of enriched uranium, with only about one kilogram of fission uranium. Nonetheless, in August 1945, Little Boy completely destroyed the Japanese city of Hiroshima and cost the lives of about 250,000 people. Meanwhile, 3 to 5 kilograms of plutonium are enough for an effective atomic bomb and its construction is no longer a miracle.

It is not without reason that Israel, one of the states that already has nuclear bombs, has intervened militarily several times in the neighbouring Arab countries such as Syria or Iran. Fears run high that nuclear weapons-capable material could fall into the hands of terrorist organizations through uncontrollable channels. On its website, the German Federal Agency for Civic Education (Bundeszentrale für politische Bildung) lists the nuclear weapons status as of 2014.
Of the 15,700 nuclear warheads at the time, 80% (!) are not subject to any contractual control mechanisms.

Only 6% of the uranium stockpile is used for civilian purposes, the rest is classified as military. Of the plutonium stockpile, about 47% is civilian use and about 53% is military use. With the world's stockpile of weapons-grade uranium and plutonium, the current arsenal of 13,080 warheads could be increased hundredfold.[59] At the same time, 100 nuclear warheads alone would be enough to wipe out the entire human race.

Nuclear power plants serve as a cover for bomb-making, because they produce the plutonium needed. Theoretically, it is available worldwide, and civilian and military nuclear complexes are communicating vessels. French President Macron said so quite openly: "Without civilian nuclear power, no military nuclear power; without military nuclear power, no civilian nuclear power."[60] Therefore it is not surprising that especially the major nuclear powers such as France, US, Great Britain and China are investing massively in new nuclear technologies.

At the same time, none of these countries has signed the UN Treaty on the Prohibition of Nuclear Weapons. In fact, the design of today's nuclear power plants is of military origin, including the modern light water reactors as well as Bill Gates' sodium reactor.[61] The nuclear expert, Jan Haverkamp, refers to the latter as a "proliferation nightmare", because it includes the technology for extracting weapons-grade uranium.[62]

It would be an illusion to assume that the world's plutonium stockpiles are securely under surveillance and control at all times. And security would become even more difficult if a plethora of new small NPPs were to be built everywhere. Although smaller quantities of radioactive material are produced per mini reactor, guarding the smaller volumes is no less costly than for larger reactors.

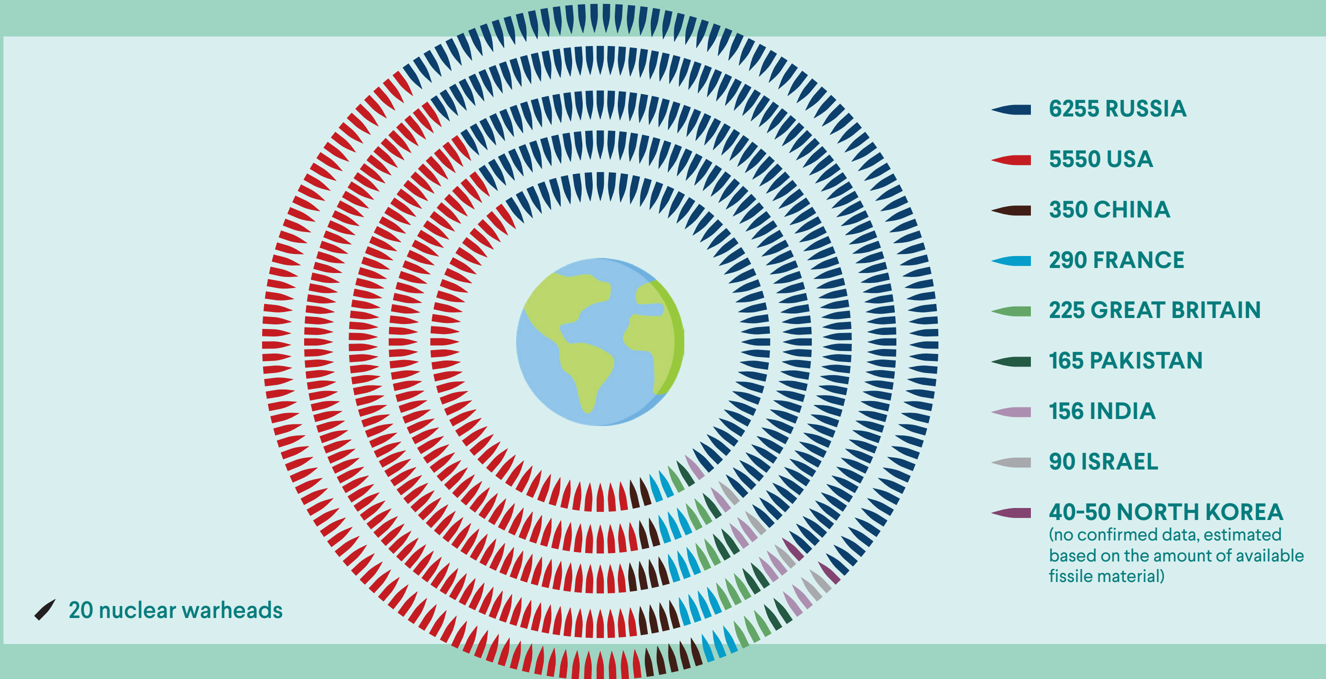
Moreover, there is no need for a nuclear bomb with the destructive power of Little Boy. For a quick terrorist attack, the small format suffices.

This is another unresolved safety issue of nuclear power plants. Nuclear power and nuclear weapons are twins that mutually ensure their continued existence.

Photo: Michael Schmid

# NUMBER OF NUCLEAR WARHEADS PER NATION

Status 2022




Source: Nuclear Free Future Foundation/Hoffmann, CC BY 4.0, Uranium Atlas 2022

Hiroshima Memorial | Photo: Armin Forster / pexels

# Nuclear power plants are not bombproof

## NPPs in the event of war

Since the beginning of the nuclear era, there have been no theatres of war in the immediate vicinity of nuclear power plants. This changed with the Russian invasion of Ukraine, and along with it, the risk of a nuclear disaster of historic proportions.

Nuclear power plants are bombproof in the truest sense of the word was the motto for decades. It was considered to be out of the question that a nuclear power plant would come under fire in the event of war, because it would put all parties of the conflict in the greatest danger. Also the attackers. However, since the Russian attack on Ukraine in February 2022 and the nuclear power plants there, the situation has changed. Additionally, it does not take a bombardment or a missile attack to collapse the safety structures of a nuclear power plant.

Power grids are vulnerable, including those of nuclear power plants. Who hasn't found themselves suddenly in the dark during a heavy thunderstorm? Power failures can quickly become dangerous at nuclear power plants, because the fuel rods must continue to be actively cooled, even years after a shutdown. If the external power connection is destroyed, emergency cooling systems take over. At the Zaporizhzhya nuclear power plant in Ukraine, for example, diesel generators are available that can continue to cool the plant for around seven days. At the latest after this time, the generator must be refuelled or the power grid repaired to prevent a meltdown. This is highly uncertain in wartime.

A key pillar of NPP safety is the mental and physical condition of the staff. Exhaustion and fatigue were probably involved in the reactor disasters of Chernobyl (Ukraine, 1986) and Three Mile Island (USA, 1979).

When Russian troops took over the damaged Chernobyl nuclear power plant and disrupted the scheduled shift changes of the Ukrainian staff technicians, the safety of the radioactive ruin was no longer guaranteed. Lack of concentration due to exhaustion or threats to the staff from armed combatants can quickly lead to oversights or bad decisions. With fatal consequences.

A direct attack on the reactor shells was always considered unlikely. But it does not even need a deliberate and targeted attack. Modern weapons lock on to their targets via electronic control systems. There is no such thing as one hundred percent certainty. A small programming error or a hacker attack can cause deviations from the planned course.

There is no protection against this. The lethal radiation load would affect everyone for a long time and to a far greater extent than has ever been assumed by the nuclear industry when calculating their models.

Photo: Johannes Plenio / pexels

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# Nuclear power

## Dead end for climate change mitigation

**After the maximum credible accident disaster at Fukushima, it seemed like the exit from nuclear power was a done deal. However, confronted with the climate crisis and rising energy demand, the nuclear industry is now making new promises: mini-nuclear power plants, thorium reactors and simple solutions to the nuclear waste problem.**

**This brochure compares the tempting illusions with the hard facts. Concisely and in plain language.**

Brochure produced by FREDA - Die Grüne Zukunftsakademie and Member of Parliament Martin Litschauer, Anti-nuclear Spokesman

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