THE CASE AGAINST NUCLEAR POWER

# Climate change and why nuclear power can't fix it

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# Introduction

**As any activist engaged in anti-nuclear advocacy knows, nuclear power is a complex topic. It can be challenging to describe all the various dangers and detriments in simple, concise language.**

To address this, we have created a series of booklets that, taken together, comprise The Case Against Nuclear Power: Facts and Arguments from A-Z.

Each booklet presents simplified, boiled down explanations of the topic at hand. We also rebut the false pro-nuclear propaganda in circulation. And we endeavor to help everyone – whether a long time campaigner or an ingenue – feel confident about their ability to articulate the facts, and to do so in compelling and non-technical language.

Each booklet will be posted to the Beyond Nuclear International website when completed and will also be available as a standalone piece in print. Once all the booklets are completed, the entire work may be downloaded as a single handbook. The content of each booklet is documented through references and footnotes.

In assembling such a wealth of information, omissions will be inevitable. The status of nuclear power is also constantly changing and some of these facts and figures may quickly go out of date. We encourage you to find the updates on line.

By necessity, some sections focus mainly on the US. However, many if not most of the facts and arguments are universally true. We encourage you to use and share these booklets widely. They are also freely available to download and reprint without permission.

# Climate Change

Nuclear power has no constructive role to play in climate change solutions. In fact, it is a hindrance.

In this booklet, we break down the specific reasons why nuclear power cannot address climate change. There are some other tangental issues that also rule nuclear power out of the climate solutions mix. It is too expensive, and part of the reason for that is due to the immense safety risks, and the unsolved radioactive waste management challenge. These issues are addressed in the separate booklet chapters on Costs, Safety and Waste.

The pursuit of nuclear energy as a climate change solution inhibits the necessary rapid development of solutions that are available, less expensive, safer and more environmentally effective.

## Nuclear power does have a carbon footprint

When nuclear power is said to have "zero emissions," this refers only to the electricity generation phase and only to greenhouse gas emissions. There *are* emissions at this stage, especially heat and radioactivity. Certain emissions during reactor operations, such as carbon-14 in CO2 form and methane, are greenhouse gases. However, there are plenty of carbon emissions involved in making a nuclear power plant a reality. Therefore, when discussing the carbon footprint of nuclear energy compared to other energy forms, the entire uranium fuel chain needs to be taken into account. In doing so, nuclear energy compares poorly to renewable energy and energy efficiency. Lifecycle emissions along the nuclear fuel chain occur through uranium mining and milling, transportation, plant construction, operation, reactor site decommissioning, and nuclear waste management.[1]

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## Life-cycle carbon emissions of a nuclear power plant

When taking into account planning, permitting, construction, operation, refurbishing and decommissioning, a nuclear power plant emits at least 6-24 times more carbon-dioxide equivalent emissions than wind per unit energy produced over the same 100-year period.[2]

## Life-cycle carbon emissions from the entire nuclear fuel chain

How do we calculate this? Evaluating the total carbon output of the nuclear industry involves calculating emissions from every carbon-emitting phase of the uranium fuel chain, then dividing them by the electricity produced over the entire lifetime of the plant.[3] Some of the most reliable analysis on this has been done by Dr. Benjamin Sovacool whose data we use here (see footnote 1). Let's take a look at the mean carbon emissions of each phase:

- **The entire uranium fuel chain.** This includes every phase from uranium mining to decommissioning and waste management. **66 gCO2e/kWh. (StormSmith has 80-130 gram CO2/kWh.)**[4]
- **Uranium mining, milling, processing, refining and fuel fabrication.** Calculations can vary depending on factors such as grade of uranium ore, energy source used to mine etc. **25.09g/kWh**
- **Construction of a nuclear power plant.** This includes fabrication, transportation and use of materials. **8.20 g/kWh**
- **Reactor operation and maintenance. 11.58g/kWh**
- **Radioactive Waste Management and storage. 9.20 g/KWh**
- **Decommissioning. 12.01 g/KWh**

## Carbon emissions broken down by percentage

*Percentage of total carbon emissions released by each stage of the uranium fuel chain.*

| | |
|---|---|
| Uranium mining, milling, and enrichment: | 38% |
| Construction: | 13% |
| Operation (inc. backup diesel generators): | 17% |
| Fuel processing and waste management: | 14% |
| Decommissioning: | 18% |

## Life-cycle carbon emissions of the nuclear fuel chain compared to other resources

| | |
|---|---|
| Scrubbed coal-fired plants: | 960 gCO2e/kWh |
| Natural gas-fired plants: | 443 gCO2e/kWh |
| Nuclear power plants: | 66 gCO2e/kWh |
| Solar photovoltaic: | 32 gCO2e/kWh |
| Onshore wind farms: | 10 gCO2e/kWh |

So nuclear emits twice as much carbon as solar PV and six times as much as onshore wind.

Here's one way Sovacool sums it up:

***"Every dollar you spend on nuclear, you could have saved five or six times as much carbon with efficiency, or wind farms."***

## Nuclear energy is not "renewable"

Nuclear energy should more properly be called "uranium" energy since that is what is required to create the fuel to power a reactor. Uranium is a finite resource and not "renewable." Continued use of nuclear energy will deplete the resources of high-grade uranium ore needed for the fuel.

Current global energy use requires approximately 70,000 tons of uranium a year. Ramping up the use of nuclear power would dramatically increase this figure and require the discovery of new resources of uranium.

The option of using lower grade uranium ores requires more energy per unit recovered uranium and consequently causes higher CO2 emissions which will eventually equal to if not surpass that of fossil-generated electricity. This could happen within the lifetime of new nuclear build.[5]

The option to "mine" uranium from sea water is also impractical. Uranium concentration in sea water is tiny – 3.3 parts per billion. It would take as much energy to remove it from the sea as it would provide, says Professor Derek Abbott in his paper, Nuclear Power: Game over.[6]

## Building new nuclear plants won't replace coal plants

Assuming a life-span of 40 years (although the average reactor lifespan is 22 years), and that older reactors will continually close, we would need to build 80 new plants in the next 10 years to keep global nuclear production at present levels. Then we would need to build – and connect to the grid – another 200 plants in the 10 years after that. Given the average construction time of 10 years, even if we start building tomorrow and we manage to build 280 new plants in the next 20 years, we will still have only replaced the present nuclear capacity and not replaced a single coal-fired plant.[7]

## Using nuclear plants to address climate change has huge downsides

Even if nuclear power could be scaled up enough to address climate change (which is unlikely if not impossible; see "Time" section at the end of this booklet), it would lead to many major serious consequences:

The probability of accidents would increase. Accidents endanger and irreparably damage ecosystems, harm human and animal health, and destabilize social and economic orders. While all energy systems include risks and impacts, those of nuclear are on a scale far greater than those of renewable energy.

The nuclear waste problem, still unsolved, would mount dramatically.

Proliferation risks would be increased due to greater use of nuclear energy in more countries, making a transition to nuclear weapons programs easier and more likely.

The lack of uranium supplies would force a transition from once-through to closed cycle systems that necessitate reprocessing, a highly polluting process that releases liquid and gaseous radioactive wastes into the air and water and encourages and enables nuclear weapons development.


An emphasis on nuclear power over cleaner electricity generators, could derail climate mitigation if a serious accident occurred at a nuclear facility, nuclear power plant, enrichment plant, or waste facility. Nuclear energy would have to be abandoned and sufficient renewable energy replacement power would not be in place, setting back climate change abatement.

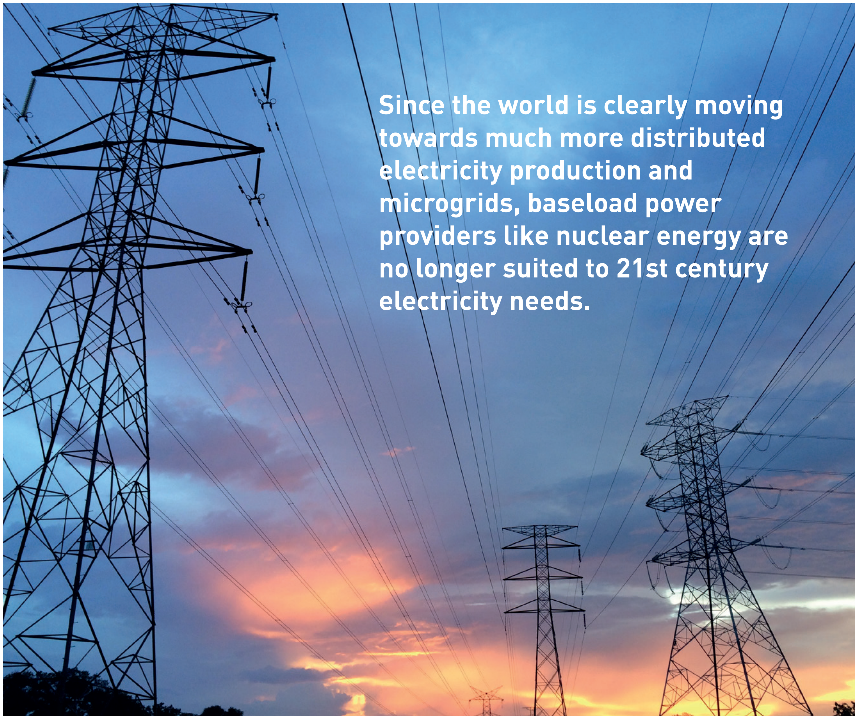
## It's all about the baseload

Nuclear proponents claim that "baseload" energy is necessary because renewables are too "intermittent." Baseload power generators such as nuclear and coal plants are typically large units that operate more or less continuously at 70 to 90 percent of their rated capacity.[8]

But being "on" all the time is not efficient. Baseload plants cannot power up or shut down quickly. They run at high capacity even at night when energy demand is much lower. In fact, nuclear energy has the lowest flexibility and the worst response speed compared to all other power technologies.[9]

Since the world is clearly moving towards much more distributed electricity production and microgrids, baseload power providers like nuclear energy are no longer suited to 21st century electricity needs. The focus is now on renewable energy, and on flexible generation, demand management, and energy efficiency.

Managing this mix is about predictive ability, and this is solvable. Variable renewable energy does not mean unreliable: as long as it can be reliably projected, with sufficient advance time, what the wind will do and thus how much wind power will be available where, and the same for the sun, then a variable grid can be highly reliable.[10]




## Grid reliability

Where grid operators have better predictive information and are willing to analyze real-time conditions and to match generation with demand, the so-called intermittency of renewables is easily accommodated. In fact, countries with the highest levels of renewable penetration have the least trouble in managing their grids.[11]

It is the unwillingness of grid operators to innovate, not the need for baseload power, that has perpetuated the dominance of nuclear and fossil fuel energy on the grid. The issue is no longer about "the sun doesn't shine and the wind doesn't blow all the time."

Furthermore, since storage challenges are now being solved, storing renewable energy and adding it to the grid when demand is there, is a flexible, practical and economical option.

As Germany has demonstrated, a grid based on smaller, distributed variable power sources can be just as reliable, and even more resilient and secure, than a grid reliant on baseload power.[12]

## Nuclear power does not belong in state renewable portfolio standards

In the U.S., at least 29 states (at publication time) and the District of Columbia have adopted renewable portfolio standards (RPS). These standards require utilities to sell

**In a world under global warming conditions, water is fast becoming a precious commodity. It makes no sense to continue with large thermoelectric plants that consume large quantities of water.**

a specified percentage or amount of renewable electricity. The percentage varies from state to state. Hawaii currently has the most aggressive RPS: 30 percent by 2020; 40 percent by 2030; 70 percent by 2040; 100 percent by 2045.[13] An RPS helps drive the market for wind, solar and other renewable sources and enables states to diversify their energy mix and reduce carbon emissions.

Including nuclear power in an RPS, as some proponents have tried to do, would undermine these efforts[14], slow renewable energy expansion, and cut into its market share.[15]

## Nuclear power plants consume too much water

In a world under global warming conditions, water is fast becoming a precious commodity. It makes no sense to continue with large thermoelectric plants that consume large quantities of water. Once-through cooling plants draw in as much as a million gallons of water a minute which is later discharged at heat, usually into the same body of water, heating it up. Plants that use cooling towers (closed-loop cooling), draw in water and then evaporate it as steam, thereby consuming and depleting water supplies.

While once-through nuclear plants withdraw more water from the source, plants with cooling towers consume more water as only a fraction of the water is "returned" to the environment as steam. According to the Union of Concerned Scientists:

- Daily water withdrawal by closed-loop (cooling tower) recirculating cooling: 19–62 million gallons daily for a 1GW reactor
- Daily water withdrawal by once through cooling: 0.6–1.4 billion gallons daily for a 1 GW reactor

## Nuclear power plants must power down or shut down during droughts and heatwaves

Droughts and heatwaves will increase under global warming. Under these conditions, nuclear power plant cooling efficiency requires it to power down and even shut down altogether.

In a heatwave, the water supply source may become too warm to use to safely or efficiently cool the reactor. The Nuclear Regulatory Commission sets limits on how warm the cooling water can be for each nuclear plant. As global warming increases, these limits will be reached more often, causing more frequent nuclear power plant outages. When cooling water temperatures are higher, a nuclear power plant needs to consume even more water than usual.


During a drought, the water source level may drop too low due to evaporation to be usable, or may be needed for more immediate needs such as drinking water and agriculture.

Ironically, this means that nuclear power plants are not operating just when their electricity output is needed most, during hot weather when air conditioning usage peaks.

## Coastal nuclear plants could end up under water

Under climate change, sea levels will rise. Many nuclear plants are located along coastlines. As we saw most dramatically at Fukushima, Japan in 2011, inundation can be catastrophic. But it need not take a tsunami. As seas rise, coastal nuclear power plants in at risk regions will eventually become submerged, making them inoperable. Their radioactive waste inventories, if not moved in time, would then leak into the oceans. National Geographic identifies 14 U.S. nuclear power plants as at risk of submersion due to climate change-caused sea-level rise.[16]

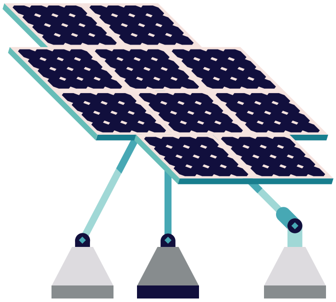
Even storm surges and coastal flooding, already a risk today, could inflict serious damage on some high-risk U.S. coastal plants, especially in the Mid-Atlantic and Northeast region.[17, 18]

## Closing nuclear reactors does not mean an increase in fossil fuel use

When nuclear power plants close, they are not automatically replaced by fossil fuel plants. For example, after the Ft. Calhoun nuclear plant closed in Nebraska, Omaha Public Power District opted to replace its output with wind energy rather than fossil fuels. The company predicted that wind power would generate 40% of its electricity by the end of 2019.[19] Pacific Gas and Electric has stated that after it closes Diablo Canyon nuclear power plant – the last nuclear plant in California – it will replace that electricity with renewable energy and energy efficiency, silencing nuclear boosters who predicted a rise in the state's carbon emissions.[20]

## Climate change was not caused by prioritizing fossil fuel development over nuclear power

The fact that President Nixon's prediction of 1,000 U.S. nuclear reactors by the year 2000 did not materialize is not what led to the over-use of fossil fuel resulting in climate change. It was the choice to use nuclear energy at all. In 1952, the U.S. was at an energy crossroads. That year, the recommendations of President Truman's Materials Policy Commission report urged "*aggressive research in the whole field of solar energy – an effort in which the United States could make an immense contribution to the welfare of the world*."[21] The report concluded that nuclear energy could deliver only a "*modest fraction of American energy requirements at best*."



**The continued use of nuclear energy necessitates the maintenance of an electricity system that accommodates inflexible baseload power. This slows and impedes a transition to decentralized renewable energy systems.**

But the succeeding Eisenhower administration chose the nuclear path over solar and implemented "Atoms for Peace" instead. The reasons, of course, were not entirely related to energy needs, but inextricably tied to nuclear weapons development. Early efforts focused on "dual use" reactors that served the need for weapons-grade plutonium production with electricity as a mere by-product.

Even when dual use military reactors were abandoned in favor of commercial power plants that just produced electricity, nuclear power plants turned out to be slow and extremely expensive to build. But the U.S. commitment to stick with it closed the door on massive renewable energy development and led the way to our current dependence on cheaper, less complex fossil fuels.

Nuclear power never fulfilled the bold predictions of President Nixon. But because of the fateful decisions of the 1950s, we do not have that recommended massive development of solar and wind energy that would now be ready to replace nuclear power and fossil fuels. That has allowed natural gas to fill the void, thus condemning us to a fossil fuel dependency, and both causing and worsening climate change. This could have been avoided if renewables, and not nuclear power, had been adopted in the first place.

## Nuclear energy use impedes renewable energy development

The continued use of nuclear energy necessitates the maintenance of an electricity system that accommodates inflexible baseload power. This slows and impedes a transition to decentralized renewable energy systems. (See Baseload above).

As the financial condition of nuclear power corporations steadily worsen, these companies are looking for loan guarantees and federal subsidies to keep their plants operational. This significantly draws down essential federal funding for a rapid deployment of a proven, reliable and marketable renewable energy sector.

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[2] https://web.stanford.edu/group/efmh/jacobson/Articles/I/15-12-30-ResponseHansen.pdf

[3] http://www.nature.com/climate/2008/0810/full/climate.2008.99.html#B2

[4] http://www.stormsmith.nl/i05.html

[5] http://www.stormsmith.nl/i05.html

[6] https://bit.ly/2Hb5EJY

[7] http://www.foeeurope.org/sites/default/files/publications/foee_nuclear_power_no_solution_only_problems_0207.pdf

[8] http://www.zdnet.com/article/why-baseload-power-is-doomed/

[9] https://www.worldfuturecouncil.org/the-climate-nuclear-nexus/ pgs15-16

[10] https://safeenergy.org/2015/08/20/the-archaic-nature-of-baseload-power-or-why-electricity-will-become-like-long-distance/

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[17] https://www.washingtonpost.com/opinions/protecting-nuclear-plants-from-natures-worst/2012/10/31/5af389ac-2374-11e2-8448-81b1ce7d6978_story.html?utm_term=.41856fff7826

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[21] The Report of the President's Materials Policy Commission. William S. Paley. (Washington, DC: Government Printing Office, June 1952).

# Time

The fundamental flaw in the argument that nuclear power is vital to address climate change is the factor of time. There simply isn't enough of it left for nuclear power to make any difference.

## Nuclear power plants take too long to build

Consensus among climate scientists is that global warming is a rapidly escalating crisis. Estimates of how many years remain before drastic changes are irreversible continue to shrink. Most nuclear power plants under construction around the world

are years behind schedule. While some non-nuclear countries aspire to build nuclear power plants, progress is slow to non-existent. All of this makes it difficult to predict with any accuracy how quickly a single unit could be built. Looking only at reactors that were completed and have come on line between 2006-20016, the global average construction time is 10 years. This is too late for climate change.

## Scale-up time is even longer, and far longer than renewables

The scale-up time for nuclear, which includes the time between the start of planning to actual operation, can take up to 20 years. The scale-up time for wind and solar is typically 2-5 years.

## We can't build enough nuclear plants in time to make a difference

Nuclear power is an inefficient and risky way to address climate change. A 2003 MIT study concluded that in order to displace a significant amount of carbon-emitting fossil-fuel generation, another 1,000 to 1,500 new reactors (1,000 MW or larger) would need to come on line worldwide by 2050, more than two new reactors every month. Nothing even remotely close to such a pace has actually happened.

Even if such a massive construction plan became a reality – which is highly improbable – it would still only achieve a relatively minor displacement of CO2. MIT came out again in 2015 with another analysis that estimates that even if the 2015 Paris CO2 accords (COP 21) are implemented and 1,000 new nuclear reactors are constructed, global CO2 emissions will still increase to a minimum of 64 GT.

## So-called advanced reactors are decades away from reality

Climate scientists, (including James Hansen who promotes so-called Generation IV reactors like the Integral Fast Reactor), warn that we are fast running out of time to reduce carbon emissions before runaway climate change could become impossible to mitigate. Yet Gen. IV reactors are theoretically decades away from a deployed reality, far too late for the climate crisis, and could never be produced in enough numbers to make an impact on carbon emissions. Small modular reactors, by definition much smaller in capacity – typically 10-300 megawatts – would be needed in even greater numbers to achieve any greenhouse gas reductions. Given that there are zero orders for SMRs, this is also a futile strategy.

## REACTOR CONSTRUCTION TIMES 2006–2016

| Construction Times (in years) – Startups Between 2006 and July 2016 | | | | |
|---|---|---|---|---|
| **Country** | **Units** | **Mean Time** | **Min** | **Max** |
| China | 25 | 5.7 | 4.3 | 11.2 |
| India | 6 | 7.7 | 5.0 | 11.6 |
| South Korea | 5 | 5.3 | 4.0 | 7.2 |
| Russia | 4 | 28.8 | 25.3 | 32.0 |
| Argentina | 1 | 33.0 | 33.0 | 33.0 |
| Iran | 1 | 36.3 | 36.3 | 36.3 |
| Japan | 1 | 5.1 | 5.1 | 5.1 |
| Pakistan | 1 | 5.2 | 5.2 | 5.2 |
| Romania | 1 | 24.1 | 24.1 | 24.1 |
| USA | 1 | 43.5 | 43.5 | 43.5 |
| **Total** | **46** | **10.4** | **4** | **43.5** |

Sources: IAEA-PRIS, MSC, 2016

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