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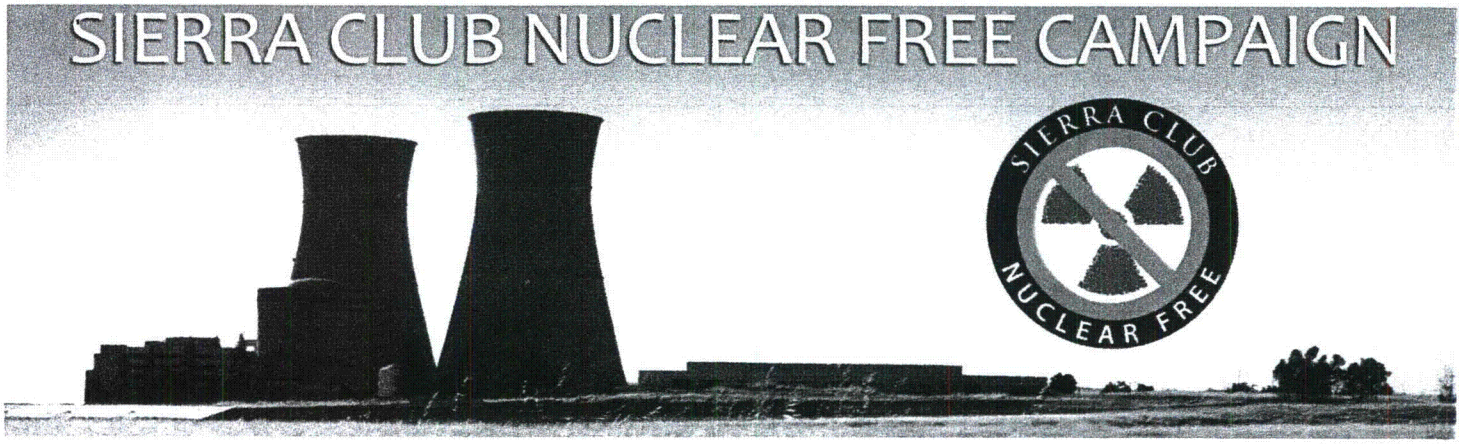


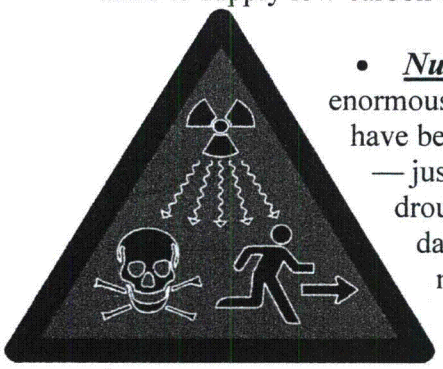
NUCLEAR POWER MAKES CLIMATE CHANGE *WORSE*

The nuclear industry has been selling the world a story that nuclear power is a solution to climate change because it does not generate carbon dioxide (CO2), a major greenhouse gas. While this is true of the nuclear chain reaction itself, the front and back ends of nuclear power generate a large volume of CO2 and leave a trail of endlessly dangerous radioactivity along the way.

- ***Nuclear power has a big carbon footprint.*** At the front end of nuclear power, carbon energy is used for uranium mining, milling, processing, conversion, and enrichment, as well as for transportation, formulation of rods and construction of nuclear reactors (power plants). At the back end, there is the task of isolation of highly radioactive nuclear waste for millennia—a task which science has so far not been able to address.

  All along the nuclear fuel chain, radioactive contamination of air, land and water occurs. Uranium mine and mill cleanup demands large amounts of fossil fuel. Each year 2,000 metric tons of high-level radioactive waste and twelve million cubic-feet of low-level radioactive waste are generated in the U.S. alone. None of this will magically disappear. Vast amounts of energy will be needed to isolate these dangerous wastes for generations to come.

- ***Nuclear power takes too long to deploy.*** Construction of the 1500 new reactors that the nuclear industry claims are needed to address global warming would mean opening a new reactor once every 2 weeks for the next 60 years. Reactors can take 10-15 years to build with an estimated cost of $12-15 billion each. In the past, cost and time needed for construction have each more than doubled from original estimates. We need to supply low-carbon energy sources ***NOW.***



- ***Nuclear power is not suited for warming climates.*** Nuclear reactors need enormous amounts of ***cool*** water to continually remove heat from their cores. Reactors have been forced to close during heat waves due to warmth of sea, lake or river water — just when electricity is being used most. Low water levels during heat and drought have also forced reactors to shut down. In addition, cooling causes serious damage to aquatic life, killing millions of fish and untold numbers of macroinvertebrates and fish fry.

- ***Six times as much carbon can be saved with efficiency or wind.*** Benjamin Sovacool from the Institute for Energy and Environment at Vermont Law School averaged the high and low estimates of carbon pollution from nuclear power. His study revealed that nuclear power's carbon emissions are well below scrubbed coal-fired plants, natural gas-fired plants and oil. However, nuclear emits twice as much carbon as solar photovoltaic and six times as much as onshore wind farms. Energy efficiency and some of the cheaper renewables also beat nuclear by sixfold or more.

- ***Nuclear power is not flexible.*** Nuclear is all-or-nothing power. A reactor can't be geared to produce less power as electricity from renewables (like wind and solar) increases. This can make it challenging to increase renewables past a certain point.

When a reactor shuts down due to accident, planned upgrade or permanent closure, a large amount of power has to be found elsewhere. And nuclear plants are being closed, not opened — some because they no longer are making a profit.

- ***Nuclear subsidies rob research on renewables.*** Nuclear power has been subsidized throughout most of its fuel chain. In 2011 the Union of Concerned Scientists published ***Nuclear Power, Still Not Viable without Subsidies.*** This report shows that in some cases subsidies were greater than the value of the electricity produced. Subsidies are supposed to be for new innovations — not for propping up outdated technologies like fossil fuels and nuclear. Nuclear power could also be called a fossil fuel, because like coal, oil and gas, nuclear depends on a limited supply of natural resources in the ground.

  If some of the tens of billions spent on nuclear were funneled to national- and state-planned programs for clean energy and efficiency, we could achieve a fully renewable energy supply, a more democratized energy grid and energy independence much sooner.

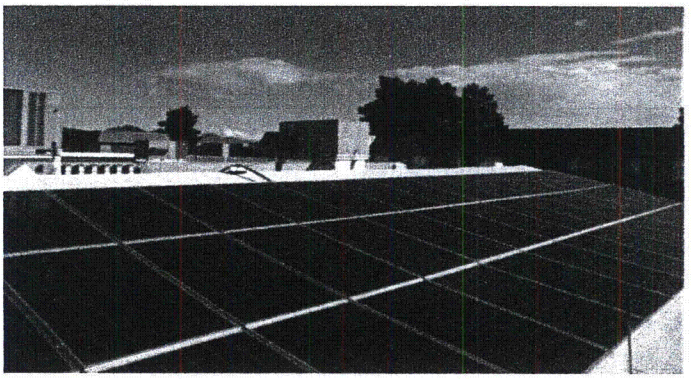
- ***Cost of nuclear is going up, while cost of renewables is going down.*** Estimates for new reactors are, on average, four times higher than estimates from just eight years ago. Estimates for new reactors are invariably far less than the final cost, with the final cost often doubling. Costs of renewables continue down while their efficiency increases. Sometimes, as in the case of the Columbia Generating Station, Cherokee, and Perry, billions were spent for reactors that were never finished.

RENEWABLES ARE THE *REAL* ANSWER!

Mitigating climate disruption demands sound investment in economical, expedient, clean and, most of all, safe technologies.
Wind and solar are getting cheaper and more efficient by leaps and bounds. Advances are being made in energy storage. Geothermal energy is being tapped extensively.

Wind farms added about 13 gigawatts of new power in the U.S. in 2012. Solar photovoltaic (PV) plants added 4.2 gigawatts of electricity in 2013. And that's just solar PV. Solar water heaters have become very economic and popular. There are also concentrated solar power plants that generate electricity directly from the sun's heat, so the total amount of solar power is actually higher than the PV number alone.

Back in 2007, nuclear engineer Arjun Makhijani of the Institute for Energy and Environmental Research wrote the book *Carbon Free and Nuclear Free: A Roadmap for U.S. Energy Policy.* In the book he outlined how the United States, with the political will, could generate its energy needs with renewables by the year 2040. The phasing out of nuclear power and coal is now well underway, and the switch to wind, solar and efficiency is quickly gaining momentum.



Check out the **Nuclear Free Campaign of the Sierra Club** Facebook Group.
Follow **@NuclearFreeSC** on Twitter.

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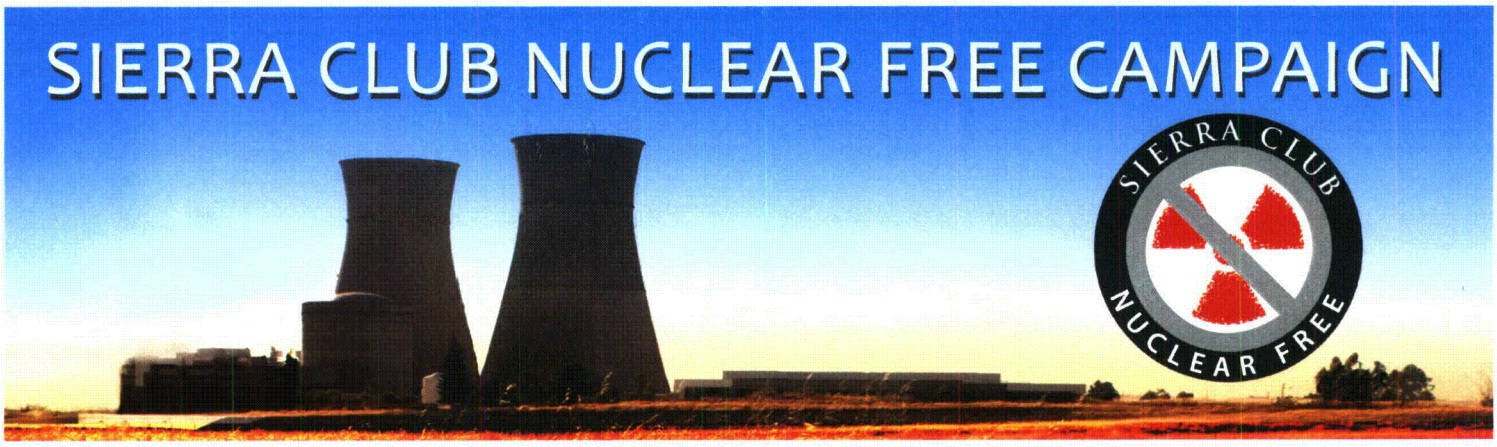


SIERRA CLUB NUCLEAR FREE CAMPAIGN

"We envision an energy efficient world, powered by clean, renewable technologies, free from dirty, dangerous, costly nuclear power and its legacy of toxic waste".

We oppose all aspects of the nuclear fuel chain from the environmental justice tragedy of uranium mining and reprocessing to the relicensing of old nuclear plants, and the public subsidies involved in the construction of new plants. We want safe, secure transport and storage of radioactive waste. Most of all, we want the United States to stop generating nuclear power, weapons and the unavoidable radioactive waste that is the result of the fuel chain.

We are convinced that renewables and energy efficiency are the future of energy generation. We support diverting the billions of dollars budgeted for nuclear projects to research, to create energy efficiency in industry and to develop storage capacity for renewables.

We are concerned after the nuclear disaster in Fukushima that we have reactors with similiar designs on-line in the United States. Many of these reactors are located in seismic and flood zones that provide additional risk of disasters to people and the environment. We need to replace the power generated by these plants in order to protect our families and our economies.

NO NEW NUKES - TROUBLE IN PARADISE

Why Are We Building New Ones When There Is So Much Trouble With The Old Ones?

New Nuclear Plants

- The proposed plants are not needed
- We have sufficient power now. Efficiency is already coming on board (as much as 40%), buying enough time to allow renewable energy to provide new source replacement.
- Extremely expensive nuclear energy would rob financial resources from clean energy efforts

Bad Economics

Wall Street doesn't want this risk. Why should we?

- Costs are paid by taxpayers and ratepayers through Loan Guarantees and CWIP (Construction Work in Progress), leaving little fiduciary responsibility and accountability for the energy company
- Taxpayers on the hook if something goes wrong
- More expensive energy than other energy sources
- Uncontrollable costs including design issues, maintenance problems, waste disposal and cleanup have caused nukes to run over budget.

Waste Confidence

A recent court ruling overturned the Nuclear Regulatory Commission's (NRC) long-standing yet unsubstantiated Waste Confidence Decision, which claimed that the high level radioactive waste problem would be solved. Now, the NRC cannot license new nukes until it establishes a defensible policy, so it has frozen new licensing and renewals.

- No new nukes should be built without a viable radioactive waste solution
- The current radioactive waste stream is already unmanageable and dangerous
- No new waste should be produced when there is no solution for the old waste which is piling up dangerously. Pools are overfull, creating a dangerous hazard.
- Cleanup for old plants has not even been properly addressed

Dangerous & Untested New Models

Experimenting with new reactor models doesn't lead to a secure energy future.

- Major catastrophic accidents at 3 Mile Island and Chernobyl occurred when they were new plants
- New Designs (AP1000) are unproven technology that have never been built. Fukushima design concerns are not addressed.

RETIRE OLD NUKES

Why are we risking our own Fukushima with outdated power plants that continue to create radioactive waste?

Sierra Club

The Sierra Club is focused on changing our energy sources to go beyond coal, natural gas and oil. Phasing out nuclear power plants is the next phase in this campaign. Nuclear power is not clean power. We propose that nuclear power plants can be replaced by energy efficiency and renewables within our lifetimes. We propose that the U. S. follow in the steps of Germany, Italy and Switzerland by phasing out our nuclear reactors.

Vintage isn't Cheap

Many of the U.S. plants were constructed at least forty years ago. Their equipment is often old and in need of expensive overhauls. Crucial parts like boilers need to be replaced. This aging inventory is not only expensive to maintain, but also prone to equipment fatigue, creating a high risk of emergency events that endanger workers and neighboring communities.

Risky Design

There are 23 plants in the US that have the same containment design as the Fukushima plants. This brings up the question as to whether nearby communities are in jeopardy for disaster when the design fails again. Experts report that plants are being operated beyond the capability of their original design. Should we continue to take a chance?

Bad Siting

The location of nuclear power plants became an issue after Fukushima. We need to examine how many of our plants are located in a seismic zone, in a flood plain or on a coast. Poorly sited energy plants put large populations of people at risk.

Environmental Disaster

The fuel for nuclear power plants contaminates the environment before it reaches its destination. After being used in a nuclear reactor, the fuel becomes highly radioactive. There is no definitive answer to safely storing the radioactive waste. The Sierra Club supports waste stored in place in hardened casks. The club advocates not creating any more waste.

Economic Nightmare

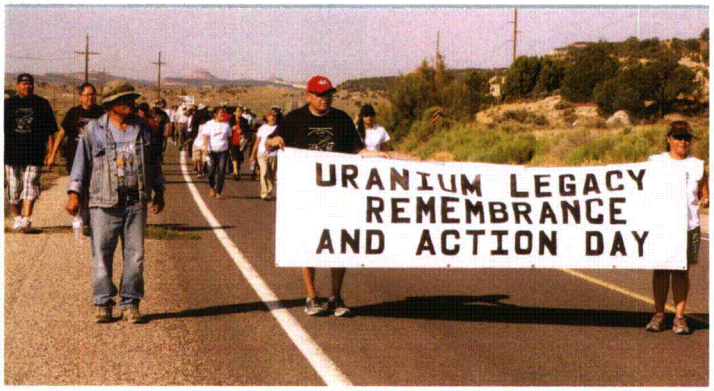
To quote Senator Bernie Sanders of Vermont, "R&D and Price-Anderson insurance are still just the tip of the iceberg. From tax breaks for uranium mining and loan guarantees for uranium enrichment to special depreciation benefits and lucrative federal tax breaks for every kilowatt hour from new plants, nuclear is heavily subsidised at every phase. The industry also bilks taxpayers when plants close down with tax breaks for decommissioning plants. Further, it is estimated that the cost to taxpayers for the disposal of radioactive nuclear waste could be as much as $100 bn" Sanders, B. and Alexander, R. (2012).

Price-Anderson was first passed in 1957. This law lets nuclear power operators off the hook from paying the high insurance premiums that would be justified by the risks of operating a nuclear plant. This means that, if there is a Fukushima-type disaster here, U.S. taxpayers will be the ones writing the checks.

THE "FRONT END" OF NUCLEAR POWER

Why is nuclear not the answer to climate change?

When the nuclear industry talks about nuclear power, they don't tell you about what goes on at the "front end"—that is, how a nuclear power plant gets its fuel. ***Front-end industries are not only dangerous and expensive, but they also irreversibly pollute our lands and endanger public health and workers.*** Mining, milling, enrichment and fuel manufacturing consume large quantities of fossil fuel energy, making nuclear power anything but "green".



Uranium Mining

Uranium occurs naturally in the ground, but when it is mined and exposed to air and water, radioactivity is released into the environment. In the United States, large-scale mining takes place chiefly in the West, where it heavily impacts Native American, Latino and low-income communities. Open-pit mines scar the land, while in-situ mines pollute aquifers and put communities' water supplies at risk. Mining accidents, loss of traditional lands, declining property values and public health concerns plague mining and milling communities.

Uranium Ore Milling

After uranium ore is mined, the milling process treats the ore to extract uranium from the rock. Over 99% of the rock is left over from this process, in the form of a toxic sludge referred to as tailings. Tailings are radioactive for 800,000 years and contain 85% of the ore's original radioactivity — plus other rock substances such as heavy metals and arsenic — along with the processing chemicals. Over the past 70 years, most uranium tailings were dumped into large, unlined piles. Cleanup and maintenance of tailing piles is costing taxpayers billions.

Uranium Enrichment

Enrichment is a technically complicated and energy-guzzling process that involves converting uranium to uranium hexafluoride and then "enriching" or increasing the amount of fissionable uranium-235 in the product. Taxpayers heavily subsidize enrichment for nuclear power plants, and totally subsidize enrichment for nuclear weapons. Enrichment plant waste is known as "depleted" uranium (DU), which has been used in armor-piercing shells and bunker-buster bombs.

Additional Front-End Processes

Fuel fabrication consists of forming enriched uranium into pellets, placing the pellets into fuel rods and putting the rods into assemblies. Special plants are built for de-conversion of chemically-reactive DU hexafluoride waste back to uranium oxide. Some commercial nuclear fuel manufacturers down blend highly-enriched uranium from dismantled nuclear weapons.

Mixtures of radioactive and chemical pollutants have so contaminated many front-end operations that some have become Superfund sites and others have been declared public health hazards by federal health agencies.

HIGH LEVEL WASTE

Why do we continue to make deadly waste?

In the United States, High Level Radioactive Waste, or HLW, is mainly defined as the irradiated, or spent, nuclear fuel that comes out of a reactor. The irradiated fuel is the number one source of HLW and must be remotely handled very carefully, as a single rod can give a lethal dose in a few seconds.

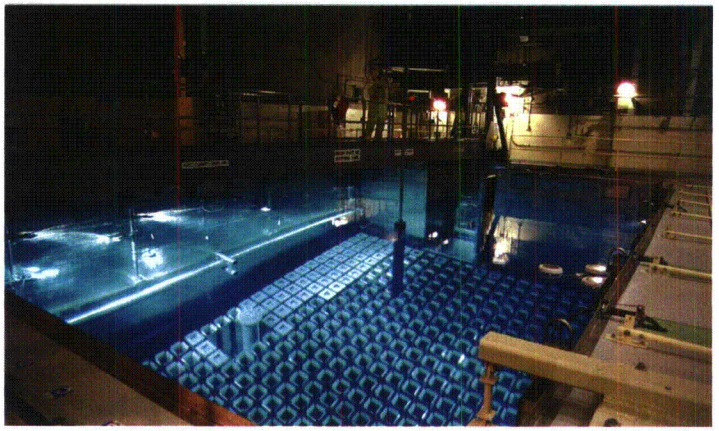
Every year, each of the 104 U.S. reactors produces 25-30 tons of irradiated fuel. As the uranium fuel undergoes the fission process, atoms are split, heat is released, and new radioactive atoms are created. When the fission process slows down, the fuel is "spent", or "irradiated" and must be removed.

Reactors Shut Down

Reactors are shut down periodically to allow for removal of the irradiated fuel, and for new fuel to be loaded. When the irradiated fuel is removed, it is loaded into a pool of water, to cool thermally and allow some of the dangerous radioactivity to decay. The water in the pool contains a large amount of dissolved boric acid which is a heavy absorber of neutrons; this assures that the fuel assemblies in the pool will not go critical and begin the fission process again. It is critical that the water levels remain consistent to avoid a serious accident and release of radiation. The fuel remains in the pool at least 5-7 years.

Interim Storage

Once the fuel has cooled in the pools for 5 years, it can be removed and placed in casks, called "dry cask storage". These casks can be arranged in bunkers and stored relatively safely for the short term. Most of the nation's operating reactors are using dry cask storage as a way to manage the high level waste.



Irradiated fuel is stored in pools, in buildings with minimum containment. The pools require active maintenance and control. Loss-of-coolant accidents would release huge amounts of radiation.

Permanent Storage

The real question is what to do with this waste permanently. Originally, the expectation was that several permanent geologic repositories would be located and built. In 1987, Congress designated Yucca Mountain, Nevada, as the final and only National Nuclear Waste Repository. Due to serious technical difficulties as well as environmental, environmental justice and political problems, the site has not been licensed, and is not likely to be licensed. The current 2012 national inventory of 70,000 tons of irradiated fuel has nowhere to go and no permanent solution.

Sierra Club Policy

The Sierra Club opposes consolidating waste at any central "interim" storage site due to concerns about transport, cost, and the temptation it poses to promoters of reprocessing (which Sierra Club also opposes), and advocates instead that waste be kept at the reactors sites in Hardened On Site Storage, (HOSS) a more robust, secure and long lasting form of dry cask storage.

Sierrans around the country opposed Yucca Mountain because it was poorly sited. It could well be at least a century before enough repository space is ready to receive these casks. And if we continue to make waste at the current rate or more, if we build new reactors, several repositories will need to be built. The costs continue to mount, along with questions about the ethics of leaving deadly waste for generations millions of years from now.

"Surely there are better, cheaper, safer ways to boil water that do not leave this toxic legacy for the world of the future."

– Arjun Makhijani

"LOW LEVEL" WASTE

Why is any radioactive waste considered "low-level"?

"Low-Level" Radioactive Waste

Despite the low misleading description, "low-level" radioactive waste is not low risk. It includes the same radioactive elements and isotopes (radionuclides) as high level waste – including the irradiated fuel rods in the core of nuclear power and weapons reactors. In fact, the same Plutonium atom that is "high level" waste if it is in a fuel rod becomes so-called "low level" waste when it leaks out through cracks or tiny holes in the cladding of the rods into the cooling water. The whole nuclear reactor itself, except the fuel rods, becomes so-called "low-level" radioactive waste.

Deadly Waste

Filters and resins used to remove radioactive materials from nuclear power reactor cooling water can become so heavily loaded that they can kill a person if exposed for just 20 minutes without shielding. If the Plutonium atom makes it past the filters and resins, it becomes a legal, "routine release" to the river, lake or ocean. The legal (not safe) levels are based on nuclear industry needs, not on protecting humans or other species.

Radioactive Waste in the Food Chain

Some radioactivity comes from splitting of the uranium atoms when they release their binding energy to turn the turbines and make electricity. These get into the food chain and the body and irradiate from within (example: Cesium-137 concentrates in muscle, Strontium-90 concentrates in bone and teeth displacing calcium, Iodine-129 concentrates in the thyroid). Very heavy radioactive elements like Plutonium, Neptunium and Americium are incredibly long-lasting and especially dangerous if inhaled or ingested because they emit alpha particles which are 10 to 20 times or more dangerous than gamma rays when lodged in the body. Once they escape from the fuel rods, they become "low-level." Other "low-level" waste comes from activation by neutrons hitting nonradioactive materials and making them radioactive.

"There is no safe level of exposure and there is no dose of radiation so low that the risk of a malignancy is zero."
– Dr. Karl Z. Morgan, dubbed the father of Health Physics

Radioactive Consumer Products

DOE makes all our nuclear bombs. In 2000, it banned metal from radiation areas going to commercial recycling (to make everyday household and personal items), but in 2012-2013 DOE is reversing the bans to make it cheaper to "clean up" the weapons complex. Sierra Club of Canada, in coalition with numerous organizations in both US and Canada, has taken a leading role in preventing radioactive metal steam generators from the Bruce nuclear reactors being shipped through the Great Lakes and across the Atlantic to Sweden, to be melted and released into the international metal supply. The consequences of this made the news when they found radioactive tissue containers at a national home goods retailer. What is next? Children's toys?

Sierra Club Action

In the 1980s, the Sierra Club adopted its "low-level" radioactive waste policy, calling for a redefinition of the term to exclude anything radioactively hazardous longer than the 100 year "institutional control period" required by the Nuclear Regulatory Commission (10CFR 61.59) for disposal sites.

"Low Level" Dumps

After hundreds of millions of dollars were spent searching for new waste disposal sites in 18 states over 3 decades, no new dump has opened — until April 2012 in Andrews County, West Texas. Sierra Club continues to challenge this troubled dumpsite.

Kick and roll burial technique: This may not be done anymore — barrels are now stacked in the ditches and no more cardboard boxes-- but the long-lasting waste from decades ago buried this way is still radioactively hazardous and could be leaking today.

The Sierra Club Nuclear Free Campaign is an offshoot of the Sierra Club Activist Network. Volunteers from the United States and Canada are working together to make a difference on these issues. We are interacting on the Activist Network through the No Nukes Activist Team, conference calls on specific issues, national action alerts, our act-net list serve, regional and national meetings.

If you face threats in your backyard or just want to make North America Nuclear Free, sign up for the campaign today at: sc.org/no_nukes

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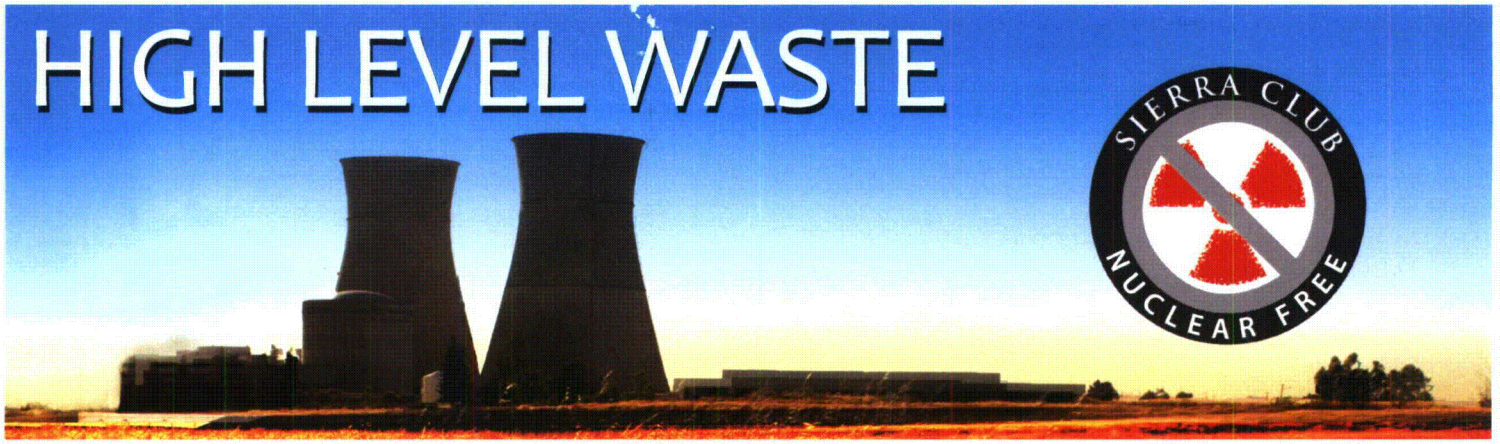
HIGH LEVEL WASTE



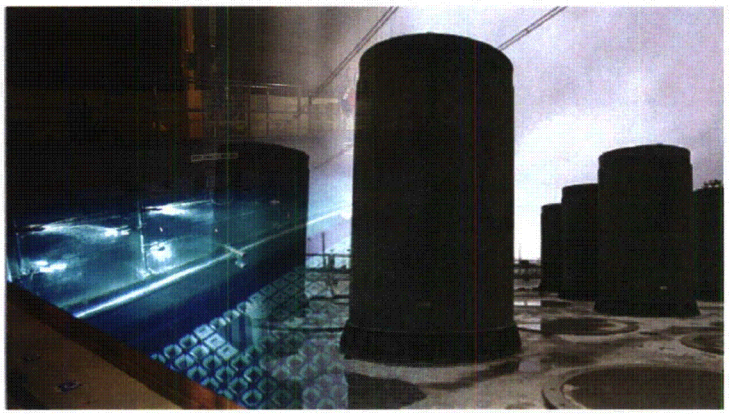
NUCLEAR WASTE IS FOREVER

Waste generated by the nuclear industry will be deadly for millions of years.

Over the past 50 years, the commercial nuclear industry has generated over 70,000 tons of deadly, high level nuclear waste in the form of irradiated or "spent" nuclear fuel. There is no way to dispose of this fuel. The industry and the government have been desperately seeking a solution. But there is none. **Nuclear waste is forever!**

Every reactor creates high level nuclear waste as it burns its uranium fuel. Irradiated or spent nuclear fuel is deadly. A single fuel rod would deliver a lethal dose in seconds. This fuel must be handled remotely and stored safely to avoid deadly releases of cancer- and birth defect-causing radiation. Transportation of irradiated fuel on our highways and through our cities poses a serious threat to our communities. We must halt this madness!

When the irradiated fuel is removed from the reactor, it is so hot and radioactive, it must be stored in a spent fuel pool for 5-7 years to cool down. The water in these pools must constantly circulate to keep the fuel cool. Any loss of coolant, accident or power outage that would stop the flow of water would cause the irradiated fuel to melt and burn, releasing enormous amounts of deadly radiation into the environment.



Once the fuel is removed from the fuel pools, it is stored at the reactor in "dry cask storage". This is a temporary solution ONLY.

YUCCA MOUNTAIN

Yucca mountain was a complete failure as a permanent solution.

The Federal government spent billions of taxpayer dollars on a location that was never suitable to isolate this deadly waste from the biosphere for the next million years. The site never should have been selected; it has only made it more apparent how difficult it will be to find a permanent disposal location, if any exists at all. Yucca was forced on the people of Nevada, without good science or the consent of the people, or the Native tribes on whose land it exists. Nuclear power is an environmental justice issue in that minority communities are more adversely impacted and have no say in the process.

OTHER BAD SOLUTIONS

Reprocessing is not "recycling" – it just creates more waste and separates out weapons-usable plutonium.

A few countries have chosen to reprocess their irradiated fuel, but this has only complicated the situation. Reprocessing creates huge volumes of liquid high level waste, while separating out weapons-usable materials like plutonium. Security becomes a huge risk. Reprocessing is expensive, dirty, and does not negate the need for a permanent repository. The French dump large amounts of liquid radioactive waste in the ocean. They have not solved their waste problem, and have large stockpiles of weapons-usable materials as a result.

The Hanford Tank Farms house 53 million gallons of high-level radioactive and chemical waste that is the by-product of "reprocessing" spent nuclear fuel. One million gallons of this waste is officially acknowledged to have leaked from the tanks, contaminating the groundwater and threatening the Columbia River. Learn more: hanfordchallenge.org/the-big-issues/tank-waste/

THE SOLUTION: STOP MAKING IT!

The Sierra Club's solution to nuclear waste is first, to **stop making waste, period.** Nuclear power should be phased out as soon as possible, and no new plants built. In the short term, we recommend a more robust form of dry cask storage called Hardened On Site Storage (HOSS), keeping the waste at the reactors, until a safe, scientific and environmentally sound solution is offered. There should be **no transportation** of deadly waste across our country on trucks and rails for some short term fix. Only when all parties and impacted communities agree upon a responsible solution should the waste be transported, and then using the safest methods possible.

Join the Sierra Club Nuclear Free Campaign to replace nuclear power with energy efficiency and clean, renewable power.

You can join our campaign at: sc.org/no_nukes

Images from NRCgov, Steve Miller, and D.O.E.

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