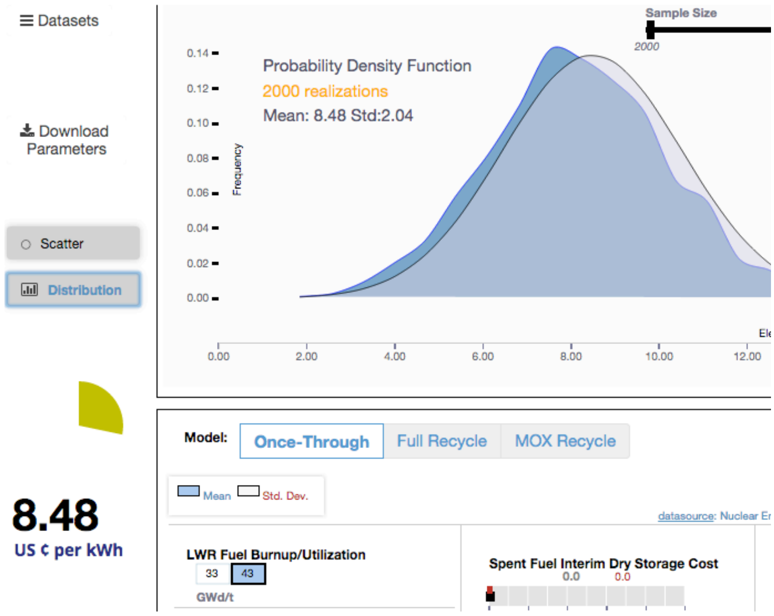

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Introducing the Nuclear Fuel Cycle Cost Calculator

John Mecklin

China has dozens of nuclear power plants under construction and in the planning stages. India is planning its own massive expansion of nuclear generation capacity. Countries across the Middle East —from Saudi Arabia and the Gulf emirates to Tunisia and Jordan—are seriously considering the creation of nuclear power sectors. And as countries around the world make policy decisions about nuclear technology, they will also be making choices about nuclear fuel cycles and whether to reprocess spent nuclear fuel, separating out uranium and plutonium for reuse. These decisions will have major implications for international security. If the growth of nuclear power is accompanied by increased reprocessing, new stores of plutonium will be created around the world, increasing the chances that terrorists or governments could steal or divert it to make nuclear bombs.

Over the last two years, the *Bulletin of the Atomic Scientists* and the University of Chicago have created an online tool that will help countries understand the true cost of choosing the reprocessing route—and perhaps also help limit the spread of nuclear reprocessing. The Nuclear Fuel Cycle Cost Calculator (http://thebulletin.org/nuclear-fuel-cycle-cost-calculator) estimates the full cost of electricity produced by three configurations of the nuclear fuel cycle. This calculator is the first generally accessible

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model to provide a nuanced look at the economic costs of nuclear power, particularly in regard to the reprocessing of spent nuclear fuel. Among many other things, the calculator clearly demonstrates that in most cases, reprocessing results in electricity that is considerably more expensive than other nuclear power, when all costs are added in.

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The Nuclear Fuel Cycle Cost Calculator (http://thebulletin.org/nuclear-fuel-cycle-cost-calculator) estimates the price of electric power produced in:

- The once-through fuel cycle used in most US nuclear power plants, in which uranium fuel is used once and then stored for later disposal.
- A limited-recycle mode in which a mix of uranium and plutonium (that is, mixed oxide, or MOX) is used to fuel a light water reactor.
- A full-recycle system, which uses a fast neutron spectrum reactor that can be configured to "breed" plutonium that can subsequently be used as either nuclear fuel or weapons material.

The calculator lets users test how sensitive the price of electricity is to a full range of components—more than 60 parameters that can be adjusted for the three configurations of the nuclear fuel cycle considered by this tool. Users can select the fuel cycle they would like to examine, change cost estimates for each component of that cycle, and even choose uncertainty ranges for the cost of particular components. This approach allows users around the world to compare the cost of different nuclear power approaches in a sophisticated way, while taking account of prices relevant to their own countries or regions.

Despite the economic and proliferation arguments against the reprocessing of spent nuclear fuel, many nuclear-capable countries continue to engage in the practice, creating stocks of separated plutonium and uranium that can be used to fuel nuclear power plants—or, in the case of plutonium, to build nuclear bombs. (Plutonium emits relatively little ionizing radiation and is smaller in volume than spent fuel, making it an attractive theft target, compared to other sources of fissile material.)

Over the past 30 years, the United States has tried to persuade other countries—France, Russia, United Kingdom, India, and Japan, most notably—to stop their reprocessing operations, but without success. US arguments have focused on the dangers of nuclear weapons proliferation as a major reason for countries to suspend or resist reprocessing. These arguments often fall on deaf ears in other countries, because the United States has contributed substantially over the past 60 years to the development and proliferation of nuclear technologies and weapons based on highly enriched uranium and plutonium. United States officials and even independent US scientists who argue for reduced proliferation are often unconvincing to countries more recently involved in the nuclear power project.

If proliferation concerns do not persuade other countries to eschew reprocessing, however, those countries may respond to factual data about the financial burden of reprocessing, in comparison to once-through use and storage of nuclear fuel.

Differences in construction, fuel, borrowing, and operation and maintenance pricing make the actual costs of different fuel cycles in each country very difficult to calculate for policy makers who are not also nuclear scientists. Often, the overall cost of a particular approach to nuclear power generation can be nearly impossible to evaluate, because vendors of nuclear technology consider some of the information required for such an evaluation to be proprietary. Furthermore, pricing and cost calculations may change dramatically over time in the dynamic global nuclear power industry. It can be challenging even for well-meaning governments to project and discuss the costs of nuclear power in a transparent and meaningful way. The Nuclear Fuel Cycle Cost Calculator (http://thebulletin.org/nuclear-fuel-cycle-cost-calculator) addresses this problem.

The Nuclear Fuel Cycle Cost Calculator (http://thebulletin.org/nuclear-fuel-cycle-cost-calculator) is based on an economic model developed by University of Chicago professor (and *Bulletin* Science and Security Board member) Robert Rosner, with assistance from former colleagues at Argonne National Laboratory. Rosner partnered with two University of Chicago research assistants, Sam Olofin and Jeremy Klavans, to translate his initial model, optimizing its computer code so it could instantaneously display results over the Web. Experts from Princeton University's

Program on Science and Global Security (http://www.princeton.edu/sgs/) provided feedback on these efforts, and *Bulletin* staff helped Rosner's team work through several different iterations of the cost calculator, aiming to make it accessible and valuable to nuclear power experts, to governmental leaders, to advocates involved in nuclear power decisions, and to ordinary citizens. The project was supported by significant funding from the MacArthur Foundation.

In coming weeks and months, nuclear power experts from around the world will be invited to give their assessments of the Nuclear Fuel Cycle Cost Calculator (http://thebulletin.org/nuclear-fuel-cycle-cost-calculator). Those comments will be published below this introduction and will inform the *Bulletin*'s efforts to improve this interactive tool over time.

9 Comments Bulletin of the Atomic Scientists Login

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jimhopf • 18 hours ago
Another reason for other nations being unconvinced is that the plutonium isotope distribution in commercial spent nuclear fuel renders it almost useless for making weapons. That, and the fact that for people wanting to make a bomb, simply digging up uranium and enriching it is a far easier method.
1 △ | ▽ • Reply • Share ›

StevenStarr • 21 hours ago
Does the model include the costs of short and long-term storage of nuclear waste? Or does that remain outside the box?
△ | ▽ • Reply • Share ›

jimhopf > StevenStarr • 18 hours ago
Waste disposal in a repository (e.g., Yucca mountain) costs ~0.1 cents/kW-hr. Dry-storing the spent fuel for decades on the plant site adds even less to the cost (less than 0.05 cents/kW-hr). These costs are an insignificant fraction of the overall nuclear power cost.
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John_Mecklin Mod > StevenStarr • 21 hours ago
The calculator includes waste storage costs for the three fuel cycles addressed. For instance, the once-through cycle includes interim dry cask storage and geologic disposal costs.
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StevenStarr > John_Mecklin • 21 hours ago
Thank you, I'm impressed!
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Dendric • a day ago
Aside from splitting hairs with varieties of nuclear power generation, a review of Union of Concerned Scientists' information and information available at nirs.org gives a very dim future for nuclear power in terms of safety, security, cost and other factors. Craig Severance Industry Reports give a different picture of costs, in contrast to that claimed by nuclear supporters. Other serious comprehensive calculations do NOT make nuclear even REMOTELY feasible to reduce greenhouse gases. Helen Caldicott makes the point that much is not admitted to in terms of regular radioactive releases, as well as investigated events related to Three Mile Island (200 some claims legally sealed)... not to mention the disasters of Chernobyl and Fukishima. Ernest J. Sternglass has studied radiation dangers for many decades also. There are emerging better solutions now.

Cold fusion (LENR/LANR) has been replicated for years and now appears to be in a couple of technologies coming out (http://brillouinenergy.com/ , E-Cat). Other new "over-unity" technologies are being developed... see www.projectearth.com , peswiki.com , www.globalbem.com (esp. Moray King and Mike Waters). Phi ratio geometry and better intelligent design can make magnitudes of difference in energy efficiencies (see

see more

△ | ▽ • Reply • Share ›

Julia L Baumann > Dendric • 20 hours ago

It alarms me that the design specifications were not followed when some of the reactors were constructed. Although a much smaller reactor, the reactor at the Santa Susana Field laboratory is one example of the problems engineers and physicists encountered.

Materials such as zirconium alloy were unavailable so zirconium was used instead. This is significant because zirconium has a lower oxidation temperature than the alloy. So when an unexpected increase in thermal energy occurred, the oxidation fatigued the metal and sodium leaked through the cracks. Unfortunately, the ambient air created enough water vapor for the sodium to ignite and melt the components.

This is only one example of many that caused the reactors to fail.

If nuclear technology is to be used safely, then those in authority must listen to the scientists.

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