Destroying nuclear waste to create clean energy? It can be done

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Long-term nuclear waste can be “burned up” in the thorium reactor to become much more manageable.

Image: REUTERS/Jochen Luebke

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Decarbonizing Energy

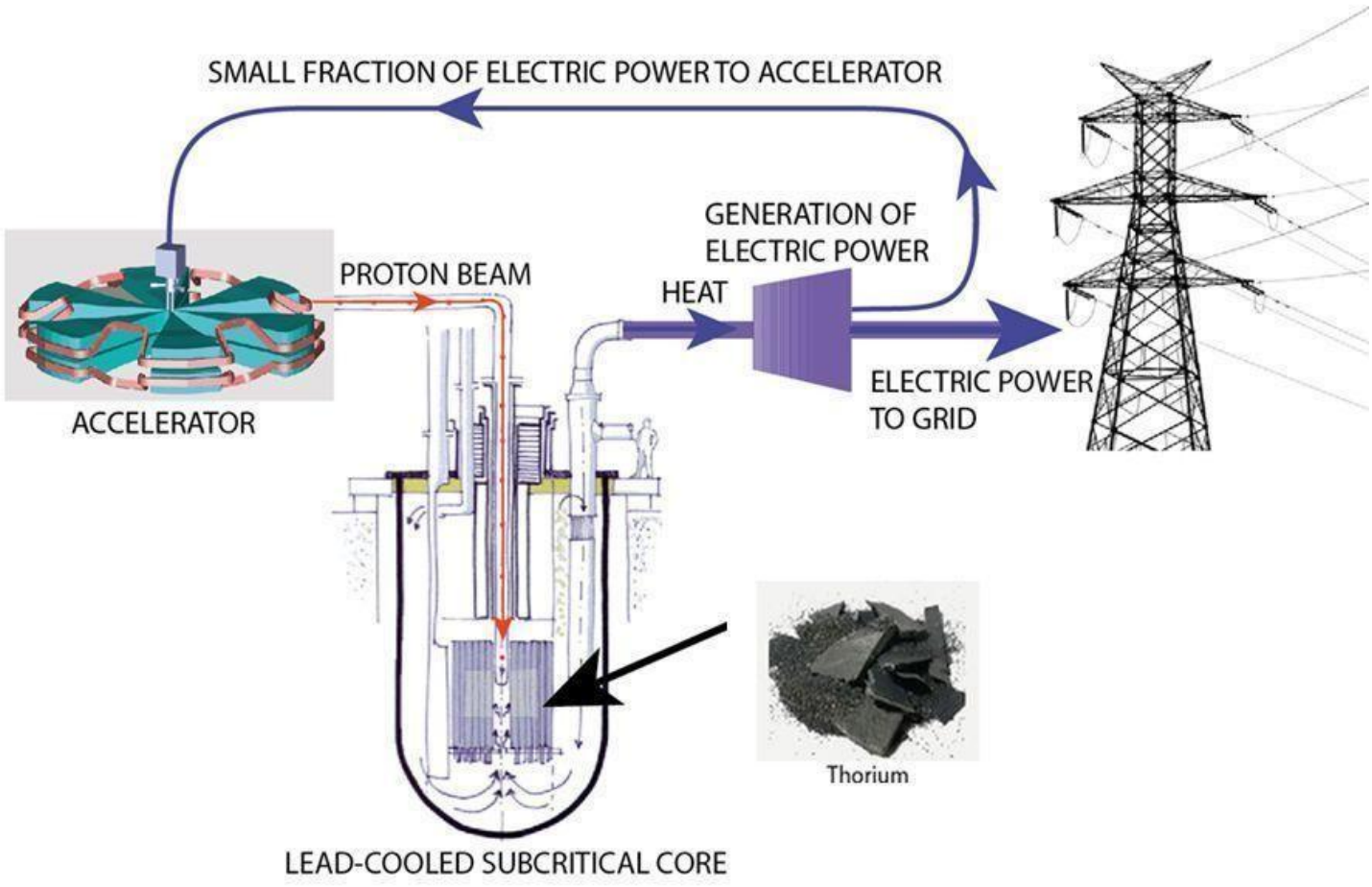
If not for long-term radioactive waste, then nuclear power would be the ultimate “green” energy. The alternative to uranium is thorium, a radioactive ore whose natural decay is responsible for half of our geothermal energy, which we think of as “green energy.” More than 20 years of research at the European Centre for Nuclear Research (CERN), the birthplace of the internet and where Higgs boson was discovered, demonstrate that thorium could become a radically disruptive source of clean energy providing bountiful electricity any place and at any time.

Coal and gas remain by far the largest sources of electricity worldwide, threatening our climate equilibrium. Non-fossil alternatives, such as solar power, use up a forbidding amount of land, even in sunny California, plus the decommissioning will pose a serious recycling challenge within 20 years. Solar is best used on an individual household basis, rather than centralized plants. Wind requires an even larger surface area than solar.

As Michael Shellenberger, a Time magazine “Hero of the Environment”, recently wrote: “Had California and Germany invested $680 billion into nuclear power plants instead of renewables like solar and wind farms, the two would already be generating 100% or more of their electricity from clean energy sources.” Correct, but the disturbing issue of long-term nuclear waste produced by conventional, uranium based, nuclear plants still remains.

In the early 1990s, Carlo Rubbia, Nobel prize winner in physics (1984) and then CERN’s director general, launched a small experiment applying cutting-edge accelerator technologies toward energy production. The First Energy Amplifier Test (FEAT), funded by the European Commission, successfully demonstrated the principles of a clean and inherently safe process of energy production, based on widely available thorium. Since then, numerous experiments have demonstrated the feasibility of a large scale-up for industrial use. They also demonstrated that existing long-term (240,000 years or more) nuclear waste can be “burned up” in the thorium reactor to become a much more manageable short-term (less than 500 years) nuclear waste.

An Accelerator-Driven System (ADS), as the process is called, comprises an assembly of key technologies developed at CERN: an accelerated proton beam focuses on a metal target, usually lead, in a process called spallation. This spawns neutrons that in turn convert thorium into fissile uranium233, producing heat by way of nuclear fission. The heavy uranium233 nuclei divides into smaller nucleus such as zirconium (think Shopping Channel jewellery) or xenon (used in camera flash bulbs), with only minimal radioactive waste produced.



An Accelerator Driven System (ADS) for clean electricity, based on 20 years of research at CERN.

The advantages of an ADS over other energy production process are many:

Clean: No emissions are produced (CO_2, nitrogen or sulphur oxides particles, among others), unlike with fossil fuel. Heat is generated from the transmutation of thorium into the highly radioactive uranium233 and its subsequent fission into smaller particles.

Feasible: ADS technology development has been proven to be a bounded problem with a realistic development timeline. In comparison, fusion is an unbounded problem that does not have a constrained development timeline.

Transmutation of nuclear waste: the ADS process has been proven to transmute long-term nuclear waste, harmful for 240,000 years or more, into short-term radioactivity waste of less than 500 years toxicity. The technology would solve the intractable problem of very long-term radioactive waste storage.

No military usage: The International Atomic Energy Agency has repeatedly stated that the technology is “intrinsically proliferation resistant.”

Large thorium reserves: enough for 20 centuries at 2018 level of global electricity consumption. Thorium is well distributed around the globe, with no nation having a monopoly.

High energy density: 1 tonne of thorium would provide the energy equivalent of 3 million tonnes of coal, or 200 tonnes of natural uranium enriched for use in a nuclear reactor.

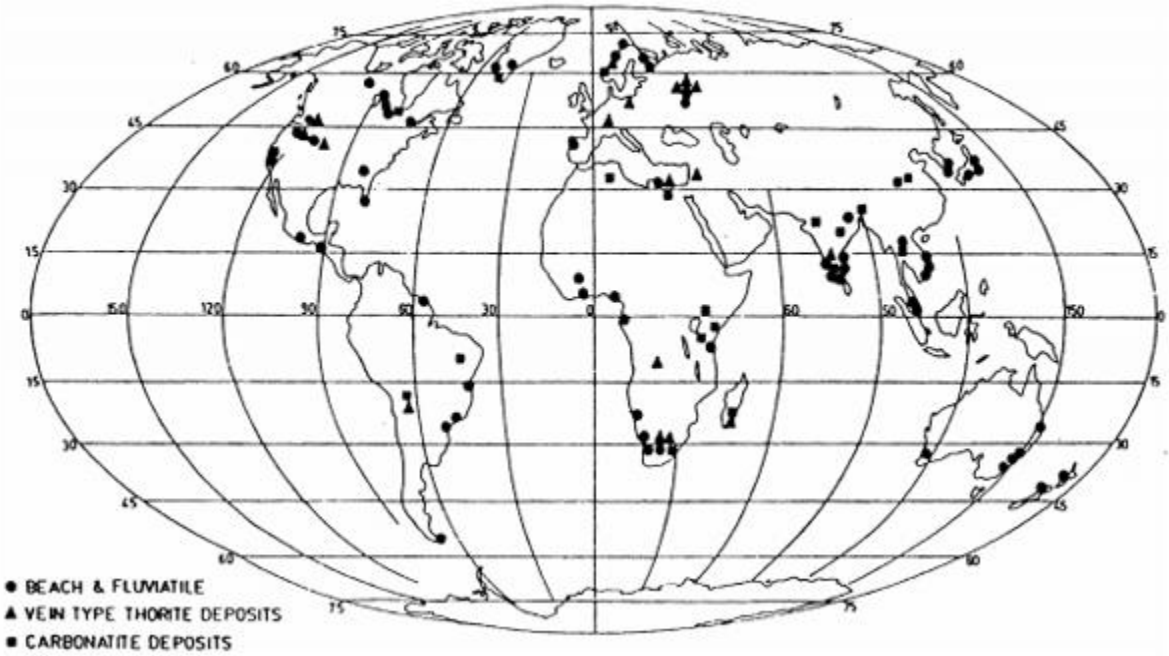
Inherent safety: the process operates at atmospheric pressure therefore the plant can't explode (unlike Chernobyl). The reaction is also stops immediately when the proton beam is interrupted, providing inherent safety.

Smart grid friendly: Immediate ON/OFF capability would make ADS power plants ideal for base load energy production for smart grids.

Small footprint: A 500MW ADS plant would only be as large as a mediumsize factory, compared to 26 km2 (10 mi2) for the 550MW Topaz solar farm in the sunny California desert. In the wintery north-west, an equivalent solar farm would be almost three times larger, approximately 62 km2. Wind turbines require even more space.

Proximity: inherent safety and small size make ADS ideally suited for any use, industrial or urban, and able to be located in remote regions, including high latitudes with little sunshine.

Decarbonized hydrogen production: reactors could be set close to abundant freshwater at high latitudes for clean hydrogen production, allowing the conversion of electrons into a green gas used for transport, heating and industrial processes.



Estimated thorium deposits around the world.

ADS technology advances the double promise of boundless clean electricity, together with the destruction of highly toxic long-term nuclear waste. Its inherent safety will allow power plants to be located anywhere, even close to urban areas, and in any climate. ADS offers the possibility to provide sustainable energy on demand and with easy integration into smart grids. Combined with the production of green hydrogen, it could decarbonize our entire energy needs, from transport to industrial.

The development of this promising technology offers hope for a paradigm shift in clean energy production, achievable in years instead of decades, helping the fight against global warming.

Source*: https://www.weforum.org/stories/2018/11/destroying-nuclear-waste-to-create-clean-energy-it-can-be-done/*