

TeraOpenScience

Sustainable Nuclear Energy

Nicole Haragutchi



AGENDA

1. Overview by Nicole Haragutchi
2. Future Technology
3. Design
4. Conclusions
5. Bibliography

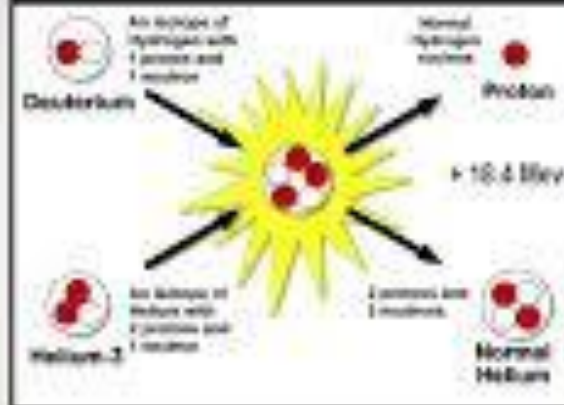
Meet Nicole Haragutchi

8th grader, 14 years old

Founder of Innovation
International created to
mentor K-12 students
worldwide in environmental
protection STEM solutions



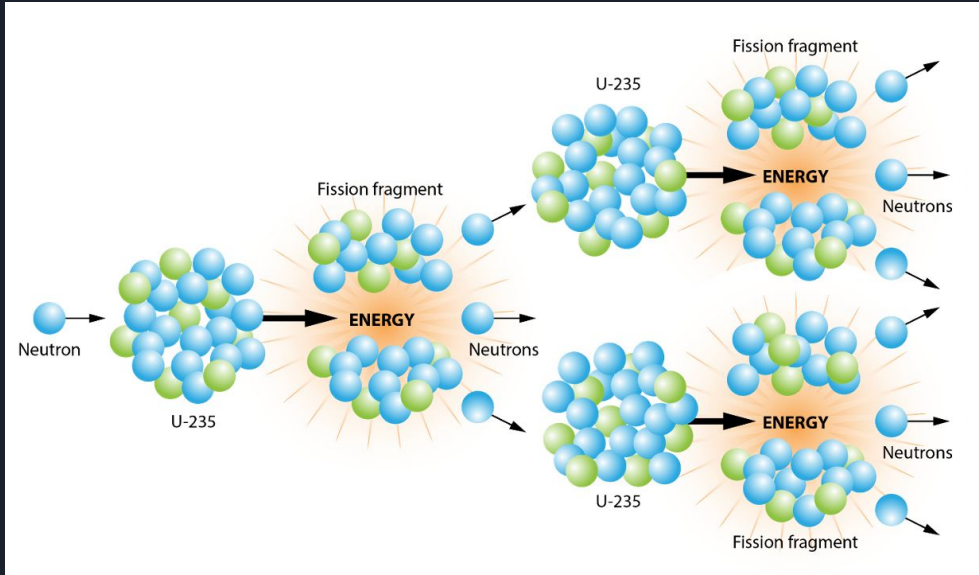
Sustainable Nuclear Energy Overview



An even more
sustainable fuel
but for Moon
Colonization



Present Technology



Nuclear fission (splitting process) of Uranium-235 generates intense heat

Special rods are added into the reactors to avoid a total nuclear reaction

(Pros) The process does not result in carbon dioxide emissions

But... (Cons on next page)

Present Technology

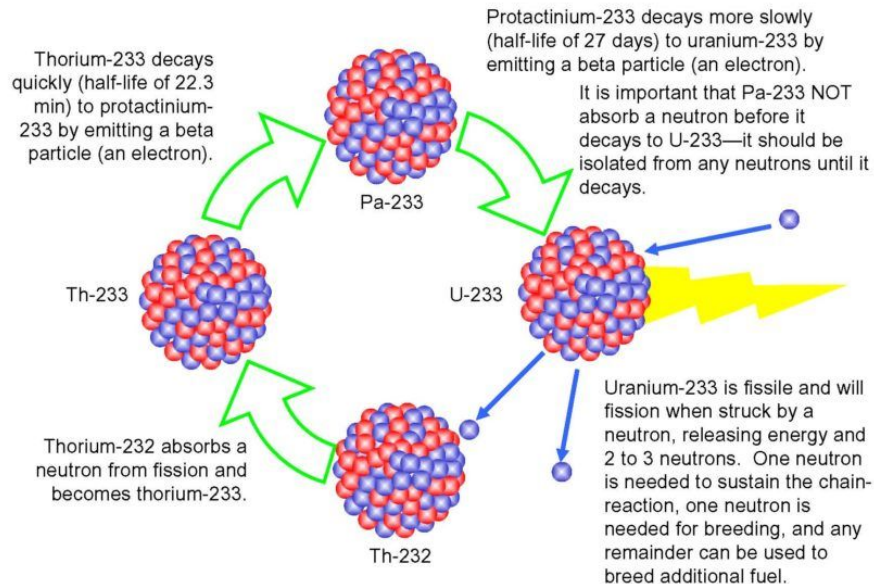


This is not sustainable

- The uranium mining contaminates the environment with arsenic and radon.
- They create thermal pollution in the vicinity of the power plant.
- Uranium is not renewable and requires constant replenishment.
- They create radioactive waste which is toxic and remains harmful for thousands of years (barium, krypton, strontium, cesium, iodine, and xenon)
- They use a large quantity of water to cool.
- They pose a risk of catastrophic results, even though the chances are minimal.

Thorium

Thorium-Uranium Breeding Cycle



3 to 4 times more plentiful
on Earth than uranium

One ton of thorium can
produce as much energy as
35 tons of uranium

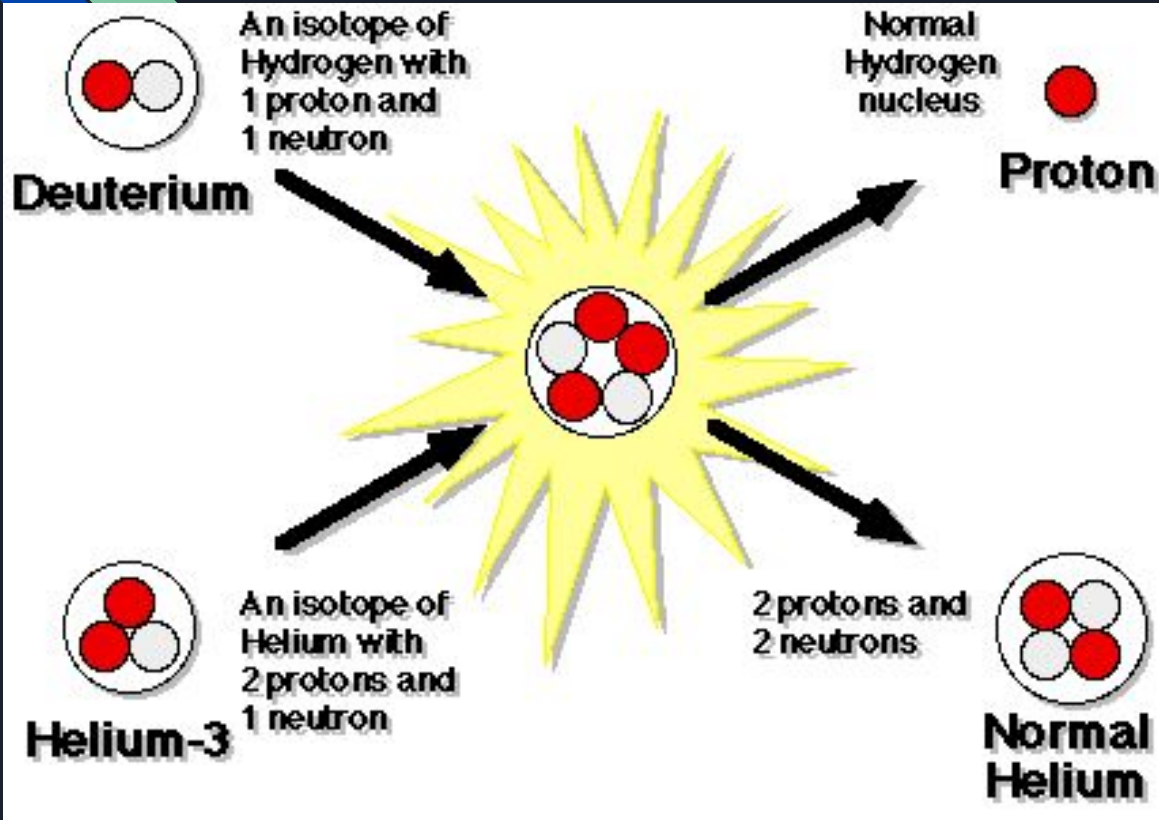
Thorium is fertile rather
than fissile, meaning it must
be converted to
uranium-233 in the reactor



Thorium Reactors in the World

- There are no commercial thorium nuclear reactors
- Experimental thorium use occurred in the 1960s in the United States
 - Energy Point Energy Center, NY
 - Molten Salt Reactor Experiment (MSRE) at Oak Ridge National Laboratory
- Testing done recently at the Idaho National Laboratory
- United States is ranked behind only India and Brazil in thorium reserves
- China has successfully developed the world's first experimental thorium-based molten salt reactor

Helium-3



Estimated 1,000,000,000 kg deposits on the Moon

One ton of helium-3 can produce as much energy as 8 tons of uranium

Helium-3 fuses with deuterium to produce energy

No radioactive waste



Helium-3 Reactors in the World

- There are no commercial helium-3 nuclear reactors in the United States
- Experimental helium-3 reactors exist in Germany, USA, and China
- Most helium-3 on Earth are deep in Earth's mantle (created after the Big Bang)
- Elevated levels are found in volcanic rocks nad hotspots such as Hawaii and Iceland, and hydrothermal vent systems
- This year a large amount of helium-3 was found deep underground in Minnesota with concentration similar to lunar samples (Topaz project from Pulsar Helium Inc.



Technology Comparison

Metric	Uranium	Thorium	Helium-3
Technology	Fissile	Fertile	Fusion
Stage	Current	Prototype	Experimental
Fuel	U-235	Th-232	He-3
Generation	Low	Very high	High
Reactor	Solid Fuel	Molten Salt	Fusion Reactor
Waste	Long-lived	Short-lived	Virtually none



Nuclear Batteries

Metric	Plutonium	Strontium	Tritium	Nickel	Carbon
Technology	Thermal Conversion	Thermal Conversion	Solid State	Solid State	Solid State
Stage	Current	Current	Current	Current	Experimental
Generation	300W	100W	Microwatts	Microwatts	Picowatts
Half-life	88 years	29 years	12 years	100 years	5,700 years
Use	Deep space	Arctic sensors	Microelectronics	Embedded/Medical	Not yet a product

Conclusions

- Use of more sustainable material benefits our planet, its biodiversity, and humankind
- Migration to a more sustainable and more efficient solution is logical and imperative
- We need to invest more in research and development of environmental friendly technologies or we risk being left behind





Bibliography

- World Nuclear Association, January 20, 2026, What is Uranium? How does it work?, <https://world-nuclear.org/information-library/nuclear-fuel-cycle/introduction/what-is-uranium-how-does-it-work#:~:text=Ener%20from%20the%20uranium%20atom.make%20steam%20to%20produce%20electricity>.
- The Momentum, The 5 Biggest Disadvantages of nuclear Power, Jonathan D. Bourdeau, <https://www.themomentum.com/roundups/the-5-biggest-disadvantages-of-nuclear-power>
- World Nuclear Association, July 17, 2025, OUTLINE History of nuclear Energy, <https://world-nuclear.org/information-library/current-and-future-generation/outline-history-of-nuclear-energy>
- IAEA, Thorium's Long-Term Potential in Nuclear Energy, Artem Vlasov, <https://www.iaea.org/bulletin/thoriums-long-term-potential-in-nuclear-energy#:~:text=What%20can%20thorium%20offer?,%2Dday%20uranium%2Dfuelled%20reactors>.
- Labxchange, Why is Thorium a Potentially Safer Alternative to Uranium, Not Used in Nuclear Reactors?, August 4, 2021, <https://www.labxchange.org/library/items/lb:LabXchange:cfd693a9.html:1>
- World Nuclear Association, Thorium, May 2, 2024, <https://world-nuclear.org/information-library/current-and-future-generation/thorium#:~:text=Thorium%20is%20more%20abundant%20in.seawater%2C%20in%20contrast%20to%20uranium>.



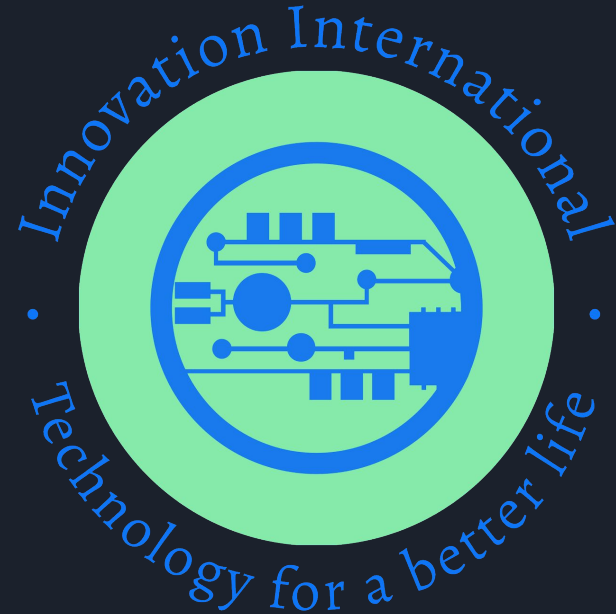
Bibliography

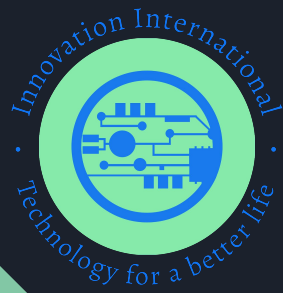
- Nucnet Independent Nuclear News, China Scientists Announce Breakthrough in Refueling Thorium Nuclear Reactor, David Dalton, May 1, 2025, <https://www.nucnet.org/news/china-scientists-announce-breakthrough-in-refuelling-thorium-nuclear-reactor-5-4-2025>
- EnerTherm, Fusion Breakthrough! Stellarator Creates Helium-3 Milestone, May 22, 2025, <https://enertherm-engineering.com/fusion-breakthrough-stellarator-creates-helium-3-milestone/#:~:text=Researchers%20a%20W7%2DX%20have,a%20milestone%20for%20fusion%20research.>
- Mother Jones, A Short Primer on Modern Nuclear Reactor Design, Kevin Drum, July 23, 2019, Thorium Nuclear Reactor Diagram, <https://www.motherjones.com/kevin-drum/2019/07/a-short-primer-on-modern-nuclear-reactor-design/>
- Chris Orcutt, Helium-3, Alternative Energy & The China Problem, Helium-3 mining operation diagram, <https://orcutt.net/weblog/helium-3-alternative-energy-the-china-problem/>
- Computer Aided Design & The 118 Elements, How Helium-3 Fusion Powers Spacecraft Generators, Florin Fodor, Nuclear Fusion diagram, <https://americanbobcat.blog/2025/10/26/how-helium-3-fusion-powers-spacecraft-generators/>
- Webpages images downloaded from Pexels, <https://www.pexels.com/>



More Information

- Complete research done by Nicole at:
 - <https://sites.google.com/view/sustainablenuclearenergy>
- Contact us:
 - haragutchi@gmail.com





TeraOpenScience

THANK YOU