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ENERGY

Atoms For Peace – ANEEL To Sustain It

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I write about nuclear, energy and the environment

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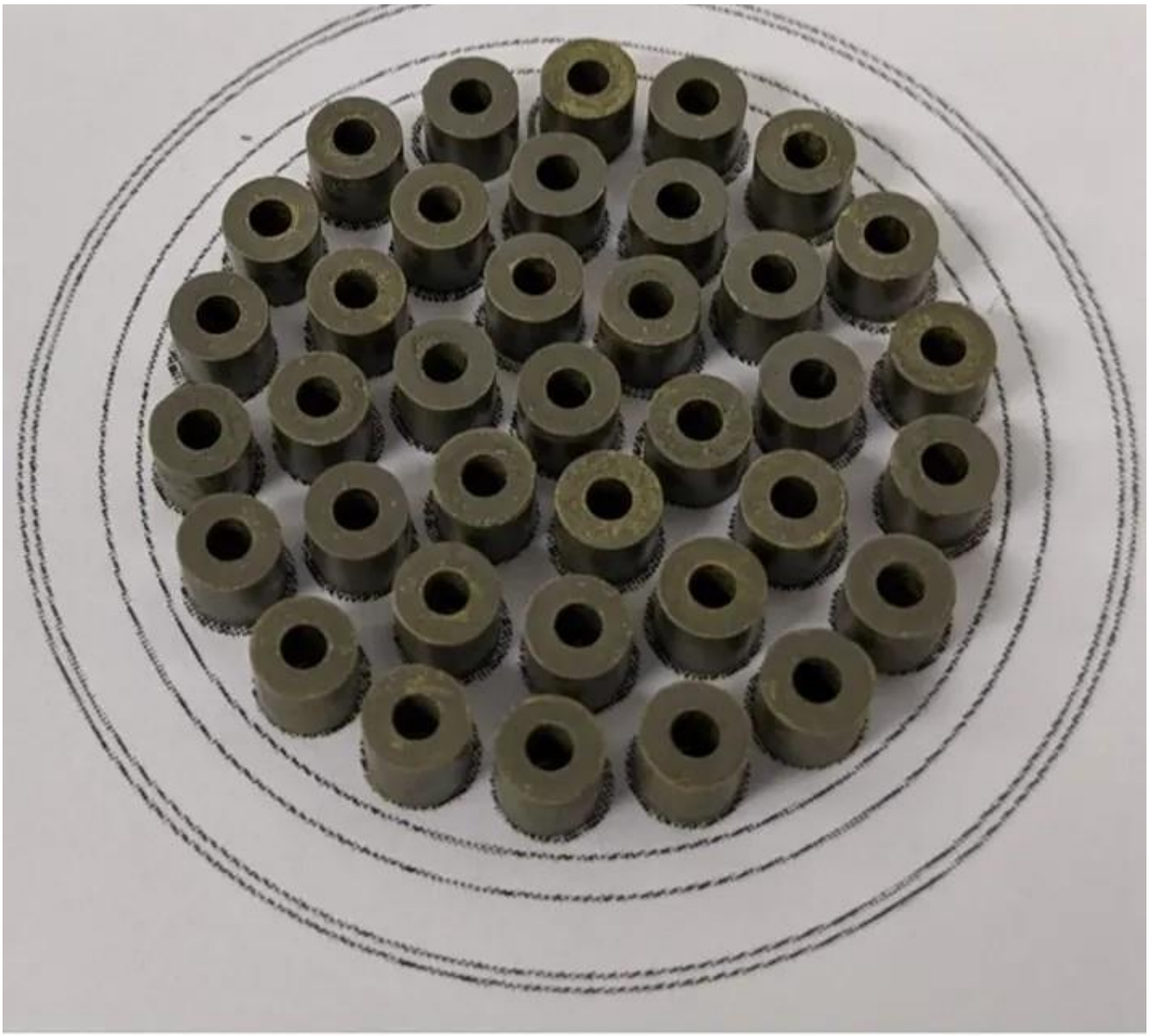


ANEEL fuel pellets in a 37 Pin layout. This fuel combines thorium and high-assay, low-enriched uranium to address cost, proliferation and waste. There is no reprocessing involved with this fuel. [-]
CLEAN CORE

Clean Core Thorium Energy (Clean Core) announced that the Texas A&M Engineering Experiment Station's Nuclear Engineering and Science Center has successfully fabricated the first fuel pellets of Clean Core's proprietary advanced nuclear fuel technology in partnership with the Idaho National Laboratory (INL).

In addition to focusing on new reactor designs to address a variety of issues like climate change, backing up renewables, and replacing fossil fuels with a reliable baseload alternative, the nuclear industry is moving forward quicker by using new types of advanced nuclear fuel.

A variety of new nuclear fuels are being developed to address existing and new generation reactors, including being accident tolerant, being longer lasting, being cheaper, providing more power, providing some recycling of previous fuel, providing easier refueling, being easier to store and dispose, and being proliferation resistant.

Clean Core's proprietary fuel technology ANEEL (Advanced Nuclear Energy for Enriched Life) fuel technology uses a combination of thorium (Th) and high-assay, low-enriched uranium (HALEU) for a much-improved fuel performance in CANDU reactors and in other pressurized heavy-water reactor (PHWR) designs.

ANEEL is a proliferation-resistant advanced nuclear fuel that enables CANDU and similar reactors to operate more economically while significantly minimizing waste and proliferation risk. ANEEL fuel can also be optimized for use in PWRs, BWRs, HTGRs and related SMRs. There is no reprocessing involved with this fuel.

Texas A&M has fabricated the ANEEL fuel pellets for accelerated irradiation testing and qualification at INL's Advanced Test Reactor in 2022, in anticipation of full commercialization by late 2024.

"The successful production of ANEEL advanced nuclear fuel pellets brings us a step closer to our goal of providing a clean energy solution that can benefit people around the world. We applaud Texas A&M University and INL for successfully fabricating these innovative advanced nuclear fuel samples," said Mehul Shah, CEO of Clean Core.

Combining Th and U has some real benefits. Thorium is about three times more abundant than uranium on Earth.

This is a CANDU/PHWR nuclear fuel bundle which will look identical to the CLEAN CORE's new ANEEL fuel bundle but with a different composition and configuration of U/Th. Both, the current CANDU/PHWR and ANEEL fuel bundles are about 50 cm long and 10 cm in diameter.
DREAMSTIME

Natural uranium is only 0.7% URANIUM-235 (U-235), which splits easily. The rest is U-238, which does not. It has to be enriched to around 5% U-235 in order to maintain a continuous chain reaction in most nuclear reactors. The exception is the CANDU (Canada Deuterium Uranium)/PHWR (Pressurized Heavy Water Reactor) reactors which use natural uranium and heavy water (D2O - Deuterium is hydrogen with one neutron in its nucleus).

It has long been known that higher levels of U-235 enrichment will provide more power per mass of fuel, provide longer life for the reactor core, will allow smaller plant sizes, and give a higher burn-up rate for nuclear waste.

The world's existing fleet of light water reactors (LWRs) use fuel enriched to about 5% U-235. But many advanced reactor concepts require HALEU, which is enriched to a higher degree - between 5% and 20%. CANDU/PHWR reactors can especially benefit from HALEU.

Above 20% enrichment is considered highly enriched and not acceptable for civilian applications.

ANEEL fuel, being made-in-America, positions it as a prime candidate for export to emerging nuclear markets, something that the Departments of State and Energy appreciate. It creates a market demand for HALEU of which the United States is poised to take advantage and become the world leader in HALEU supply.

“It is one thing to talk about designing an advanced nuclear fuel; it is another level of accomplishment to announce its fabrication. Our team here at the Fuel Cycle and Materials Laboratory at Texas A&M has worked extensively to develop ANEEL fuel pellets, and we are thrilled to have established a fabrication process to blend HALEU and thorium oxide successfully. This is the first of its kind nuclear fuel, in that it combines HALEU and thorium in proprietary unique compositions that can drive a global clean energy future,” said Dr. Sean McDeavitt, director of the Nuclear Engineering and Science Center and professor in the Department of Nuclear Engineering at Texas A&M University.

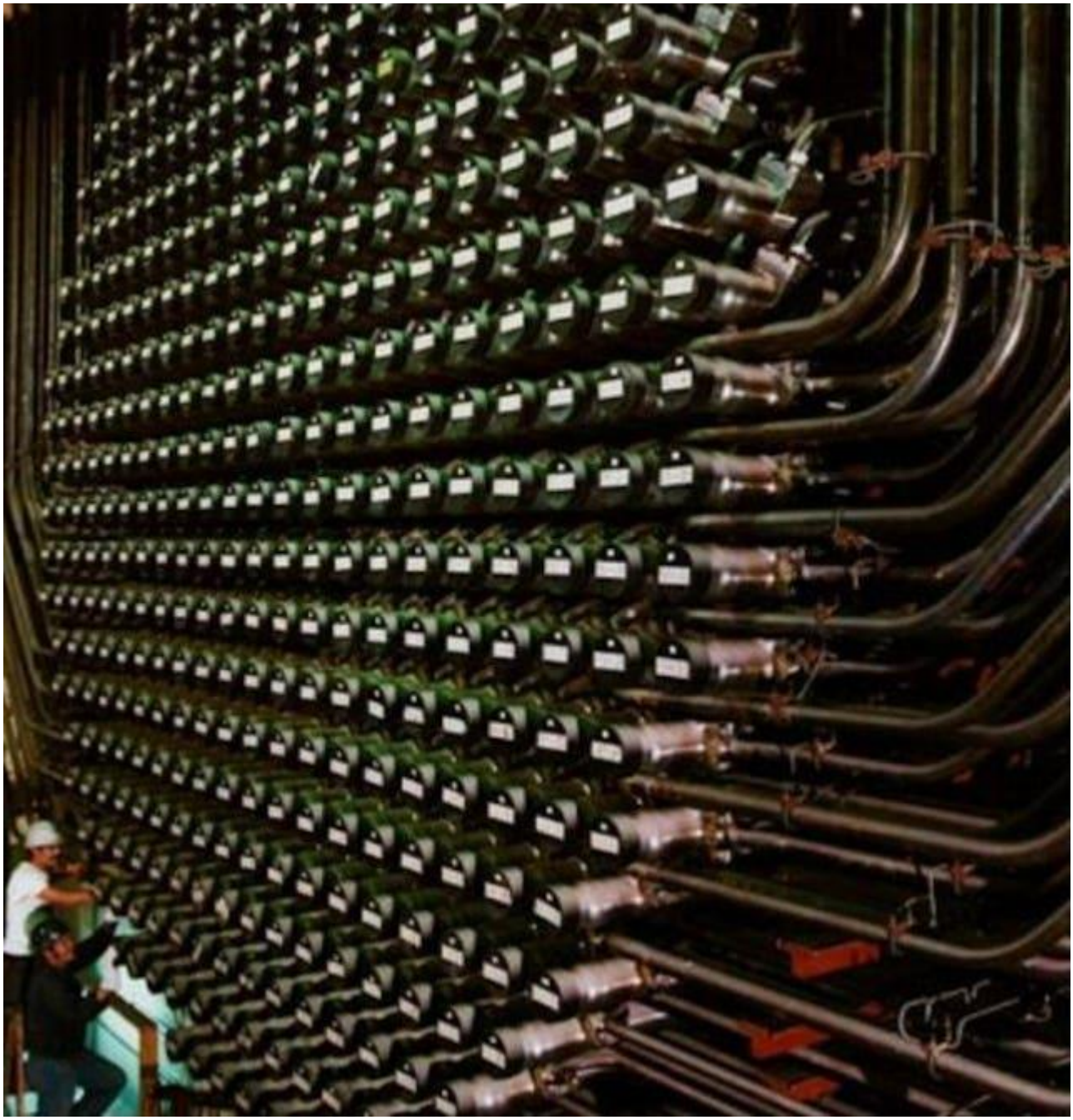
ANEEL is a proprietary combination of Th and HALEU. This means much less U-238 than ordinary fuel, less than 20% compared to over 94% used in LWRs. The rest of the fuel is a Th matrix that uses the U-235 as a fissile driver, providing sufficient neutrons for continued fissioning.

Th-232 captures a neutron and converts to U-233 which is also fissile and begins providing more neutrons and more power. At the same time, U-238 captures a neutron, converting to Pu-239 which also fissions, almost as fast as it’s created.

With all this fissioning going on, the burn-up rate in the ANEEL fuel is high, providing more power in the reactor from the same amount of fuel. In fact, ANEEL’s burn-up rate of over 50 GWd/t, is so much more than the 7 GWd/t rate of CANDU/PHWRs current natural uranium fuel, that the reactor only needs about a seventh of the amount of fuel over its life, translating into significant savings and benefits in operations, fuel and waste.

Using ANEEL fuel reduces the waste by over 80%. Less spent fuel means less refueling, less cost, less fuel handling and less volume to dispose.

ANEEL fuel is designed to be proliferation resistant throughout its life cycle. Higher burn-up rates cause deep burning of Pu quickly. That also increases the amount of Pu-240 and Pu-242 that breeds into the fuel, which are neutron poisons to the uncontrolled chain reactions needed for a nuclear weapon. This makes the spent ANEEL fuel prohibitively difficult to make into a weapon.



The face of a CANDU reactor core, with hundreds of pressure tubes that are able to be refueled during operation. With a Th-U mix fuel like ANEEL, they only need to be filled one-eighth of the time. [-]MENELEY AND RUAN, ENERGY EDUCATION

CANDUs/PHWRs are well established small and medium reactors. All of Canada's 20 nuclear reactors are of the CANDU design. Other nations with CANDU reactors include Argentina, China, India, South Korea, Pakistan, and Romania. India has 18 PHWRs that are based on the CANDU design. The nearly 50 CANDU and PHWR reactors comprise roughly 10% of reactors worldwide.

On the other hand, there are 30 countries considering, planning or starting nuclear programs, and an additional 20 countries that have expressed an interest in launching a nuclear program in the future. Most of them are developing countries. With the right fuel, the CANDU/PHWR is an optimal reactor for these developing nations.

Unlike LWRs, CANDU/PHWR reactors can be refueled at full power and don't have to be shut down. After 150 days of initial operation in the current smaller CANDU/PHWR reactors (200-300 MWe), eight natural uranium bundles, weighing about 15 kg, have to be replaced each day for the rest of the reactor's operating life of 60 years.

But with an ANEEL fuel bundle, weighing approximately 10.65 kg, after 1,100 days of initial operation, only one such bundle on average would be replaced each day for the rest of the reactor's life of 60 years, leading to over eight times less waste and the other benefits as described.

As an example, a 37 PIN natural uranium-fueled 600 MWe CANDU/PHWR, would require 348,000 fuel bundles over 60 years. With 37 PIN ANEEL-fuel bundles, the same 600 MWe CANDU/PHWR would require only 61,500 ANEEL fuel bundles over the same 60 years. This would translate to a savings of CAN$2 Billion towards the fuel cost, direct disposal of spent fuel and the operational costs over the 60-year life of a reactor.

Thus, there is an opportunity to harvest such benefits by deploying ANEEL fuel in the CANDUs/PHWRs around the world that are planned for refurbishment, in which reactor life would be increased by another 30 to 40 years.

"In front of us lies a path to serving and raising the prosperity and common good of emerging and established countries while fighting the climate crisis with a quickly implementable, cost-effective, clean, safe base-load energy", says Mehul Shah, CEO and Founder of Clean Core. "The urgency of realizing such a vision becomes even more critical as time is lost in the face of accelerating climate change."

James Conca

I have been a scientist in the field of the earth and environmental sciences for 33 years, specializing in geologic disposal of nuclear waste, energy-related research, planetary surface processes, radiobiology and shielding for space colonies, subsurface transport and environmental clean-up of heavy metals. I am a Trustee of the Herbert M. Parker Foundation, Adjunct at WSU, an Affiliate Scientist at LANL and consult on strategic planning for the DOE, EPA/State environmental agencies, and industry including companies that own nuclear, hydro, wind farms, large solar arrays, coal and gas plants. I also consult for EPA/State environmental agencies and industry on clean-up of heavy metals from soil and water. For over 25 years I have been a member of Sierra Club, Greenpeace, the NRDC, the Environmental Defense Fund and many others, as well as professional societies including the America Nuclear Society, the American Chemical Society, the Geological Society of America and the American Association of Petroleum Geologists.