Thorium can power the future

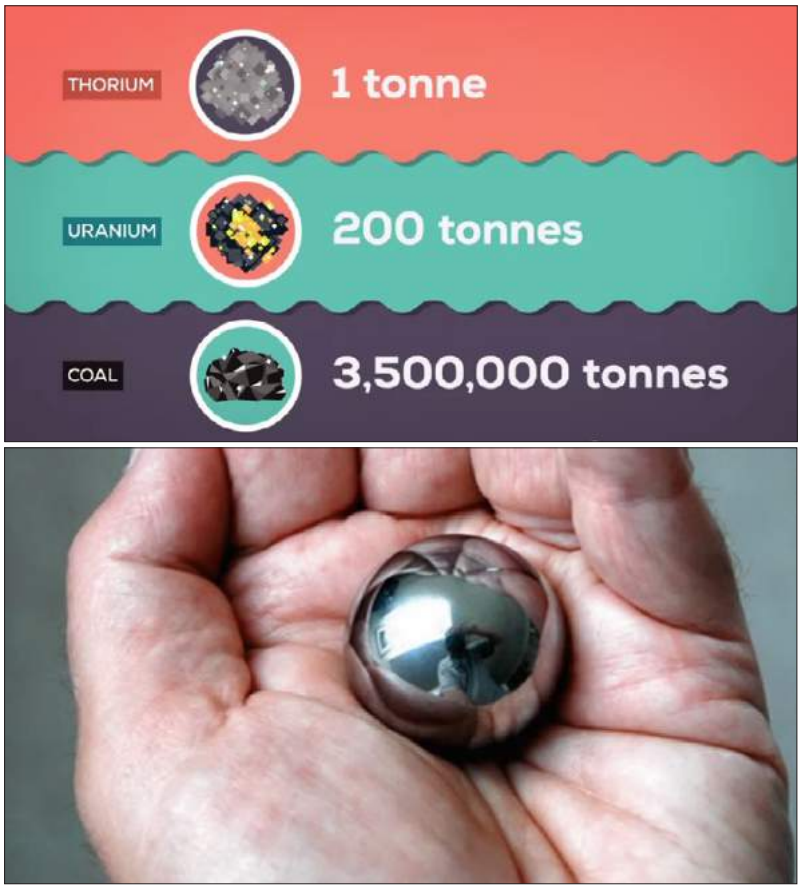
By Jeremy Beck

More than a dozen countries are reassessing thorium as an alternative nuclear fuel which, given its abundance, could power industrial civilisation indefinitely, regardless of when fusion power becomes a reality. Thorium is found in the Earth's crust at a concentration around 500 times that of fissile uranium-235. The thorium fuel cycle is not suited for nuclear weapons production so it has excellent non-proliferation credentials. Several reactor designs suited to thorium are meltdown-proof, including variations of molten salt reactors (MSRs) and High-Temperature Gas-Cooled Reactors (HTRs). Adding to its safety, the thorium fuel cycle creates negligible nuclear waste.

The benefits of the thorium fuel cycle have long been known. At the US Oak Ridge National Laboratory, the Molten-Salt Reactor Experiment (MSRE) reactor was constructed by 1964 and operated until 1969. Political decisions intervened and the project was dropped. The thorium fuel cycle takes advantage of the fact that nearly all naturally occurring thorium in the Earth's crust is of the one isotope, thorium-232, which can be transmuted in a reactor to create uranium-233. This uranium isotope, which does not occur naturally, is a superior fuel to the uranium-235 that most fission reactors use now.

In April 2006, the Citizens Electoral Council reissued and expanded its 2002 "Infrastructure Road to Recovery" report in the *New Citizen* newspaper, with a special feature article, "Thorium: The Preferred Nuclear Fuel of the Future", by nuclear engineer Ramtanu Maitra (published in the Fall 2005 issue of *21st Century Science & Technology* magazine). At that time the latest data indicated that Australia had the world's largest extractable reserves of thorium, amounting to 300,000 tonnes. Today the World Nuclear Association reports that Australia has 595,000 tonnes of thorium resources, ranking at number three behind India and Brazil.

With the world's largest known thorium resources (846,000 tonnes), India is embracing a thorium future with great enthusiasm. While speaking during this November's debate on the International Atomic Energy Agency's (IAEA) annual report, Sandeep Kumar Bayyapu, a first secretary in India's UN Mission, presented thorium-based technologies as solutions to some objections to nuclear power. As the 10 November *Economic Times* reported, "Bayyapu said that thorium-based fuel cycles and technologies are inherently less susceptible to be used for weapons production and can also provide enhanced passive safety features". India's Department of Atomic Energy (DAE) reports that the nation will more than treble its nuclear electricity generation capacity from the current 6,780 megawatts to 22,480 MW by 2031. The DAE's vision statement calls "to empower India through technology, creation of more wealth and providing better quality of life to its citizens"; and the number one point in its Mandate statement makes clear reference to thorium: "Increasing share of nuclear power through deployment of indigenous and other proven technologies, along with development of fast breeder reactors and thorium reactors with associated fuel cycle facilities".



Top: The relative energy density of thorium compared with uranium and coal. Above: Thorium is so energy-dense, one person's life-time supply of energy can fit in the palm of your hand. Photos: Thorkil Søe; Screenshot

In an exciting breakthrough for the thorium fuel cycle, on 20 March India's Fast Breeder Test Reactor (FBTR) in Kalpakkam produced 30 MW of power for the first time. The FBTR is the only uranium-233 reactor in the world, its fuel supplied by an adjacent Fast Breeder Test Reactor in which thorium dioxide is irradiated to produce U-233.

China meanwhile has mounted the world's largest national effort to commercialise the thorium fuel cycle. In January 2011 the China Academy of Sciences launched an R&D program on the Liquid Fluoride Thorium Reactor (LFTR), also known as the thorium-breeding molten-salt reactor (Th-MSR or TMSR), on which it hopes to obtain full intellectual property rights. The LFTR design is literally meltdown-proof. It uses no water, so high-pressure steam or hydrogen explosions are impossible. And if the temperature were to rise beyond a critical point, a drain "freeze plug" would melt allowing the liquid fuel to flow via gravity, safely to drainage tanks.

The *South China Morning Post* reported 5 December 2017 that China will spend 22 billion yuan (US$3.3 billion) to develop two "molten salt" reactors in the Gobi Desert in northern China. The technology "has the advantage for China of using thorium as its main fuel", reported Stephen Chen. "China has some of the world's largest reserves of the metal." The lead scientist on the project, Jiang Mianheng, is the son of former Chinese president Jiang Zemin. The reactors are planned to be up and running by 2020.

With such enormous thorium resources, Australia has the opportunity to join this world move to thorium to power the future. What are we waiting for?