Thorium cycle: Trick or treat?

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Outline

- The rise and fall of thorium
- Thorium revival
- The really good stuff about thorium
- The bad news
- When and where would a thorium cycle make sense?

The rise and fall of thorium

Philadelphia Electric Co.

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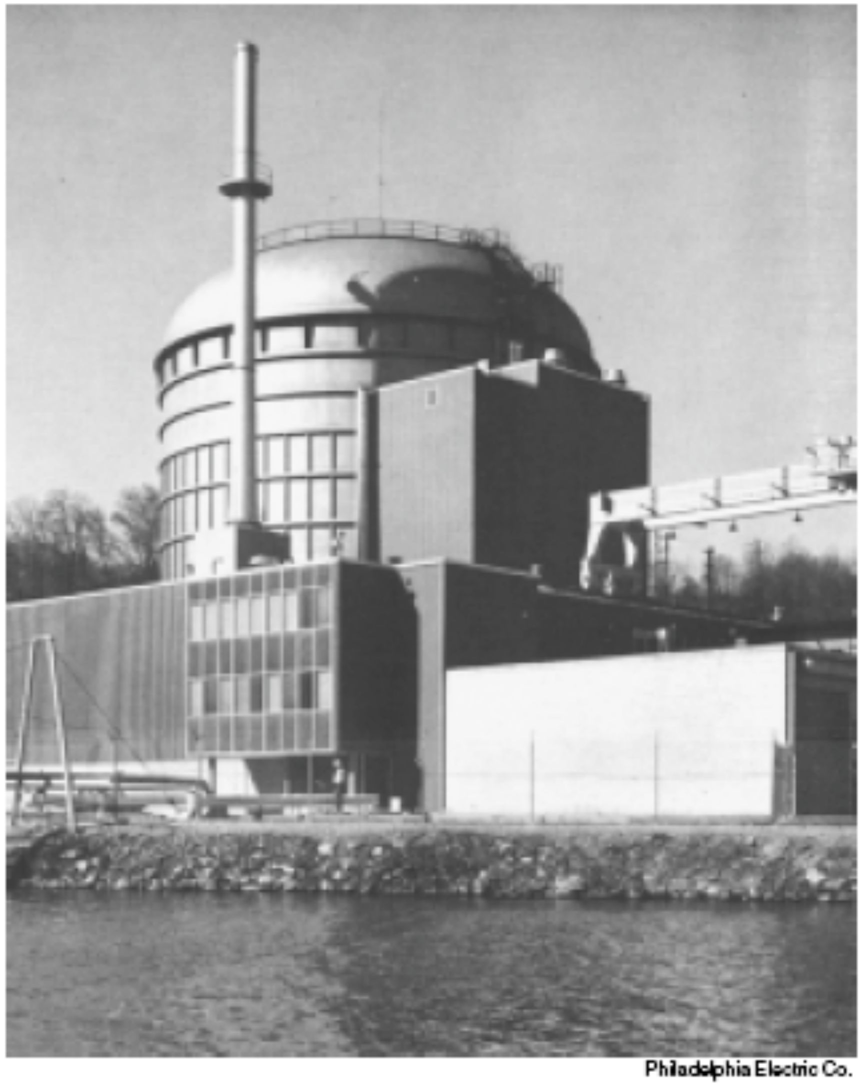

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- **Thorium cycle technology was preserved and developed in India.**

Thorium revival in Europe

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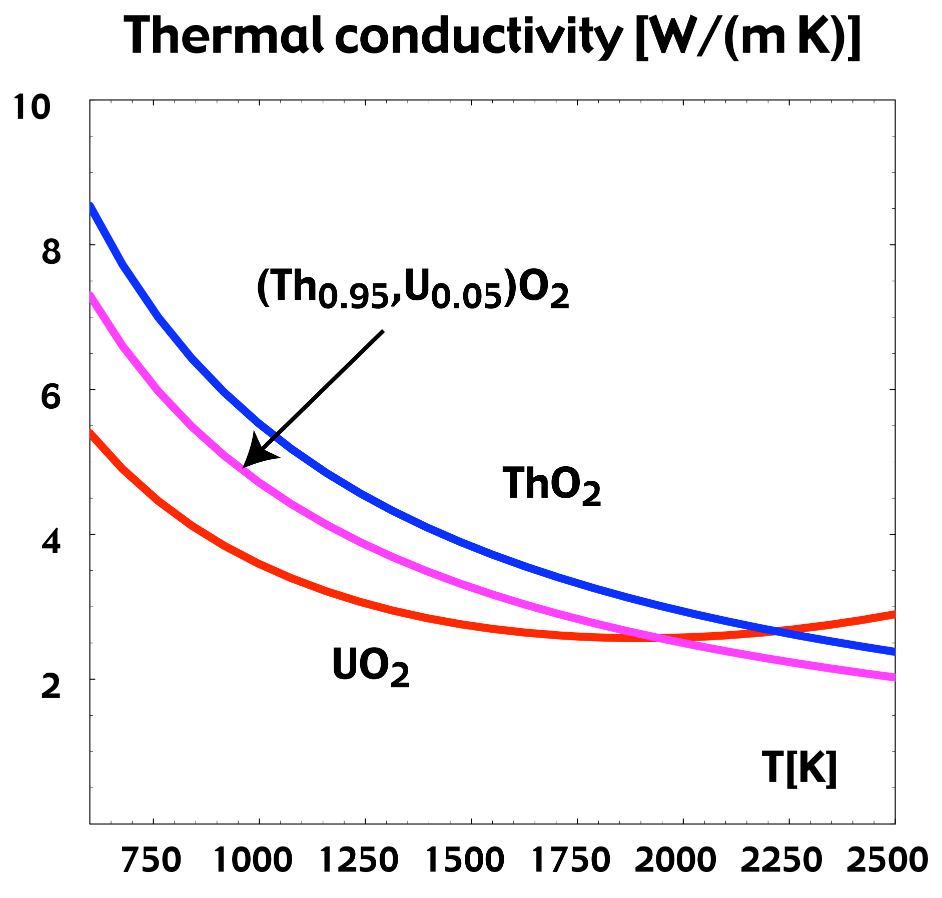
- 1st revival: Energy amplifier concept of Carlo Rubbia (1993)
- Generally flawed approach. Role of ADS is rather for minor actinide burning than for implementation of thorium cycle.
- 2nd revival: Th as matrix for Pu burning in LWRs. Kurchatov Institute in Russia develops Radkowsky design for VVER-1000, 5th framework programme in EU.
- 3rd revival: Norwegian solar cell billionaire starts thorium project in 2006, with intention to build two commercial reactors in the gulf of Oslo within 10 years.
- Norway hosts worlds third largets resources of thorium, located in Telemark region. Controlled by Thor Power.
- 3.3 M€ funding to feasibility study in 2007. Coordinated by Vattenfall.

Advantages of thorium cycle



- High melting temperature (3300°C for ThO_2 vs 2850°C for UO_2)
- Higher thermal conductivity – better fission product retention
- Waste radiotoxicity significant only for 10 000 years (U-233).
- Breeding ratio > 1.0 possible in thermal spectrum.
- Fuel resources in crust twice as large as for uranium

The bad news

- U-233 must be recycled if thorium cycle is to be sustainable
- Thorium oxide is insoluble in aqueous solutions, existing industrial facilities for reprocessing cannot be used!
- Pu seed for first core load and U-233 for consecutive loads would require remote fuel manufacturing, due to presence of U-232 in fuel.
- Positive void coefficient for Th-U233 fuel in LWR geometry.
- Fuel cycle facilities in total more expensive than for MOX recycle, which today is four times more expensive than UOX fuel.
- Although driver fuel may be proliferation resistant, weapons grade U-233 can easily be fabricated by use of a Th blanket in a well thermalised spectrum.

When and where would a thorium cycle make sense?

- Countries without access to commercial uranium and enrichment (like India, Israel) may accept the larger cost related to thorium cycle.
- Competence in heavy water reactor technology (Canada, India, Norway). CANDU and AHWR reactors breed more easily than PWRs and can be designed with negative void coefficient.
- R&D programme carried by limited amount of nations
- Thermal spectrum breeders may be competitive with fast neutron Generation IV systems, which may enter the market in 2050 (if the second wave of nuclear power expansion continues).

Summary

- Advantages: Existing thorium resources can be used for energy production (like Norway!)
- Disadvantages: New fuel cycle facilites for fabrication and reprocessing must be built.
- U-233 long lived waste (10 000 years of storage) if not recycled!
- Fabrication requires remote handling.
- Cost similar to that of MOX fuel.
- Perceived advantage from non-proliferation perspectives not correct. Weapons grade U-233 can be obtained by thermal neutron irradiation of Th-232.