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THORIUM BASED REACTORS:

The Best, Most Overlooked Solution to Global Warming and Long-Term Energy Supply

….. BUT CAN IT BE FINANCED IN TODAY'S ENVIRONMENT ???

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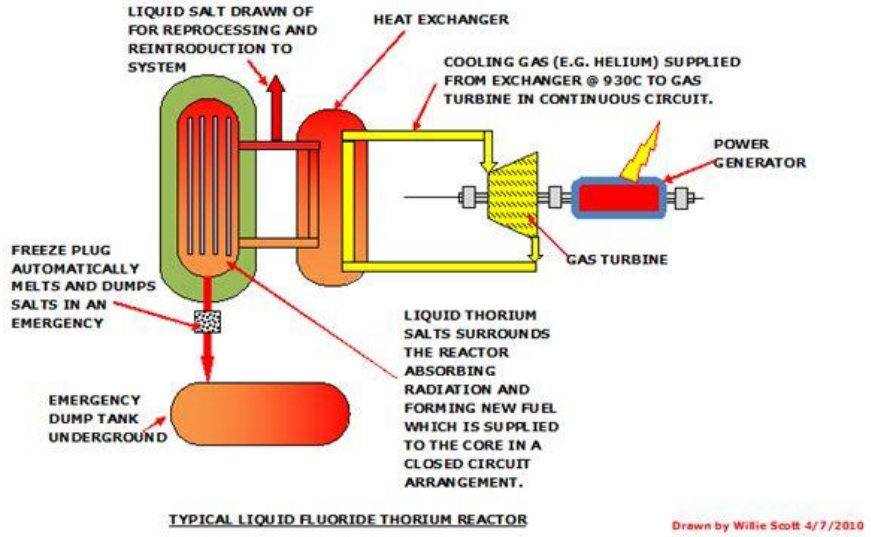

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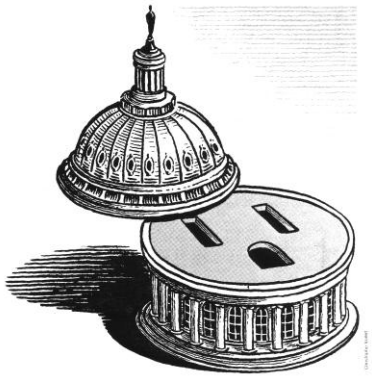
We would have been much better off if we had started out with Thorium-fueled power reactors instead of Uranium.

- The uranium-fueled reactor was a technological by-product of the "Manhattan Project[1]"
  - *The "Project's" goal was to obtain fissile uranium and plutonium for nuclear weapons*

- In 1953, U.S. President Dwight Eisenhower's "**Atoms for Peace[2]**" speech at the UN created a ***"moral imperative"*** to show that ***uranium*** and ***plutonium*** had non-military uses such as electrical generation

- Although the use of thorium as a fuel for nuclear reactors was known in the late 1940s, the political and technological environment focused on reactor designs that justified the production of enriched uranium (and plutonium), and many in the scientific community believed that uranium-fueled reactors would be safe, relatively cheap, and eagerly embraced by the public
  - *During 1950 -1970, a number of options using thorium to enrich uranium were investigate by the U.S. and U.S.S.R*



The development of uranium-fueled power reactors and related infrastructure was primarily motivated by political factors and technological familiarity – not economics

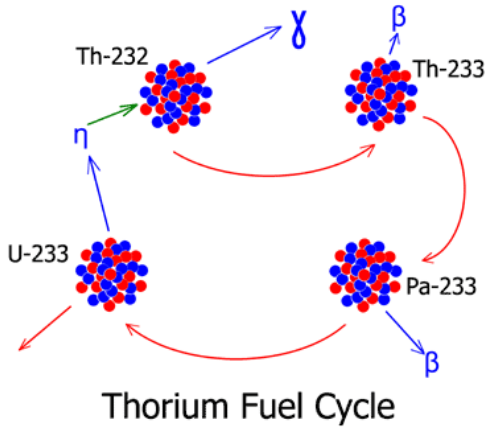
1- The first nuclear reactor was build in 1942 under the supervision of Enrico Fermi and Leo Szilard in Chicago and used uranium fuel moderated by graphite

2 -The speech was possibly a tipping point for international focus on peaceful uses of atomic energy, even during the early stages of the Cold War. It could be argued that Eisenhower, with some influence from Albert Einstein, was attempting to convey a spirit of comfort to a terrified world that the horror of Hiroshima and Nagasaki would not be experienced again.

New Thorium reactors designs (e.g., LFTR) have several technological, and safety advantages over conventional (uranium) reactors

Benefits

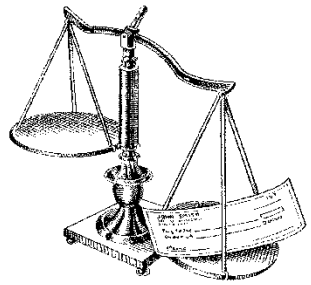
- Inertly safer than uranium-fueled reactors – no “meltdowns”
- Lower proliferation risks (U^{233} is difficult to separate for weapons) in thorium reactor designs
- Waste has shorter half-life, quantity produced is significantly smaller
- There is a significantly larger supply of recoverable Thorium (3 -10x?) in the world than uranium and breeding thorium fuel is far easier and safer
- Continuous refueling – no 30 to 60 day shutdown for refueling
- No greenhouse gas emission
- Plants could be less expensive than uranium reactors



Thorium Fuel Cycle

Unfortunately, the financial challenges are significant and will be difficult to overcome in today's risk-adverse financial environment

- High Capital Costs ($4,000 - $10,000/kW)
- No existing infrastructure or commercially operating plants[3]
- Licensing issues & long lead times (10+ years?)



- Public fear and skepticism over any type of power technology using radioactive fuel
- **Low Natural Gas prices and abundant supply due to new recovery technologies (fracing)**
  - *NG prices are expected to stay low for the next 20+ years*
  - *Thorium power technology cannot economically compete with electricity generated by gas so long as NG prices remain in the $3 - $6 per mmbtu price range*

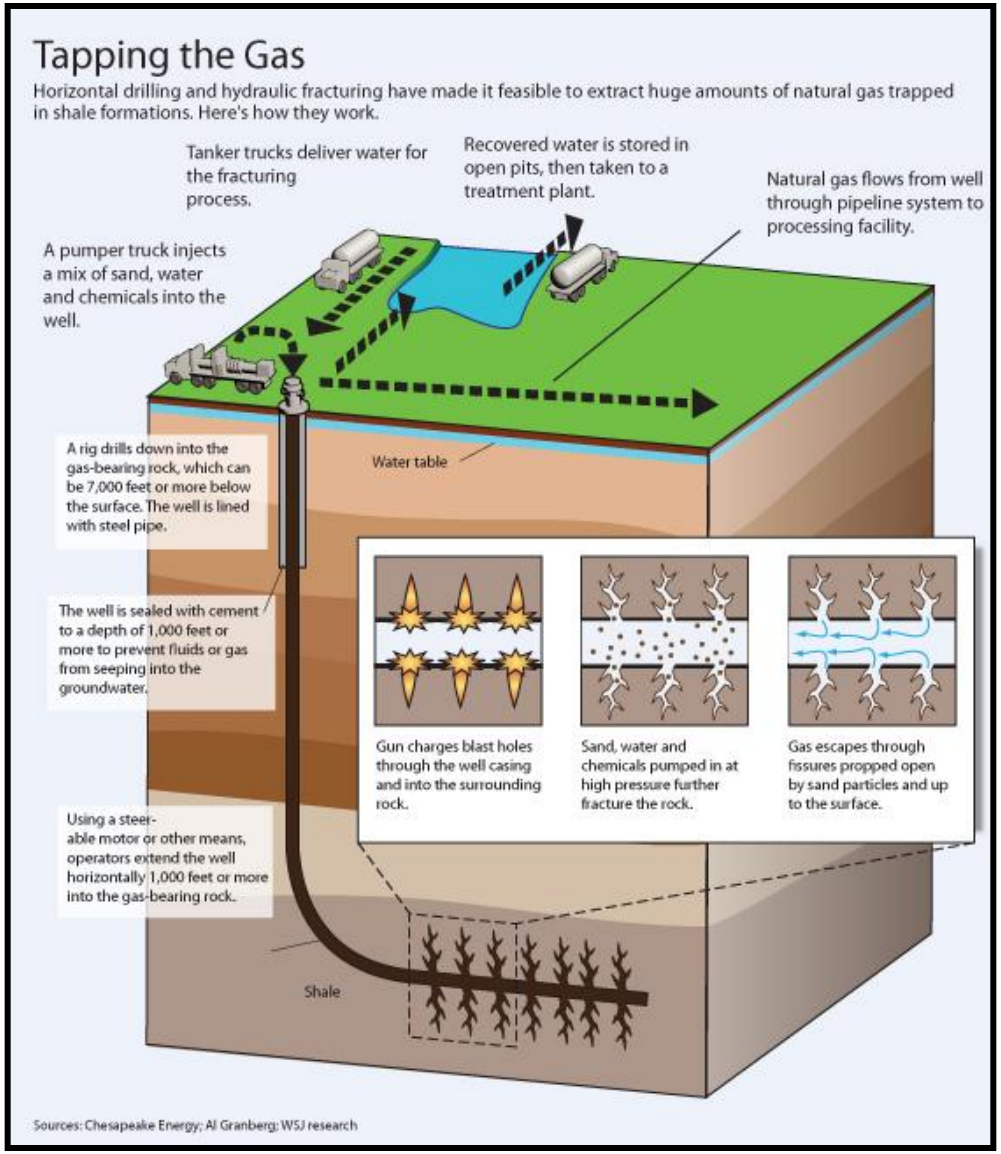
Today's low natural gas prices and its relatively low CO_2 emissions are the biggest obstacle to obtaining funding for Thorium-based power plants

3- India is currently using Thorium in its pressurized heavy water reactors (PHWRs) and its liquid metal fast breeder reactors but these are not the designs being advocated by Thorium technology supporters

The revolution in shale gas recovery technology: "U.S. Gas Fields Go From Bust to Boom"

- Advances in "shale gas" recovery have dramatically increased domestic natural gas supply (> 400%)[1] in just the past 3 years
- New estimates project that the U.S. alone has over 2,200 trillion cubic feet of "cheap" recoverable natural gas[1]
  - *Equal to **100 years** of current demand*[2]
- Natural gas prices are now projected to stay under **$5/MCF** through at least 2022[3]. In 2003, gas sold in the U.S. for $19/MCF and $13/MCF as recently as 2008

The Large supply of low cost, low carbon emitting natural gas has adversely impacted the economics of thorium-based and most other alternative energy technologies



1 - The Wall Street Journal: April 20, 2009
2 - Petroleum and Other Liquid Fuels. International Energy Outlook 2010, EIA/DOE
3 – EIA/DOE Annual Energy Outlook 2011 Early Release Overview

Natural Gas will probably be the fuel of choice over the next decade or two as the world transitions to cleaner energy sources (including thorium?)

- The U.S.'s and the world's electric power providers face big questions about new generating capacity and fuel choice
- New gas-fired plants can be built more quickly (1 - 2 years vs. 5 - 10 years) and far more cheaply than nuclear or coal-fired plants
- Using natural gas to generate electricity emits significantly less pollution and CO_2 (~ 50% less) than coal-fired plants
- Alternative energy sources (excluding traditional hydro) are still expensive and most (but not Thorium) have reliability & dispatching issues – they need backup sources
- ***Water contamination issues, however, from shale gas fracing could reduce expected new supply and raise NG prices but it appears to be a problem only where the shale is near the water aquifer, and there is no shortage of deep shale deposits***

What would private investors need to finance Thorium technology?

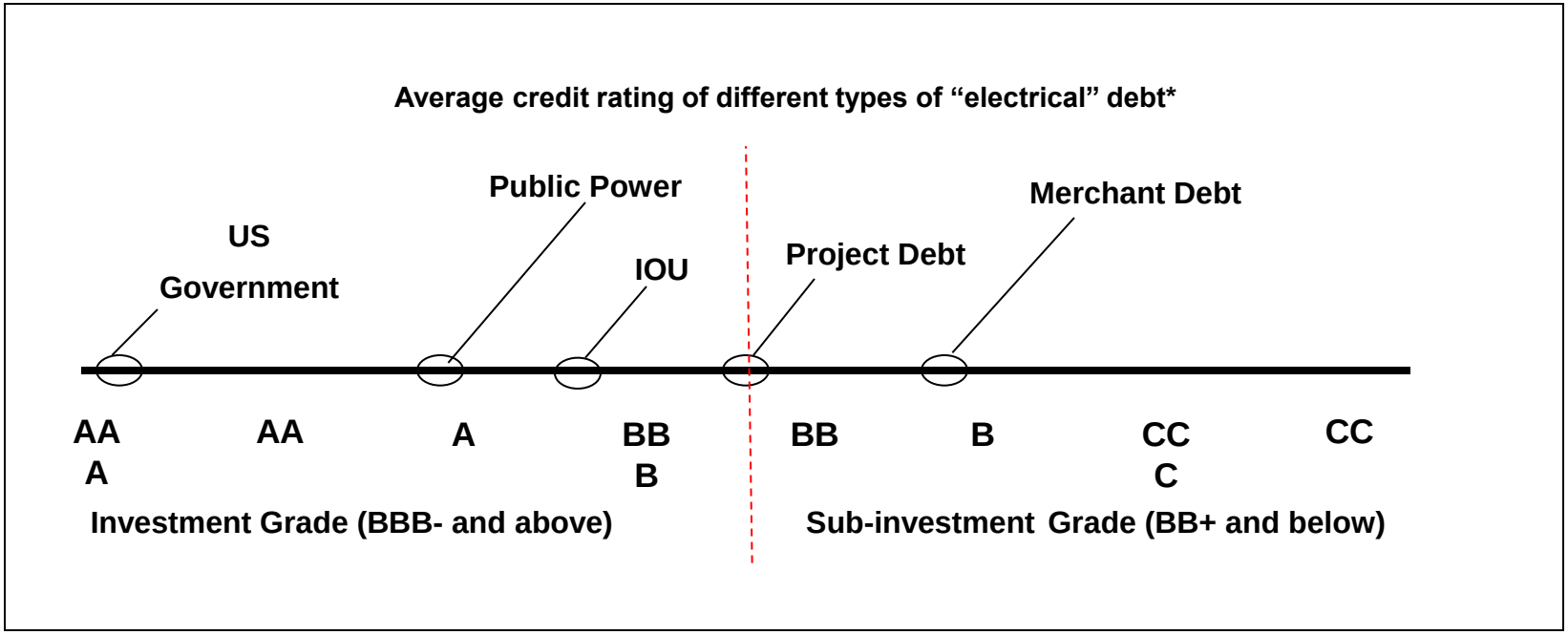
- **Economic viability** – must be able to produce power competitive with gas generation
- Demonstrated need for thorium-fueled reactors (e.g., strict regulations regarding greenhouse emissions)
- Minimal "new technology" risks
- Expectations for a high return on their investment
- Price, completion date, and performance guarantees from EPC contractors (e.g., Bechtel, Shaw) with liquidated (cash) damages provisions
- Permits/licensing already approved or pending prior to seeking financing
- **Investment grade credit ratings – a very important criteria in a risk adverse financial environment**

Societal benefits (reduced dependence on fossil fuel, greenhouse gas emissions, public safety, nuclear non-proliferation, etc.) are *not prime* considerations for investors

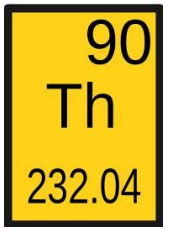
"there only in it for the money"

The importance of credit quality – the higher the ratings, the lower the financing costs

- **U.S. ratings are currently set by 3 agencies: *Moody's*, *Standard & Poor's*, and *Fitch*, although the recent fiasco with their high ratings of CDO/mortgage-backed securities may change that**
- **Bond ratings range from Aaa/AAA (very secure) to D/D (in default or bankruptcy)**
- **It would be difficult for a new "thorium-based reactor" to get investment grade ratings (BBB- or higher; an important threshold for many investors) without guarantees from a highly-rated sovereign state(s) and/or an operating demonstration plant**



Conclusions



Thorium-based technology will have a hard time attracting needed capital

- Despite safety and environmental benefits over uranium-fueled nuclear reactors, private investors are unlikely to provide the financing needed to deploy thorium-based technology because of:
  - ***Low natural gas prices which reduces the need and economic viability of this option***
  - *Public opposition and skepticism over radioactive power technologies regardless of actual benefits*
  - *Insufficient educational outreach programs to the public, decision makers and investors about the safety of Thorium technology as well as its reduced waste issues & proliferation risk*
  - *Lack of an operating demonstration plant(s) nor licensing criteria to built a commercial Thorium-fueled reactor*

- The current weak global economy makes it difficult for any single nation/state to provide sufficient funding or economic incentives to investors to develop thorium-based power plants

- For thorium-based technology to remain a viable option for the future, those advocating its deployment will need to devote more resources to educating and lobbying the international community
  - *Unpredictable changes in natural gas availability and price, potential climate change issues, uncertainty in future electrical demand, and the need for a sustainable long-term environmentally acceptable energy source make this technology too important to be abandoned at this time*