Sustainable Energy Sources and

Benefits of Thorium in Modern Society

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I was seven years old when my family moved from a small house near central Salt Lake City to a suburb in Millcreek. The new house was considerably larger, prettier, and more open than our previous home. It was situated on approximately an acre of land; ideal for rambunctious boys (my friends and me), determined gardeners (my mother), amateur princesses (my sisters), and unruly miniature dachshunds. It seemed ideal, however, my parents were fairly alarmed at the dramatic spike in the cost of heating, air conditioning, water and electricity bills. The larger house required much more energy than the previous home, and had, in retrospect, a much bigger toll on the environment. With two air conditioners, three furnaces, and two water heaters (more than doubling the previous house), the jump in energy consumption should have been no surprise.

For many decades Americans have been distancing themselves from compact city life and placing more emphasis on suburban life. This change has significantly complicated our relationship with the environment. Such a change has had an impact on farming, arable land, pollution, oil consumption, wild land, soil consistency, atmospheric pressure, and the average temperature of the globe, to say the least. However, the majority of this change is irrevocable; for example, it would be illogical, indeed impossible, to now destroy suburbs in order to reinstate wild life (Owen, 2004). Yet, there are possible solutions which will greatly decrease the negative human effect on the world. Nothing we are currently using on a broad scale, like coal or oil, is that solution; those fuels may not last. Solutions to supporting an increasing global population lies in sustainable energy. Sustainable energy sources must be the focus of a people who want to survive. One of the most exciting solutions is Thorium.

In this paper I will explore current perceptions about energy, safety, and sustainability. I will present facts about alternate energy sources, Thorium, and draw comparisons between Thorium and Uranium. Currently, nuclear reactors use Uranium, however the system is entirely inefficient–only about 0.5-0.7% of the product is used as energy, the rest is disposed (Sorenson, 2011). Thorium, like Uranium, is a naturally radioactive element. But unlike Uranium, Thorium is considerably more abundant in the earth and can be used more efficiently and effectively (Patzek, 2006). It is safer; if a Molten Salt Thorium Reactor lost power like the Fukushima-Daiichi or Daini reactors did, then the liquid Thorium would simply drain into a holding tank and solidify, rather than "explode" because of a lack of coolant. Thorium has the potential to be a better and, on the whole, a cleaner energy source because it has so few byproducts (Sorenson, 2009). Is it possible to instigate Thorium as the energy of the future? The answer is that it is not only possible, but necessary to develop Thorium as an energy source if we are serious about feeding the world's appetite for power.

Perceptions About Current Energy Technology

The general populace understands wind and solar power, and can picture a dam when hydroelectricity is produced. Perhaps vague ideas exist about geothermal, bio, and ocean energy. Coal, oil, petroleum, and natural gas are well known and relatively well understood fossil fuels. Support for different energies varies greatly, however. A poll in 2011, conducted by the Nuclear Energy Institute, shows that 62 percent supported nuclear energy. The public's view of nuclear energy facilities and production safety has "transformed over the past decades." Seventy-three percent of polled Americans believe that, “Nuclear power plants operating in the United States are safe and secure,” compared to only 35 percent in the 1990s (Nuclear Energy Institute, 2011). It is fantastic to have this increased support in nuclear energy production, however, it is still a bumpy road. “Public support [of nuclear energy] was at [the] lowest” after tragic incidents like Chernobyl; support tends to undulate in accordance to global issues (NEI, 2011). The public sees nuclear energy as safer than it was twenty years ago, but tends to believe more strongly in older forms like coal and oil. The challenge though, is that there is not an adequate supply of fossil fuels (Sorenson, 2010). A poll of the European Union in 2007 showed a definite split in the opinions about coal; nearly two thirds of the populations of Eastern and Central Europe were strongly in favor of coal production, whereas the majority of Western Europe (France, Belgium, Spain, etc.) was opposed. In Britain only nine percent were opposed to production (World Coal Association, 2012). Although coal and nuclear energy are very different in their effects on the environment, they receive similar favoring, but reliance on and general support of fossil fuels is higher.

Support for renewable energy sources depends greatly on cost. A poll by the World Public Opinion at the recent World Future Energy Summit in Abu Dhabi showed that there was strong support for tax incentives to develop alternative energy sources, “Specifically [to address] dependence on foreign energy.” On domestic soil, “91 percent of [leaders] believed investing in renewable energy is important for the U.S. to...compete with other countries in the global economy” (Brick, 2010). Yet, citizens of the U.K., Italy, France, Germany and the U.S. “disagree with paying more taxes to cut greenhouse gas emissions” (Harvey, 2009). The

International Energy Agency showed that generating electricity from current renewable energy technologies is “twice to eight times as expensive as coal-based electricity” (Harvey, 2009).

It seems to be a stalemate of sorts; it would be ideal to choose the cleaner, more cost-effiective energy source, though currently that does not exist. Cleaner energy exists in renewable forms, but those are more expensive in production. The fossil fuel non-renewable energy sources are cheaper to produce and easier to sell; there is a larger market for them; e.g. most cars are not outfitted for biodiesel or ethanol fuels, whereas nearly all cars use fossil fuels of some sort (Patzek, 2006). At this critical time where the consumption of energy is at record highs, we can choose to continue using fossil fuels and relatively inefficient renewable energies or pursue other sources. Nuclear energy, despite recent damning events, still stands as a source capable of generating huge amounts of power. The future of nuclear energy is not in Uranium. The future of nuclear energy is in Thorium; this nuclear energy seems to truly be an energy for the future. There was a stone age, a bronze age, an iron age. There was a dark age, an age of discovery, an age of enlightenment, an industrial age, and a machine age. In the twentieth century, there was an oil, atomic, space, and information age. The next “age” of human existence is already developing under framework of sustainability (Business Insights, 2009). In order to supply energy to future generations, nuclear must be considered.

Benefits of Thorium

When work on the atomic bomb began in the 1940s, scientists realized that there were many nuclear elements from which to choose. Of the long list of very radioactive elements, like Iridium, Xenon, Plutonium, Thorium, Protactinium, and even Radon, the element Uranium was chosen to be the fuel source. Uranium is a rare earth metal, similar in abundance to Gold, Platinum, Silver, and Tin (Sorenson, 2011). However, Uranium production has high-volatility waste which can be used in weapons. Perhaps this is one of the reasons why scientists in the Manhattan Project–the 1942 convention of American scientists focused on beating the Germans to the develop the atomic bomb–chose Uranium over the safer Thorium. The scientists wanted to use an element which would could be used in weaponry.

The world's Uranium can be found in few locations like Canada and Namibia (Sorenson, 2011). Uranium is also found in seawater; it is 1000 times more abundant in the ocean than it is on land. However, current methods of harvesting Uranium are very expensive: more than $100/lb, and as previously mentioned only 0.5% of the energy is used (Tamada, 2009). Still, Uranium is the only element which current nuclear reactors can handle. Nuclear energy would be better if it could yield more power more safely than Uranium does. That safer, better element is Thorium.

Let's talk about the basics of Thorium before we analyze it's amazing benefits. Thorium, named after the Norse God Thor, was discovered in 1828. Thorium-232, the most naturally occurring isotope of Thorium, has a half life[1] of approximately 14.05 billion years. Such a long half-life signifies low radioactivity levels; when Thorium particles are used up and disposed of, the threat to the environment (and to life) will be considerably less than Uranium-238 (the naturally occurring form of Uranium) because a half life of Uranium-238 is 4.47 billion years (Sorenson, 2011). Thorium, as previously stated, is more abundant than Uranium, approximately four times more so (Sorenson, 2011). The Argonne National Laboratory said:

> "Thorium is widely distributed in small amounts in the earth's crust. The chief commercial source is monazite sands, where the highest levels of Th-232 are present, in the United States (in North Carolina, South Carolina, Idaho, Colorado, Montana, and Florida) as well as in Brazil, India, Australia, and South

[1] Note: A half-life, as far as atomic elements go, is a measure of how long it takes half of the element to decay. The shorter the half-life, the more radioactive the element is.

> Africa. Thorium is naturally present in soil, rocks, surface water, groundwater, plants, and animals, at low concentrations on the order of ten parts per million."

Argonne National Library EVS (2005). Theoretically, Thorium is present in practically everything. Even humans generally have approximately 0.002% Thorium in their bloodstreams. Thorium in the body is usually dispersed by 700 days or so (Argonne National Laboratory EVS, 2005). Thorium is more abundant than Uranium, which is available approximately 2 parts per million (Argonne National Laboratory EVS, 2005). Even if Uranium were more readily accessible, Thorium is more easily obtainable. As Thorium can be found in almost any rock in the world, it is certainly easier to access than absorbing it in small, expensive doses from the ocean.

Production of Thorium

Production of nuclear energy, through Uranium, is done in what is called a Light Water Reactor. The "LWR" used in Japan–or, it *was* the technology they used up until the catastrophe of 2011. Because Uranium is such an intensely radioactive element it creates high pressure and heat; those turn the water into an incredibly dense steam which then turns the turbine to generate power. However, this immense pressure is what caused the explosions at Fukushima Daiichi and Daini. The water supply which cooled the Uranium supply was cut off and the unimaginable heat exploded. This is why nuclear energy gets a bad reputation; Uranium is so volatile. Nevertheless, no two nuclear elements are the same. Thorium is quite the opposite of Uranium. Rather than extremely volatile, it is a more "mellow" element and if power to the system is cut off, the frozen salt plug (which held the Thorium) melts, and the liquid Thorium simply drains to a holding tank where it can be used later on (Sorenson, 2011). It does all of this *without human intervention.* Despite its increased safety, Thorium nuclear energy creates more energy than

U-233 does. In fact, "Thorium is so energy dense that a lifetime supply of it can be held in the palm of your hand" (Sorenson, 2011). The Molten Salt Reactor, or Liquid-Fluoride Thorium Reactor "LFTR" uses Thorium approximately two hundred times more efficiently than Uranium nuclear plants do (Barton, 2011). The nature of the LFTR uses Thorium in a liquid state (whereas a LWR uses Uranium in solid form) and yields mere fractions of waste compared to the LWR. The LFTR utilizes nearly all the waste of Thorium, and makes it cleaner than Uranium by factors of hundreds, and cleaner than Fossil Fuels by factors of millions (Sorenson, 2011).

Conclusion

As the global population grows greater every day, so does the demand for energy. People are always going to need energy. For there to be future generations, the energy we seek must be clean and sustainable. Otherwise, we will create great deficits and eventually exhaust natural resources. That does not even include the tremendous waste and hazards of using non-sustainable sources: the pollution alone can kill thousands of people, and the damaging effects can ruin crops and contaminate water, killing even more people. Renewable energies, like wind and solar, although beneficial and important, cannot supply the world the power it needs. Nuclear energy has the capability to solve energy demands, and in Thorium there is real hope. Thorium is abundant, sustainable, and a cleaner energy source than Uranium. There is more power in Thorium than fossil fuels and renewable energies. To energize our world, indeed, to save it, we must consider the "Thorium Age."

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2011/02/17, Dr. Kiki, Sorensen
2011/04/01, TEDxYYC, Sorensen
2011/05/12, TEAC3, Hargraves
2011/05/12, TEAC3, Sorensen, Dorius
2011/12/16, Google, Sorensen
LFTR in 5 minutes
Thorium REMIX 2011

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[2] Note: Kirk Sorenson has given numerous dissertations and informational speeches to a broad variety of audiences. He is currently the most well-known advocate of Thorium. He is a reliable source of information on Thorium.