Thinking About Thorium

by Gordon Edwards, Ph.D., President of CCNR, September 16 2012

On CBC's "Quirks and Quarks" radio program aired on Saturday, September 15, 2012, there was an enthusiastic endorsement of "thorium reactors" as a nearly miraculous form of nuclear energy that will avoid all of the major problems now associated with uranium-based nuclear power.

I have been asked by several people to give my own personal opinion of this prospect, and accordingly have written the following:

Background:

When nuclear power was first presented to a credulous public, fully conditioned to respect science and admire scientists, people were quick to believe that nuclear power was safe, clean, cheap and inexhaustible -- just because scientists said so. It was also said that "peaceful" nuclear power had nothing whatsoever to do with atomic bombs and the proliferation of nuclear weapons.

It took decades for people to realize that these are all lies.

I can't believe that people are now so eager to swallow the hype about thorium with all its over-the-top claims of being safe, clean, cheap, inexhaustible, unrelated to nuclear weapons, and even a miraculous way of solving the nuclear waste problems created by the previous generation of -- what? -- safe, clean, cheap, inexhaustible, unrelated to nuclear weapons, nuclear reactors.

As the old saying goes, "once burned, twice shy". Or more explicitly, "Fool me once, same on you. Fool me twice, shame on me."

If thorium was such a good idea then its promoters would be more willing to tell the truth rather than to spin fairy tales about it.

Fairy Tale #1. "Thorium is a nuclear fuel."

False. Thorium is NOT a nuclear fuel. Fill the interior of ANY nuclear reactor with fuel assemblies made of thorium, and absolutely nothing will happen. Because thorium is not a "fissile" material -- it cannot sustain a nuclear chain reaction, no matter what.

The truth is that uranium-233 is a fissile material that can be used either as fuel for a nuclear reactor or as the explosive material in a nuclear weapon. (The USA

exploded an atomic bomb made from uranium-233 more than half a century ago, in 1955.)

But uranium-233 does not exist in the natural world. It can only be created by bombarding thorium-232 with neutrons. When a thorium-232 atom absorbs a neutron it becomes transmuted into a uranium-233 atom.

So the bottom line is that thorium (meaning thorium-232) is not a nuclear fuel nor is it a nuclear explosive, but it can be used as a raw material to produce uranium-233 which is both a nuclear fuel and a nuclear explosive.

It seems to me that if thorium proponents want to be believed, they should explain these simple facts to people right away instead of "preying on their ignorance" by telling them untruths.

Fairy Tale #2. "The use of thorium as a "nuclear fuel" [sic] has nothing to do with nuclear weapons or nuclear explosive materials."

This is wrong in several ways.

As already mentioned, thorium has to be converted into uranium-233 before "it" can be used as a nuclear fuel -- so already we have a link with nuclear weapons. While uranium-233 does have some disadvantages as a nuclear explosive material (mainly due to the presence of gamma radiation) it also has some terrific advantages for the would-be bomb-maker.

The main advantage is that uranium-233 is 100% enriched whereas naturally-occurring uranium-235 is NEVER 100% enriched. The higher the degree of enrichment, the more powerful the nuclear explosive.

But nuclear weapons are involved at the very BEGINNING of thorium reactors, because you cannot get the thorium reactor started without mixing the thorium with some weapons-explosive material -- either plutonium or highly enriched uranium. That means that you cannot even START using thorium for energy unless you first either (1) separate plutonium from irradiated nuclear fuel using reprocessing technology, as North Korea has done for example (and used the plutonium in nuclear weapons), or (2) produced highly enriched uranium in a uranium enrichment facility as Iran has done, much to the consternation of the rest of the world,

Yeah! Let's hear it for "peaceful" thorium reactors!

Fairy Tale #3, 4, 5, ... A thorium reactor cannot undergo a catastrophic accident, will not produce very much nuclear waste, will reduce the "storage time" from millions of years to hundreds of years, etc, etc.

These are all profoundly misleading exaggerations. Any bomb dropped on a thorium reactor will result in a catastrophic accident. Thorium reactors produce high-level radioactive waste just like today's reactors, and although the proportions of various radio- nuclides may be substantially different, there is NO WAY that a thorium reactor will eliminate all radioactive elements having half-lives measured in the tens of thousands of years.

Thorium is an old idea that has been promoted many times in the past. In 1977, Atomic Energy of Canada Limited urged the Canadian government to invest billions of dollars in thorium reprocessing technology of nightmarish proportions. This is documented on the CCNR web site --

see http://www.ccnr.org/AECL_plute.html [my account]
and http://www.ccnr.org/aecl_plute_seminar.html [industry's plan]

The moral of this story is: don't be too eager to buy a pig in a poke, especially when you have heard this kind of exuberant nuclear sales pitch before -- and you know how THAT turned out!

Gordon Edwards.

P.S. Here's what I wrote on this subject a year ago....

GE

Thorium Reactors:
Back to the Dream Factory

by Gordon Edwards, Ph.D., President of CCNR, July 13, 2011

The Nuclear Dream Factory

Every time a nuclear power reactor idea doesn't work out, and ordinary people get down-hearted and even start to doubt the magnificence andbenificence of nuclear energy, the nuclear proponents rush back to their well-stocked dream factory to fetch another idea -- one that issufficiently unfamiliar and sufficiently untested that ordinary people have no idea whether it is good or bad, safe or

dangerous, feasible or foolish, or whether the almost miraculous claims made about it are true or false.

Just a few years ago, nuclear proponents were pushing Generation 3 reactors -- enormous plants that would generate huge amounts of electricity, yet be cheaper and faster to build than earlier models, as well as being safer and longer-lived.

Then Areva ran into a blizzard of problems trying to build one of these behemoths in Finland -- the cost soaring by billions of dollars, the construction time extended by years, and fundamental safety-related design problems surfacing late in the game. Check and mate.

Undaunted, nuclear proponents quickly executed a 180-degree turn and are now promoting small reactors which can be mass- produced by the thousands and sprinkled on the landscape like cinnamon on toast. Pebble-bed reactors, molten-salt reactors, thorium reactors, have been paraded before the public with as many bells and whistles as the nuclear industry can muster, to distract people's gaze away fromthe construction fiascos, the litany of broken promises from the past, the still-unsolved problems of nuclear waste and weapons proliferation, and the horror that is Fukushima.

The following paragraphs are written to dispel some of the mystique surrounding the idea of "thorium reactors" -- a very old idea that is now being dressed up in modern clothes and made to seem like a major scientific breakthrough, which it is not.

Thorium is not a nuclear fuel

The fundamental fact about thorium is that it is NOT a nuclear fuel, because thorium is not a fissile material, meaning that it cannot sustain a nuclear fission chain reaction.

In fact the ONLY naturally occurring fissile material is uranium-235, and so -- of necessity --that is the material that fuels all of the first-generation reactorsin the entire world. Thorium cannot replace uranium-235 in this regard. Not at all.

Thorium is a "fertile" material

But thorium-232, which is a naturally occurring radioactive material, is about three times as abundant as uranium-238, which is also a naturally occurring radioactive material. Neither of these materials can be useddirectly as a nuclear fuel, because they are not "fissile" materials.

However, both uranium-238 and thorium-232 are "fertile" materials, which means that IF they are placed in the core of a nuclear reactor (one that is of necessity fuelled by a fissile material), some fraction of thosefertile atoms will be transmuted into man-made fissile atoms.

Some uranium-238 atoms get transmuted into plutonium-239 atoms, andsome thorium-232 atoms get transmuted into uranium-233 atoms.

Both plutonium-239 and uranium-233 are fissile materials which are not naturally-occurring. They are both usable as either fuel for nuclear reactors or as nuclear explosive materials for bombs.

(The USA exploded an atomic bomb made from U-233 in 1955.)

Reprocessing of irradiated nuclear fuel

In general, to obtain quantities of plutonium-239 or uranium-233, it is necessary to "reprocess" the irradiated material that started out as uranium-238 or thorium-232. This means dissolving that irradiated material in acid and then chemically separating out the fissile plutonium-239 or uranium-233, leaving behind the liquid radioactive wastes which include fission products (broken pieces of split atoms, including such things as iodine-131, cesium-137, strontium-90, etc.) and other radioactive waste materials called "activation products" and "transuranic elements"

Reprocessing is the dirtiest process in the entire nuclear fuel chain, because of the gaseous radioactive releases, liquid radioactive discharges, and large quantities of highly dangerous and easily dispersible radioactive liquids. Reprocessing also poses great proliferation risks because it produces man-made fissile materials which can be incorporated into nuclear weapons of various kinds by anyone who acquires the separated fissile material.

Advanced Fuel Cycles and Breeders

"Any nuclear reactor-fuelling regime that requires reprocessing, or that uses plutonium-239 or uranium-233 as a primary reactor fuel, is called an "advanced fuel cycle". These advanced fuel cycles are intimately related with the idea of a "breeder" reactor -- one which creates as much or more fissile material as a byproduct than the amount of fissile material used to fuel the reactor.

So it is only in this context that thorium reactors make any sense at all -- like all breeder concepts, they are designed to extend the fuel supply of nuclear reactors and thus prolong the nuclear age by centuries.

The breeder concept is very attractive to those who envisage a virtually limitless future for nuclear reactors, because the naturally occurring uranium-235 supply is not going to outlast the oil supply. Without advanced fuel cycles, nuclear power is doomed to be just a "flash in the pan".

Thorium reactors are most enthusiastically promoted by those who see "plutonium breeders" as the only other realistic alternative to bring about a long-lived nuclear future. They think that thorium/uranium-233 is a better fate than uranium/plutonium-239.

They do not see a nuclear phaseout as even remotely feasible or attractive.

"Molten Salt" reactors

Molten salt reactors are not a new idea, and they do not in any way require the use of thorium -- although historically the two concepts have often been linked.

The basic idea of using molten salt insteadof water (light or heavy water) as a coolant has a number of distinctadvantages,chief of which is the ability to achieve much highertemperatures(650 deg. C instead of 300 deg. C) than with watercooled reactors,and at a much lower vapour pressure.

The higher temperature meansgreaterefficiency in converting the heat into electricity, and the lowerpressure means less likelihood of an over-pressure rupture of pipes,and less drastic consequences of such ruptures if and when they do occur.

Molten salt reactors were researched at Oak Ridge Tennessee throughout the 1960s, culminating in the Molten Salt Reactor Experiment (MSRE), producing 7.4 megawatts of heat but no electricity. It was an early prototype of a thorium breeder reactor, using uranium and plutonium as fuels but not using the thorium blanket which would have been used to "breed" uranium-233 to be recovered through reprocessing -- theultimate intention of the design.

This Oak Ridge work culminated in the period from 1970-76 in a design for a Molten Salt Breeder Reactor (MSBR) using thorium as a "fertile material" to breed "fissile" uranium-233, which would then be extracted using a reprocessing facility.

Molten Salt Thorium reactors without reprocessing?

Although it is theoretically possible to imagine a molten-salt reactor design where the thorium-produced uranium-233 is immediately used as a reactor fuel without any actual reprocessing, such reactor designs are very inefficient in the

"breeding" capacity andpose financial disincentives of a serious nature to any would-be developer. No one has actually built such a reactor or has plans to build such a reactor because it just isn't worth it compared with those designs which have a reprocessing facility.

Here's what Wikipedia sayson this matter (it happens to be good info):
[http://en.wikipedia.org/wiki/Molten_salt_reactor **]**

To exploit the molten salt reactor's breeding potential to the fullest, the reactor must be co-located with a reprocessing facility. Nuclear reprocessing does not occur in the U.S. because no commercial provider is willing to undertake it. The regulatory risk and associated costs are very great because the regulatory regime has varied dramatically in different administrations.[20]UK, France, Japan, Russia and India currently operate some form of fuel reprocessing.

Some U.S. Administration departments have feared that fuel reprocessing in any form could pave the way to the plutonium economy with its associated proliferation dangers.[21]

A similar argument led to the shutdown of the Integral Fast Reactor project in 1994.[22]The proliferation risk for a thorium fuel cycle stems from the potential separation of uranium-233, which might be used in nuclear weapons, though only with considerable difficulty. Currently the Japanese are working on a 100-200 MWe molten salt thorium breeder reactor, using technologies similar to those used at Oak Ridge, but the Japanese project seems to lack funding.

Thorium reactors do not eliminate problems

The bottom line is this. Thorium reactors still produce high-level radioactive waste, they still pose problems and opportunities for the proliferation of nuclear weapons, they still pose catastrophic accident scenarios as potential targets for terrorist or military attack, for example.

Proponents of thorium reactors argue that all of these risks are somewhat reduced in comparison with the conventional plutonium breeder concept. Whether this is true or not, the fundamental problems associated with nuclear power have by no meansbeen eliminated.

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