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Responses to Solicitation of Recommendations

The following documents were submitted to the Committee on High-Level Radioactive Waste (*Nevada Revised Statutes* 459.0085) in response to Committee Chair David R. Parks' Solicitation of Recommendations memorandum dated June 20, 2012. The Committee did not act on any of the submitted recommendations; they are posted here for informational purposes only.

Board of County Commissioners
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July 2, 2012

Mr. Patrick Guinan
Principal Research Analyst
Legislative Counsel Bureau
401 South Carson Street
Carson City, Nevada 89701-4747

RE: Recommendations for Consideration by the Nevada Legislative Committee on High-Level Radioactive Waste

Dear Mr. Guinan:

Pursuant to the June 20, 2012 request from Senator David Parks, Chairman of the Nevada Legislative Committee on High-Level Radioactive Waste, Lincoln County is pleased to provide the following recommendations for consideration by the Committee during its July 13, 2012 meeting and work session. By way of background, Lincoln County is one of three units of local government originally designated by the Secretary of Energy as "affected" by the proposed Yucca Mountain geologic repository system pursuant to the Nuclear Waste Policy Act, as amended. Since 1984, Lincoln County has sought to understand and minimize the adverse impacts and risks and to understand and maximize any beneficial economic opportunities associated with the proposed Yucca Mountain repository system, including transportation. As you may be aware, the Department of Energy (DOE) has identified rail as its preferred mode of transportation and has selected the Caliente rail alignment to move spent nuclear fuel and other high-level radioactive waste from the Union Pacific mainline railroad across Lincoln, Esmeralda and Nye counties to the proposed Yucca Mountain repository site.

Given the great deal of uncertainty which remains as to whether the Yucca Mountain repository system will yet be developed, Lincoln County continues to exercise its fiduciary responsibility to monitor Yucca Mountain related developments in the policy, legal and technical arenas. The Nevada Legislature's Committee on High-Level Radioactive Waste is encouraged to do the same.

During the past 28 years, Lincoln County has sponsored over 85 Yucca Mountain related impact and mitigation planning studies covering a diverse range of topics including economic and fiscal impacts; demographic impacts; transportation safety; risk management and risk perception; community development; impacts to tourism; and impacts to local institutions; and opportunities for mitigating impacts and maximizing repository system economic benefits. In addition, over the years, Lincoln County has provided extensive written and oral testimony and comments on Yucca

Mountain repository system matters. I have enclosed a bibliography of research sponsored by Lincoln County. These documents may be accessed through the Lincoln County Repository Oversight Program website at: www.lcnop.com. I would encourage the Committee to utilize the extensive knowledge-base that has been developed and acquired by Lincoln County as you deliberate the appropriate Nevada Legislative response to nuclear waste management in the United States, particularly as said management may bear upon the health, safety and economic welfare of Nevada's residents.

The following recommendations for action by the Nevada Legislative Committee on High-Level Radioactive Waste are offered to assist the Committee in taking appropriate actions to understand and minimize the adverse impacts and risks and to understand and maximize any beneficial economic opportunities associated with the proposed Yucca Mountain repository system, including transportation.

1. The DOE is currently reviewing the recommendations of the Blue Ribbon Commission on America's Nuclear Future and devising a proposed new approach to siting, designing, permitting, constructing and operating both interim and permanent systems, including transportation, for storage and disposal of spent nuclear fuel and other high-level radioactive waste. A draft report from the DOE in this regard is expected in late July 2012. **The Nevada Legislative Committee on High-Level Radioactive Waste should submit a letter to the DOE providing the following recommendations for consideration of the Department as it prepares its draft and final nuclear waste storage and disposal plans**:

a. To ensure that the next generation is not saddled with the responsibility for resolving the nuclear waste issue, the DOE's new storage and disposal plans must provide for resolution of the nuclear waste management issue in the next 10-15 years.

b. Given failure of past local consent-based approaches to siting nuclear waste storage and disposal facilities in the United States (which did not offer any significant incentives), and recognizing the key role that states and their elected and appointed officials can and have played in confounding the siting of nuclear waste facilities to which local government has offered its consent, the DOE's new storage and disposal plans must not propose to employ or assume the success of consent based siting, particularly at the local and state level, which does not offer significant and meaningful financial incentives.

c. If the DOE is intent on proposing consent based siting, significant financial incentives must be provided to consenting local and state governments. The level of incentives must reflect the annual opportunity cost to the Nation of not developing permanent disposal capabilities. For each year that a permanent geologic disposal capacity is not available, the cost to ratepayers and U.S. taxpayers is estimated at $400 - $500 million. If the availability of incentives for hosting a repository for nuclear waste will speed siting, designing, permitting, constructing and operating both interim and permanent systems, including transportation, for storage and disposal of spent nuclear fuel and other high-level radioactive waste by 5 years, then the level of incentives to be offered to host state and local governments should be on the order of 2 to 2.5 billion dollars.

2. **The Nevada Legislative Committee on High-Level Radioactive Waste should submit a letter to the Nevada Congressional Delegation to encourage them to seek FY 2013 federal Nuclear Waste Fund funding to enable continued participation by the State of Nevada and affected units of local government (designated by the Secretary of Energy pursuant to the NWPA)** The House Appropriations Committee has passed H. 5325, the Energy and Water Appropriations Act and has provided $25,000,000 to the DOE to continue Yucca Mountain licensing and development initiatives during FY 2013. Of this amount, $5,000,000 has been set aside for use by affected units of local government which have formally provided consent to the Secretary of Energy to host a high-level radioactive waste repository as authorized by the NWPA. In addition to Nye County, the State of Nevada and several other Nevada counties which have

been designated as "affected" by the Secretary of Energy (Clark, Churchill, Esmeralda, Eureka, Lander, Lincoln, Mineral and White Pine) have admitted contentions pending before the Nuclear Regulatory Commission (NRC) and/or have been otherwise admitted to the NRC's Yucca Mountain licensing proceeding as Interested Governmental Participants. FY 2013 federal Nuclear Waste Fund funding is required by these Nevada counties to participate in the NRC's Yucca Mountain licensing proceedings in the event said proceedings are restarted during FY 2013 (an outcome which might result from voluntary action by the Nuclear Regulatory Commission; federal court decisions or Congressional directive).

3. **The Nevada Legislative Committee on High-Level Radioactive Waste should submit a letter to the Nuclear Regulatory Commission encouraging the Commission to resume and complete the Yucca Mountain licensing proceedings to enable the Nation to benefit from the lessons which would be learned from such a licensing endeavor and to position the Nation to more expeditiously resolve the nuclear waste storage and disposal issue.** Failure to complete licensing generally ignores Yucca Mountain lessons learned in the past and additional valuable information which can be gained from completing the temporarily suspended licensing proceeding before the Nuclear Regulatory Commission.

I trust these recommendations to be of assistance as the Nevada Legislative Committee on High-Level Radioactive Waste frames its recommendations for action. Should you have any questions regarding these recommendations, please do not hesitate to contact me or Ms. Connie Simkins, Coordinator of the Lincoln County Repository Oversight Program (775) 726-3511.

Sincerely,

George T. Rowe

George T. Rowe
Chairman

Nye County

Nuclear Waste Repository Project Office

2101 E. Calvada Blvd., Ste. #100 · Pahrump, Nevada 89048
(775) 727-7727 · Fax (775) 727-7919

12-087-WM (L)

July 3, 2012

To: Senator David Parks, Chair, Nevada's Legislative Committee on High-Level Radioactive Waste (*Nevada Revised Statutes* [NRS] 459.0085)

From: Nye County, NV

Subject: **Solicitation of Recommendations**

The Nye County NWRPO respectfully suggests that the Committee on HLRW ask for a briefing from DOE to help understand how the administration and Congress intend to implement the Blue Ribbon Commission on America's Nuclear Future (BRC), specifically the recommendation to establish "*A NEW CONSENT-BASED APPROACH TO SITING.*"

Background/Facts:

- Nevada's opposition to implementation of the nation's geologic disposal program at Yucca Mountain is well known to the members of the NV Legislative Committee on HLRW and the BRC and was incorporated into the BRC's recommendations.
- The Nuclear Waste Policy Act of 1982 and the 1987 Amendment remain the law of the land. Consistent with the NWPA, the Secretary of Energy formally selected Nevada as the site for the nation's first Nuclear Waste Repository. This has not changed.
- The court case challenging the administration's efforts to terminate the Yucca Mountain Program (YMP) may force the Administration to restart the licensing process.
- Regardless of any decisions on the YMP, the requirement for a repository exists.
- The BRC report includes at least two recommendations of significant interest to Nevada;
    - Prompt efforts to develop one or more geologic disposal facilities, and
    - A new consent-based approach to siting future nuclear waste management facilities that would include ***"...a flexible and substantial incentive program."***

The full text of the January 2012 BRC report can be found on the world wide web at: www.brc.gov

Nye County believes that the repository can be constructed and safely operated subject to Nuclear Regulatory Commission regulations applicable to the repository. We believe it imperative that elected officials representing the interests of Nevada's citizens have the benefit of the results of the NRC review of the YM License Application and, relative to the BRC recommendations, that they know and understand what saying yes or no means to all of us. The opportunity to negotiate for benefits will be an essential part of the consent based process regardless of the location of disposal. The attached white paper spells out a broad framework for consideration if and when a "consent based process" is implemented.

Specific Recommendation: The Nevada Legislative Committee on High Level Radioactive Waste join Nye County in asking the Federal Government to be included in a formal process to reach consent. The Committee should recommend a process for how the State of Nevada will participate when the state gets the opportunity to negotiate for benefits in the BRC consent-based approach to siting a repository.

Respectfully,
Nye County NWRPO, Nevada

Darrell Lacy
Director NWRPO

DL/wm

Attachment: Benefits White Paper, June 2012

cc: Nye County BOCC
Nye County Manager

A White Paper: The Macro Perspective
(Safeguards, Equity issues and Benefits)
July 2012

It is entirely possible that the Yucca Mountain project will "restart". If it does, Nevada needs to be prepared to advance its interests. In that regard Nye County suggests that we put in place:

*1. **An intervention process*** that includes substantive local and State participation in oversight of the repository, including at least limited influence in NRC's "stop work" authority within the construct of NRC safety oversight and the quality assurance programs.

*2. **A monitoring process:*** at the hand of Nevada's Universities that would focus on public health and environmental monitoring activities designed to provide long-term protection for the site county, the State, and potentially affected residents.

*3. **The Consent Based Siting process can address these benefits/impact mitigation issues*** : This process could be addressed in four major areas:

- ***Water:*** The western watershed allocation of water resources, coupled with desalinization plants on the California coast, could be revised to provide more Colorado River water to Nevada eliminating the need for the SNWA pipeline from northern Nevada.
- ***Land transfers:*** Eighty-seven percent of Nevada is managed by the federal government. That percentage could be modified to allow more State and private ownership with mutual consent in the enabling legislation needed to construct the repository.
- ***Program implementation activities:*** Implementation of the program is planned to include building a railroad, highways and the repository itself. Activities associated with these efforts could be privatized, portions or all of the work could be directed to state/county/community enterprises and the local governments and the state of Nevada can have input to maximize benefits to the citizens of Nevada. Examples would be a through going rail line that avoids shipping radioactive waste through Las Vegas but would provide a commercial connection from Las Vegas to Reno. Another example would be implementing the Interstate 11 corridor from Phoenix to Vegas then to Reno.
- ***Direct payments:*** The existing NWPA included provisions for direct cash payments. That potential remains, but should be negotiated for higher levels as follows:
  - Include the nuclear industry in the process to find a way to resolve the existing litigation that has a current estimated Federal taxpayer liability of $500 million per year to taxpayers
  - Provide Nevada and its local communities between $200 million and $500 million per year to accept the burden of hosting the repository
  - If necessary, increase the 1/10 of a cent fee per kilowatt-hour of nuclear generated electricity by 50% to generate an additional $375 million per year to cover the cost of incentive

It is our opinion that Nevadans deserve a more complete understanding of everything that is at stake relative to the State's continued opposition to the nation's repository program at Yucca Mountain. The fate of Yucca Mountain is directly tied to pending court cases, the FY2013 appropriations process and the next election. Nevada has already given up over 2,000 high paying jobs, millions of dollars in Payments Equal to Taxes (PETT) and millions of dollars in oversight funds. At last count by DOE, YM is nearly a $100 billion program that is Nevada's for the taking.

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Office of the Governor

August 13, 2012

Senator David Parks, Chairman
Committee on High-Level Radioactive Waste
State of Nevada Legislature
401 S. Carson Street
Carson City, NV 89701

Dear Senator Parks:

It has come to my attention that the Legislature's High-Level Radioactive Waste Committee recently received suggestions from Nye and Lincoln counties regarding recommendations the Committee might make to the full Legislature. Those suggestions include, among other things, offering to have the State of Nevada participate in a national process to reach consent and obtain benefits for hosting a repository and/or spent fuel storage site and urging the U.S. Nuclear Regulatory Commission to complete the licensing proceeding for Yucca Mountain.

As you know, I wrote to Secretary of Energy Steven Chu in March of this year, to inform him that the State of Nevada remains completely opposed to storage and disposal of spent nuclear fuel and/or high-level radioactive waste in Nevada. Since 1985, Nevada Governors and the Nevada Legislature have been on record as strongly opposing the proposed Yucca Mountain project. This consistent, united and bipartisan opposition has been essential to the state's success in halting the ill-conceived repository project and keeping tens of thousands of tons of spent nuclear fuel and high-level radioactive waste out of our state.

Studies by the State of Nevada and others over the past three decades have shown that Yucca Mountain is an unsafe place for disposing of dangerous spent nuclear fuel and other highly radioactive wastes because the site is incapable of isolating the waste from people and the environment for the extremely long time period necessary.

Suggestions by Nye County, Lincoln County, and others who advocate the acceptance of benefits in exchange for going along with the importation of high-level nuclear waste into Nevada for storage, disposal, reprocessing, or any other activity would have the state capitulate on this issue at a time when Nevada is on the verge of prevailing, once and for all, in stopping the Yucca program.

Last January, the Blue Ribbon Commission on America's Nuclear Future issued its final report containing recommendations for moving ahead with alternative approaches to Yucca Mountain. Those recommendations include the requirement that any future facility siting efforts have the voluntary consent of the prospective host state. That recommendation grew directly out of lessons learned from the failed Yucca project and Nevada's strong and unyielding opposition to it. The requirement for state consent effectively means the end of the proposed Nevada repository project. Now is emphatically not the time for a legislative committee to signal any change in Nevada's position or take any action that could be interpreted as weakening state opposition.

I urge the High-Level Radioactive Waste Committee to reject all calls for accommodation on the part of Yucca supporters and others who believe the state might somehow benefit from capitulating. The only recommendation that should issue from the Committee is one that urges the Legislature to stay the course and continue to strongly oppose the proposed Yucca Mountain repository program and any other initiative that would involve the importation of spent fuel or high-level waste into Nevada.

Thank you for your attention to this very important matter.

Sincere regards,

BRIAN SANDOVAL
Governor

cc: Robert Halstead, Nuclear Projects Office

WASTE-TO-ENERGY PROPOSAL FOR YUCCA MOUNTAIN

Occupy Carson City asks that the Committee on High-Level Nuclear Waste learn about and give your support for the implementation of Liquid Fluoride Thorium Reactors (LFTRs) as a solution for our energy needs, a disposal method of conventional nuclear waste, a productive use for the Yucca Mountain site, and a source of much needed employment opportunities.

Long have the people of Nevada been opposed to nuclear energy, due to its potential for arms development and its hazardous waste. However, recently we have become aware of another alternative for safe, inexpensive and independent energy: thorium and Liquid Fluoride Thorium Reactor (LFTR) technology. The most important aspect of this new technology for Nevada is that certain configurations of LFTRs can consume the long lived radioactive elements in our present stockpiles of nuclear waste.

The US Federal government could build a Liquid Fluoride Thorium Reactor (LFTR) in Nevada at the Yucca Mountain site. The LFTR is a safer choice than storing the waste as it exists for ten-thousand years. California's nuclear waste would be fed to the Nevada reactor with minimal reprocessing. The reactor consumes the waste and converts it to carbon-free electricity, eliminating issues of long-term storage. The excess capacity could go to Las Vegas or sold to neighboring states. Moreover, this technology is scalable. Reactors could be miniaturized and made modular to be mass produced in factories. Units could then be shipped to existing Light Water Reactor (LWR) sites and consume the waste where it now rests, avoiding any future transportation issues. Nevada will be at the forefront of green energy technology with our vast expanses of sunlight, wind, geothermal energy, and now green nuclear technology.

This is not a new idea. In 2008, Senator Reid and Senator Hatch sponsored S-3060, a bill to amend the Atomic Energy Act of 1954 to provide for thorium fuel cycle nuclear power generation. The bill was not able to advance through the legislative process; nevertheless, this is an issue that is too important to ignore. With the disaster at Fukushima, the creeping threat of global climate change, and our precarious over-reliance on foreign energy, there is no better time than now to present a new direction for the state of Nevada and the United States of America.

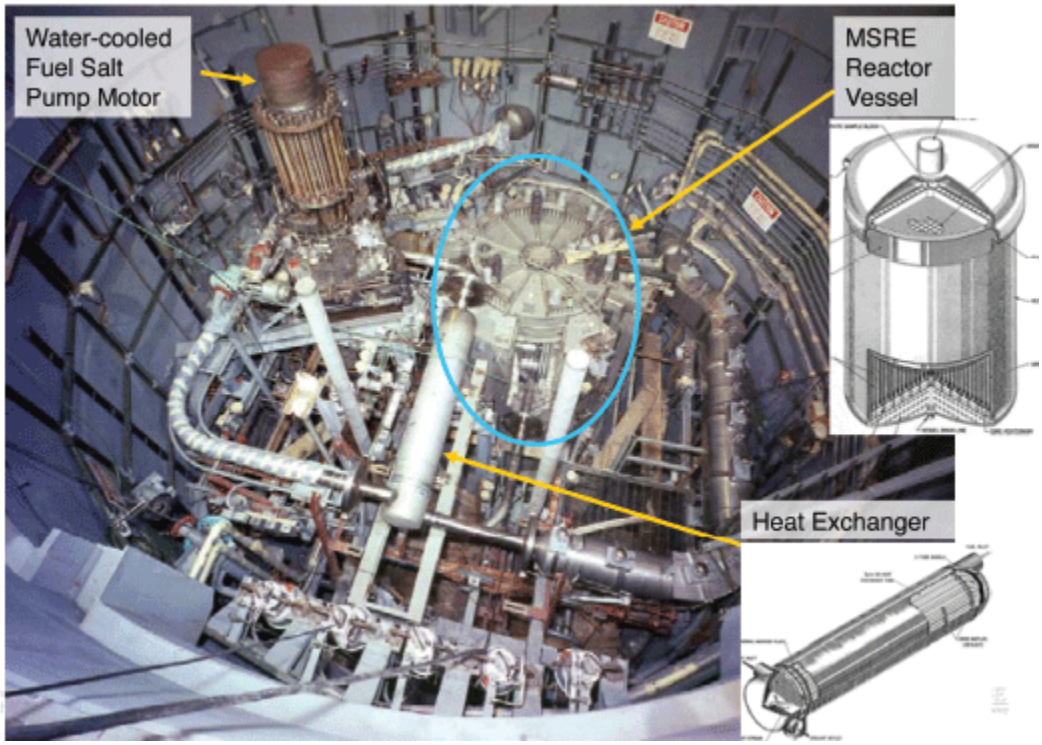
Please become informed about thorium energy and LFTRs, and consider our proposal. Thank you for your time, consideration, and the hard work you have done for the people of Nevada.

A Worldwide Energy Solution America Can Supply

Dr. William H. Thesling, Ph.D. July 2012

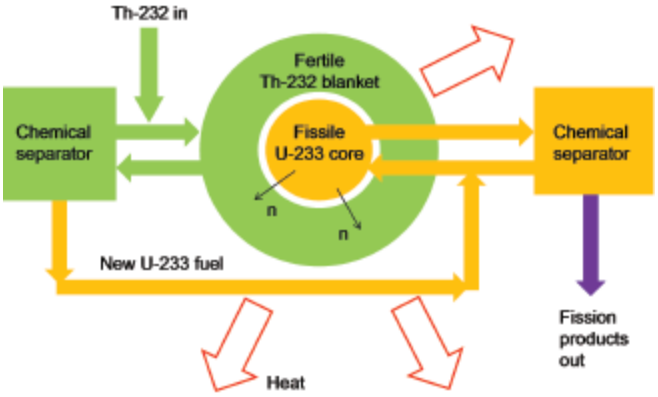
Stored solar energy is how one can think about all types of fossil fuels. Plants convert solar radiation (light) energy into chemical energy through photosynthesis. Layers of plant matter build up and, throughout millions of years, it converts into coal, oil, and natural gas.

It is noteworthy to point out that in 2011, 474 exaJoules of energy was used by the first world, or about 2 billion people – depending on how one defines the first world. This is equivalent to 449 quadrillion BTUs, representing all forms of energy combined (coal, oil, gas, nuclear, hydro, etc.). This is roughly equivalent to 15 billion tons of coal. If we wish to bring the other 5 billion people up to a first world standard of living, we would need to increase this energy production rate by three to five times, ignoring any advances in efficiency. If we wish to increase the standard of living beyond that of where the first world is today, bringing the energy per capita for everybody on the earth to twice that of the present level in the United States, we might need 10 times this rate of energy production. Achieving this with fossil fuels would be challenging to say the least. Even if one does not believe in climate change, consuming fossil fuels at 10 times the present rate should, at least, make one rethink that position.



Often considered the ultimate in renewable energy is solar energy. However, the world's energy requirements are huge. If we wanted to meet all of the world's energy needs with solar power alone, we would need a solar array that was a square, 280 miles on a side, an area approaching twice the size of the state of Ohio. Wind energy might help (wind is another form of solar energy), but it is doubtful solar energy will supply more than a small percentage of our energy needs for quite some time. Still, advances in solar cell technologies, and wind turbines, may result in solar energy being competitive with fossil fuels someday.

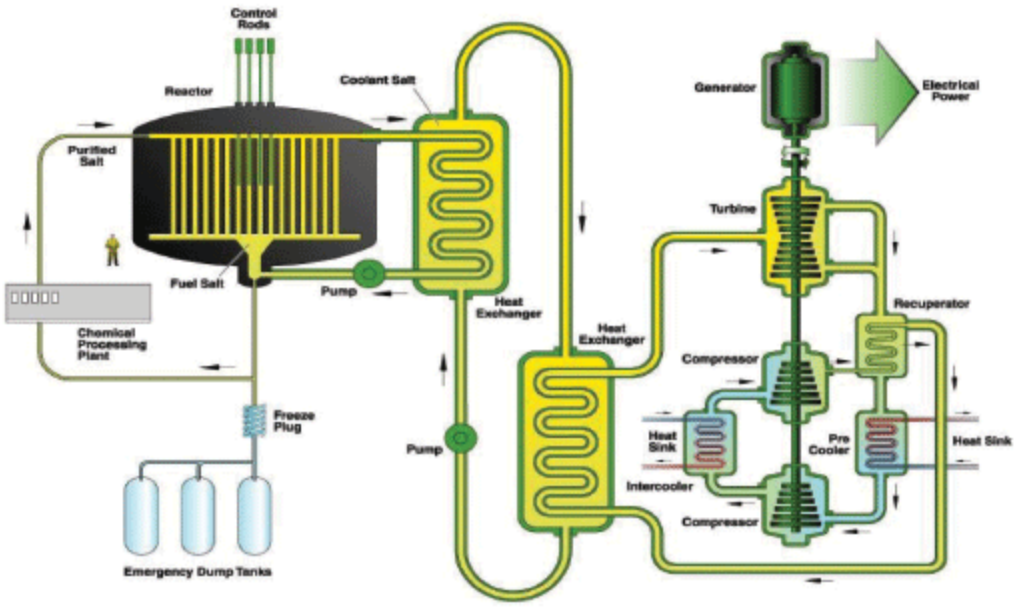
Let us aim high and ask: How can we raise the standard of living (more specifically, energy per capita) for everybody on planet Earth to U.S. levels, and increase that level by a factor of two? Also, let us achieve this without greenhouse gas emissions. To achieve this, we will almost certainly require a source that is very energy dense and available at a low cost.



Nuclear energy has one very significant advantage over all forms of fossil fuels (as well as all other forms of energy). Theoretically, nuclear energy has an energy density that exceeds that of fossil fuels by a factor of one million. The ramifications of this are enormous and cannot be overstated. If you want to have energy in abundance you need to give nuclear energy a serious look. Present day nuclear power plants consume (or burn) an isotope of Uranium, U-235. Only 0.7% of natural Uranium is U-235. The other 99.3% of Uranium is U-238. Conversion of U-238 to Plutonium-239 is through a process called breeding, where Plutonium-239 can then burn as fuel. There have been significant efforts during the past 60 years to build reactors that breed and burn Pu-239 (Liquid Metal Fast Breeder Reactors) but these have met with limited success. However, another element exists that can be bread into a consumable fuel. That element is Thorium, which can be bread into Uranium-233, also consumable nuclear fuel.

Back in the 1950s and 60s there was a significant effort to develop reactors to consume and breed U-233 from thorium. This occurred at Oak Ridge National Labs under the direction of the lab's director, Alvin Weinberg (en.wikipedia.org/wiki/Alvin_M._Weinberg). Interestingly, Weinberg is the patent holder of the light water reactor (LWR), the predominant type of nuclear power reactor used in the world today. At the dawn of the nuclear era, nearly all nuclear scientists and engineers, including Weinberg, considered nuclear power based on the consumption of U-235 as a stopgap measure. The real promise of nuclear power was to be with breeder reactors. Here, arguably, history took a wrong turn. Two methods of breeding nuclear fuel exist: Method 1 – The breeding of Pu-239 from U-238 and Method 2 – The breeding of U-233 from Th-232. Pursuit of Method 2 was not to the degree it merited. The reason's Method 1 was more vigorously pursued ahead of Method 2 were partially technical but mostly political (whitehousetapes.net/transcript/nixon/004-027). However, despite receiving only a tiny fraction of the funding of Method 1, the work done at Oak Ridge demonstrated the feasibility of breeding U-233 from Thorium as well as burning U-233 in Molten Salts. These molten salts serve as a carrier fluid for both Thorium and Uranium. The resulting design has been coined the Liquid Fluoride Thorium Reactor or LFTR. Below is a simplified LFTR diagram.

MSR lives on as a Gen-IV Concept with International Interest



In a LFTR, fission takes place in a liquid core. Fission generates heat that ultimately finds use to do some useful work (e.g. drive a turbine to make electricity). Surrounding the core is a blanket of liquid carrying Thorium. Neutrons from fission pass from the core to the blanket for absorption by the Thorium. This transforms the Thorium to Uranium-233. After chemical removal of the Uranium-233 from the blanket, it goes into the core as new fuel. Next is the chemical removal of the fission products from the core. The process is self-sustaining, requiring only Thorium as input.

A LFTR was never build at ORNL. However, they did build and operate the Molten Salt Reactor Experiment (MRSE) for four years (en.wikipedia.org/wiki/Molten-Salt_Reactor_Experiment) from 1965 through 1969. This reactor generated 7.5 Megawatts of heat, allowing the scientists to determine the design parameters and work through system issues to arrive at a design that allows for the burning nuclear fuel in molten salts. The MSRE worked out nearly all key issues needed to build a LFTR.

The MSRE demonstrated:

1. The burning of both U-235 as well as U-233 in a carrier salt of LiF-BeF2-ZrF4-UF4
2. Operation at high temperature (650°C) at full power for more than one year
3. Operation at atmospheric pressure
4. That carrier salts were impervious to radiation damage

5. The carrier salt chemistry and metals metallurgy to eliminate corrosion

6. An efficient method of on-line refueling

7. Largely validated predictions

The MSRE did not:

1. Have a blanket to breed U-233 from Thorium (therefore, it was not a complete LFTR)

2. Have the size of a utility class power plant, (this was the next step before funding ceased)

3. Have a power conversion system to generate electricity

Conventional Nuclear Power suffers from two key issues: spent nuclear fuel or nuclear waste and costs of plant construction. Significant mitigation of both of these issues is with a LFTR.

Owing to the LFTRs liquid core, fuel stays in the core until consumption. This increases the fuel efficiency enormously, by a factor of 30 or more. So, there is much less production of waste. Moreover, because there is U-233 and almost no U-238 in the core, a LFTR produces almost no transuranics, which are the reason for the long storage (300,000-year storage and Yucca Mountain). The result is that compared to conventional nuclear energy, a LFTR produces less than 1% of the waste, and that waste needs to be stored for a much shorter period (300 years).

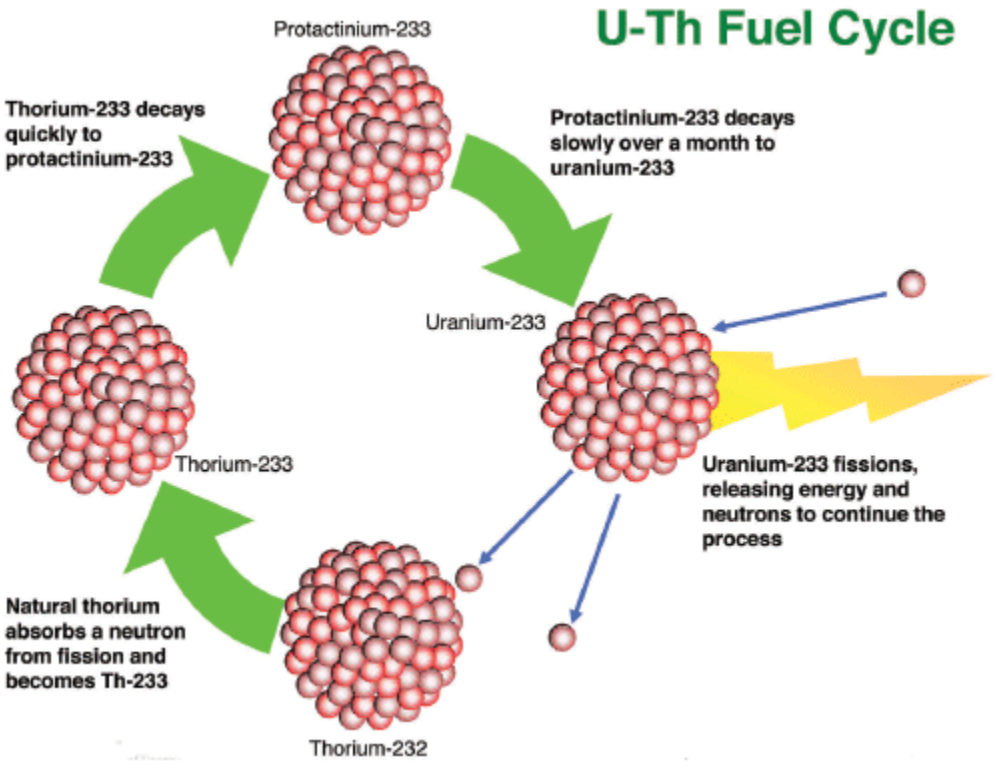
Conventional nuclear power plant costs are driven by safety issues along with the fact that water is used in the reactor to cool the core and transfer heat out to do useful work. For water to function efficiently as a medium to carry heat to a turbine, it needs to be much hotter than the 100°C where water normally boils. Accomplishment of this is by running the reactor under pressure – up to 140 atmospheres of pressure. This means the reactor is inside a pressure vessel at pressures up to 2,000psi. If for some reason pressure was lost, (e.g., a pipe break), the water would flash to steam and cooling of the reactor core would all but cease. Fission would stop, but the decay heat (heat generated from residual radioactivity from the fission products) would continue. If we do not get water on the core to cool it, the core will soon melt and release the fission products. This is what happened at Fukushima. Guarding against this event drives the design of the reactor and drives up the cost enormously. We have a thick steel walled pressure vessel, placed inside a thick walled reinforced concrete containment building with about 1,000 times the internal volume of the reactor pressure vessel (to contain the steam), and we have a variety of pumps and backup systems to get water on the core if things go wrong. All built to reactor grade specifications. Contrast this to a LFTR. Because LFTRs use molten salts that remain liquid at high temperatures and at atmospheric pressures, LFTRs have no need for a pressure vessel. LFTRs have no water that can flash to steam and thus no need for the large reinforced concrete containment building. If you need to shut down a LFTR, you drain the liquid core into a series of drain tanks underground, configured to dissipate the decay heat passively. There is no need for high-pressure backup pumping systems to keep the core cool in the event of an emergency. This significantly simplifies the total system design and lowers the capital cost. In fact, the liquid core of a LFTR allows for compact designs that can be built in a modular fashion in a factory, significantly driving down costs further.

LFTRs have some significant advantages compare to today's nuclear power. The most significant of these stem from the liquid core running at atmospheric pressure.

These advantages are:

1. No water under pressure, therefore no pressure vessel, reducing cost
2. No large reinforced concrete containment building is required, reducing cost
3. Can be built in a factory, reducing costs
4. Because the core can be drained, LFTRs exhibit an enormous level of passive safety
5. Can be refueled without shut down
6. Exhibit 100% fuel burn up and generates almost no long lived radioactive waste
7. Configurations of LFTRs can consume the long lived radioactive elements in our present stockpiles of nuclear waste
8. Allow for the extraction of molybdenum-99 for medical purposes. Eliminating a supply shortage issue (ncbi.nlm.nih.gov/pubmed/21512666)
9. Allows for the extraction (in large quantities) of other radioactive isotopes for medical purposes
10. Can operate at high temperature, allowing the use of waste heat to desalinate seawater; higher temperatures can make for economical generation of synthetic fuels, (could use CO_2 from the atmosphere, thus making synthetic fuels carbon neutral)

Thorium exists in high concentrations in a number of locations on earth, often found in high concentrations with rare earth elements (REEs). Because present policy requires treating thorium as low-level nuclear waste, very little REE mining occurs within the United States (thoriumenergyalliance.com/downloads/TEAC4%20presentations/Kennedy_TEAC4.pdf).



Since 100% of Thorium in the earth's crust is Th-232 you can use all natural Thorium as fuel. The earth's crust has nearly four times as much Thorium as Uranium. In fact, small amounts of thorium are present in all rocks, soil, water, plants, and animals. Soil contains an average of about six parts of thorium per million parts of soil. That may not sound like much, but recall that the energy density of Thorium is over 1 million times greater than that of any fossil fuel. That means there is roughly the energy of four barrels of oil (in the form of thorium) in a cubic foot of dirt, everywhere – including the dirt in your backyard. Therefore, if the population of the earth was to consume energy at 10 times our present rate, we could power the world for one year on 10 billion tons of dirt. The world presently consumes more than half this quantity of coal alone in a single year. Since we are talking about common dirt, we could supply the world with energy (at 10 times our present rate) for millions of years. Additionally, thorium exists in a number of locations around the world, including the United States, at much greater concentrations than six parts per million. To learn more visit energyfromthorium.com/lftradsrisks.html.

All images courtesy of U.S. Department of Energy and Oak Ridge National Laboratory, Advanced SMR Technology Symposium Small Modular Reactors, 2011