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On Behalf Of
The NGNP Industry Alliance

Testimony On "Helium: Supply Shortages Impacting our Economy, National Defense and Manufacturing"

July 20, 2012

Mr. Chairman and Members of the Subcommittee, my name is Mark Haynes, I am President of Concordia Power, a small company that works with the NGNP Industry Alliance. The NGNP Industry Alliance is comprised of a number of major companies including Dow Chemical, ConocoPhilips, Entergy, AREVA, Westinghouse, SGL Group, Graftech, Mersen, Toyo Tanso, Ultra-Safe Nuclear, Technology Insights and the Petroleum Technology Alliance Canada.

Our Alliance's purpose is to help ensure the commercialization of High Temperature Gas Cooled Reactors (HTGRs) as an extremely important energy option for the future. HTGRs, which are helium cooled, are unique in both their very high outlet temperatures and their intrinsic safety characteristics. Although these reactors will include multiple safety features, they will require no active or passive safety systems or operator intervention to ensure the safety of the public. Taken together, these characteristics make HTGRs not only very desirable electric power generators with extraordinarily high efficiency and safety, but they also allow HTGRs to be co-located with major industrial and extraction facilities where their high temperature output can substitute for the very large amounts of fossil fuels these facilities currently consume in the production of process heat.

In addition, HTGRs can also play an unmatched role in greatly improving the efficiency and environmental performance of converting coal or other indigenous carbon sources to liquid fuels with an extremely small carbon footprint. As explained in more detail later in this testimony, a relatively conservative estimate is that in North America, there is a market for 600 or more HTGR modules in this century.

To the point of this hearing, the unique characteristics of helium are key to making this technology possible.

I believe it's correct to say that our invitation to testify here today does not relate to any particular expertise we might have with regard to either the Federal Helium Reserve or the current helium markets. Rather, our presence here relates more to the fact that HTGRs are a unique and important example of an emerging energy technology that is very dependent on a reliable and affordable supply of helium in the future.

Why Helium is Important to HTGRs

Helium coolant is a key element of HTGR design. Helium has four characteristics that make it a superior reactor coolant:

- It is chemically inert in the HTGR process. Hence, during reactor operations, extraordinary event or interruption by natural cause (as a flood or earthquake) or a human error or equipment event that affects the plant normal operations, it does not corrode reactor internals nor does it contribute to the spread of significant amounts of radioactive particles around the plant or the environment;
- It is itself "invisible" to radiation: it does not become radioactive in the course of cooling the reactor core and the reactivity of the core is not impacted by its presence or non-presence. This second characteristic is an important added safety feature in the event of even its complete loss from the reactor core in an accident; and
- It is always in a gaseous phase at any temperature in the core. This ensures that in an extraordinary accident event there is no extreme pressure conditions created, such as can occur in a light water reactor where the flashing of coolant water into steam requires a very robust containment in the event of a loss of coolant.
- It is an efficient heat transport fluid. This allows a more economical design and efficient plant operation.

It is also important to note that the other materials (graphite and ceramic coated fuel) are also non-corrosive and very chemically compatible with helium. This combination of materials is stable at extremely high temperatures. So, in a worst-case scenario loss of helium accident, the reactor core structure remains stable and the fuel stays well within its design limits. This is additional insurance that a Fukushima-type scenario cannot happen with an HTGR.

Helium Use and HTGRs

Although it is difficult to predict with precision how much helium will be required in the future for HTGRs, our Alliance, in concert with the Idaho National Laboratory estimates that in North America, there could be a future demand for several hundred 600 Megawatt thermal modules. This includes meeting needs in petrochemical production, refining, liquid fuel production, electric power generation and other markets.

Each reactor module in a fleet of HTGRs would require an initial inventory of helium when it enters service as well as replenishment helium during subsequent years of operation for the helium consumed each year in the supporting auxiliary equipment. The initial operating inventory for each of these 600 MWt modules would be approximately 2000 kg of helium. The annual need for makeup helium is assumed to be 10% of the operating inventory which is the upper design limit. So the annual helium requirement for a whole fleet of HTGRs is the total of the initial inventory required for new modules going into service plus the makeup supply for the existing modules already in service. As the first HTGRs are deployed, the initial inventory requirement governs the HTGR fleet helium consumption. But as the fleet grows, the makeup supply for the existing fleet quickly dominates the helium demand.

Hence, if one assumed for argument's sake an 800 module fleet built out over a 50-year period, there would be a helium requirement on the order of 200,000 kg per year as the fleet approaches full deployment. This is about 1% of the world's current helium production which is in excess of 30,000,000 kg per year. So, even though a substantial deployment of HTGRs will not be a large percentage of future projected helium markets, they will be significant users. While helium is essential for the deployment of a commercial HTGR fleet, we do not expect helium supply to present a significant obstacle to HTGR deployment, under current helium market conditions. Of course, this conclusion might change if future events adversely impacted the market.

As I mentioned before, the Alliance does not claim any particular expertise in the policy issues surrounding our nation's helium reserve or the helium markets themselves. However, in anticipation of what we believe to be a very bright future for HTGRs, we do believe that it's very important for the federal government to take what steps it can to help ensure a reliable and affordable supply in the future.

The following section of our testimony includes additional information intended to help the Subcommittee better understand HTGRs and their unique role in the future

Mr. Chairman and Members of the Subcommittee, thank you for your interest in the very important issue of our future helium supplies and thank you again for the opportunity to provide the Subcommittee with this information.

Additional Information on HTGRs for the Hearing Record

HIGHLIGHTS

- Industry currently uses 20% of the energy in the US and 30% world-wide. In the US, this is primarily from burning of fossil fuels such as natural gas and petroleum derivatives to produce high temperature process heat

- High temperature nuclear reactors designed to produce process heat can displace a substantial part of this fossil fuel usage – dramatically reducing associated carbon emissions. The process heat temperatures achievable by High Temperature Gas Cooled Reactor (HTGR) technology can fulfill the process heat needs of major industrial facilities

- Process heat produced by HTGRs is competitive with fossil fuels and isolates industrial energy users from volatile energy prices historically associated with fossil fuels. Likewise, HTGR generated electric power is competitive with that of other newly built nuclear and fossil fuel generation.

- HTGRs integrated with proven carbon conversion processes can produce synthetic transportation fuels and chemicals with minimal carbon emissions and greatly improve the US' energy security and independence

- The potential market exceeds several hundred modular HTGRs, with the opportunity to contribute over one trillion dollars and tens of thousands of jobs to the US economy

- The intrinsic safety capability of modular HTGR technology increases the flexibility for reactor siting and allows for collocation with industrial facilities

DISCUSSION

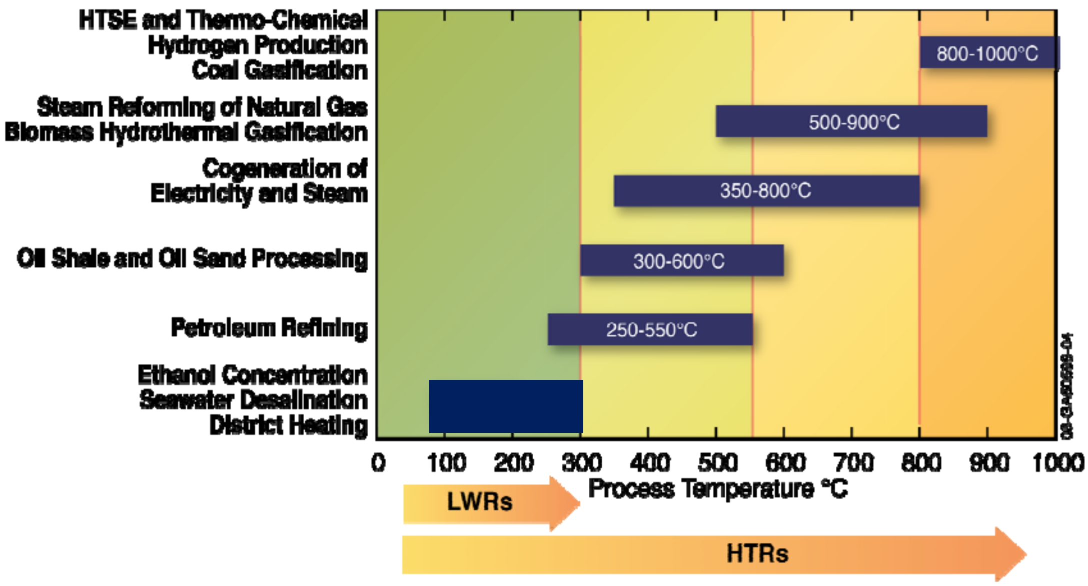
Currently, much of the discussion about nuclear power and SMRs centers on electric power which now comprises just about 40% of U.S. total energy use – of which 68% is from fossil fuels. However, 20+% of U.S. energy is used in the industrial sector – of which 90% is from fossil fuels, particularly natural gas. The carbon emissions from the process heat applications are considerable. Despite the current low price of natural gas, the U.S. industry remains vulnerable to evolving environmental regulation, potential growth of other inelastic uses (natural gas as a transportation fuel or for base load power generation) and, therefore, future price volatility. The U.S. has already demonstrated that the U.S. chemical industry serves as the effective shock absorber for high and volatile natural gas prices when it shifted production and jobs overseas during the last period of high and volatile gas pricing.

The nature of industrial energy use (concentrated, continuous and high temperature) makes renewable energy sources, such as solar or wind energy inefficient and uneconomical due to the need to 'bolt on' reliability and supplemental heat to meet the energy demands. HTGRs are the only technology on the current feasibility horizon for the large-scale substitution for fossil fuels for many industrial energy requirements.

Importantly, major industrial energy users such as petroleum refining, chemical processing and the iron and steel industries require temperatures well in excess of what LWR SMRs are capable of providing (see Figure 1). For this reason, the Department has been providing support for the Next Generation Nuclear Plant (NGNP) program which was authorized by Congress in the Energy Policy Act of 2005. This development work is focused on the development of High Temperature Gas Cooled Reactors (HTGRs).

Figure 1.

As Reactor Temperatures Go Up, Industrial Uses Increase



Work done by industry and the Idaho National Laboratory indicates a very robust potential market for HTGRs. Assuming only a 25% capture of the market for the largest categories of existing and potential industrial energy use, in excess of 700 reactor modules rated at approximately 600MWt would be required. The viability of this model is that the 700 reactor modules are likely to be concentrated in as few as 100 total sites. Further, the size of the reactor modules is about the same in thermal capacity as typical gas turbine/steam turbine cogeneration configurations, leading to analogous reliability models (ability to have one or more modules down for maintenance or unscheduled trips and still supply critical steam demands), making this a like-for-like thermal transition. Potential overseas markets in the EU, Middle East, South America and elsewhere are potentially as significant or larger. In all of the aforementioned markets, the co-production of electrical power will yield an additional very low overall carbon footprint for these industrial sectors while also providing opportunity for distributed power transmission due to the nature of the industrial applications (will lead to excess power generation in many cases).

Figure 2.

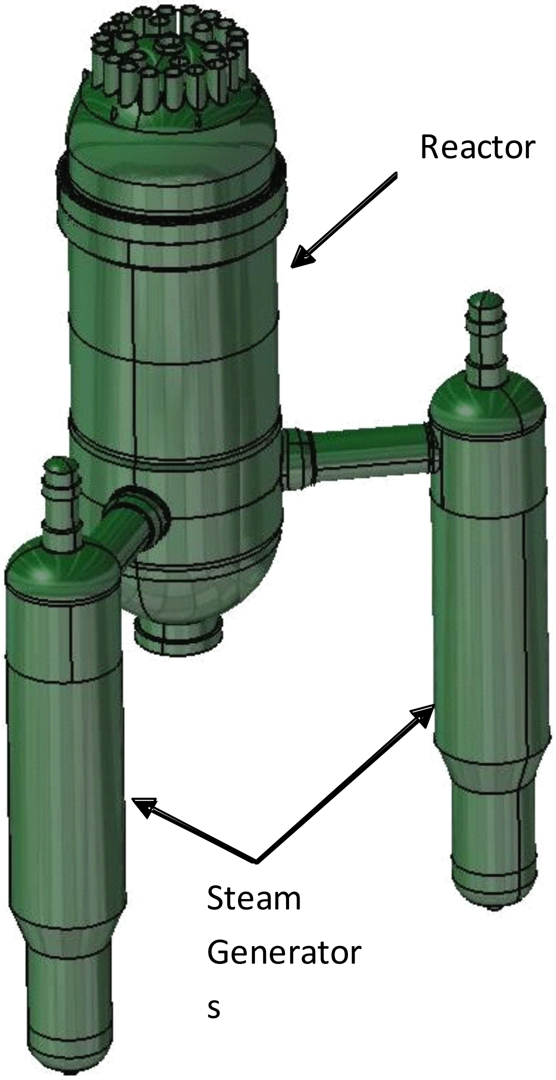
Market	Use	Demand*	HTGR ** Modules
Co-generation	Petrochemical, Refinery, Fertilizer/Ammonia plants and others	75 GWt	125
Oil Sands / Oil Shale	Steam, electricity, hydrogen & water treatment	18 GWt	30
Hydrogen Merchant Market	Hydrogen production	36 GWt	60
Synthetic Fuels & Feedstock	Steam, electricity, high temperature fluids, hydrogen	249 GWt	600
IPP Supply of Electricity	10% of the nuclear electrical supply increase required to achieve pending Government objectives for emissions reductions by 2050	110 GWt	180

* Assumes 25% market penetration
** 600 MWt each modular units

HTGRs and U.S. Industry's Reference Concept

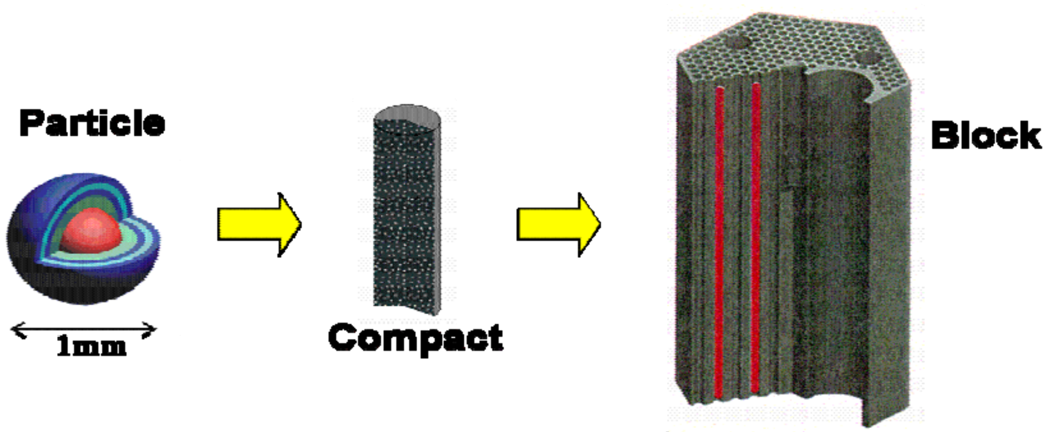
HTGR technology has been developed and demonstrated historically over the past 50 years in the U.S. Germany, Great Britain, Japan and China. HTGRs are of a fundamentally different design than Light Water Reactors: they are helium cooled, graphite moderated and have robust multi-layered ceramic coated fuel particles embedded in a graphite matrix. Modern HTGRs are designed in a manner such that no failure scenario, including a complete loss of coolant and all mechanical safety systems, can result in any significant release of radioactive particles to the public. And further, because of the chemically compatible nature of the coolant and materials in HTGR core, there is no potential for chemical reactions or explosions. Finally, the spent fuel does not require water cooling. This safety case is intrinsic to the use of HTGRs to industrial customers where a major release could impact the existing industrial assets.

A prismatic core modular HTGR with a conventional steam cycle has been selected as the reference concept for commercialization by the U.S. industrial alliance supporting HTGR development (see below). The concept provides the best match to near-term energy needs with competitive economics and acceptable risks for investment readiness, while also laying the foundation for more advanced modular HTGR concepts. It is envisioned that the reference concept module will be incorporated in multi-module plants that can provide over-the-fence supplies of energy analogous in capacity and reliability to conventional combined cycle facilities used by industry. For example, a large industrial complex might typically have 4 to 6 modules for reliable process heat and power supply.



The nuclear supply system module is based on a 625 MW thermal (MWt) annular reactor core in a large steel reactor vessel. It is a two-loop system with the reactor connected to two parallel steam generators and helium circulators.

Ceramic coated particle nuclear fuel is a key part of the modular HTGR concept. Each fuel particle consists of a fuel kernel surrounded by multiple ceramic coating layers which provide the primary fission product retention barrier under all conditions. The total fuel supply includes roughly 30 billion such particles per core. As shown below, the particles are distributed in graphitic cylindrical compacts and the compacts are placed in holes drilled in the graphite fuel blocks. The fuel blocks are loaded into the fueled annulus of the core. The rest of the core is made up of non-fueled graphite reflector blocks, that due to its heat treatment (up to 3000 degrees C), also behaves as a ceramic. Hence the basic core structure is entirely ceramic.



Circulating helium carries the heat produced in the reactor to the steam generators to produce high temperature superheated steam. The remaining steam distribution system can be configured in a variety of different ways depending on the specific needs of each energy user.

The initial fleet will adapt multiple standard reactor modules with application-specific process steam and/or power generation modules for a range of plant sizes for the target applications discussed above.

Opportunity for U.S. Leadership in HTGR Technology Deployment

Currently, Japan, China, Russia and Korea have existing HTGR programs – including operating test reactors in Japan and China. Of these, China's is by far the most aggressive with a small test reactor currently in operation for 10 years and a commercial scale demonstration in the early stages of construction. The willingness and ability of the Chinese to move forward with any exports of their specific HTGR technology variant are unclear. There is a strong potential for the U.S. to become the dominant world player in HTGR technology. The U.S. advantage in this technology stems from a long-term R&D program at the Department, a well-developed industry base including potential major industrial end-users, and what is likely the most successful HTGR fuel development and testing program in history and as noted, a U.S. fuel vendor is poised to move forward to provide for commercial scale fuel development. Further, solid groundwork has been laid for licensing the technology at the NRC. In addition, the U.S. is host to at least three major international graphite companies whose historic legacy and current work in the field would allow a quick scale up into large-scale production.

Summary

Post-Fukushima, the HTGR brings a new level of intrinsic safety that enables its co-location with other industries and communities. It can dramatically reduce CO2 emissions from petrochemical production, petroleum refining and extraction of bitumen from oil sands and shale. It is economical today in Europe, Asia and the Middle East where natural gas price is tied to oil parity. The Alliance concludes that even U.S. gas prices are likely to emerge in a range that will make this technology competitive for process heat and power in the 2020+ time-frame as utilities, transportation and natural gas compete to arbitrage the current U.S. price advantage. Further, if one envisions oil in the $130+ per barrel range in the 2020+ time-frame, it provides an economic approach to production of synthetic fuels from indigenous carbon sources with virtually no carbon footprint. It is the game changing technology that can address the overarching global energy policy goals of energy and feedstock security, economic growth/GDP (jobs) and carbon footprint (climate). Based on the current trajectory, if funding were sufficient in the coming years, this technology could be deployed initially in the mid 2025 time frame.

As with LWR SMRs, there are several compelling reasons for the federal government to support the development of HTGRs. However, by the nature of the HTGR potential markets, the reasons are somewhat different:

1. **Growth in the Economy and Jobs** – The Alliance's market analysis indicates that within the first 25 years of application in the U.S. and the Alberta oil sands industry, nearly a trillion dollars in gross domestic product could be generated. Further, the modular HTGR is particularly well suited for small to medium and developing countries, with its scalable modular deployment and superior safety characteristics that do not rely on intervention of any systems or people to safely avoid major events during operation.

Altogether, this translates into profitable growth in new market sectors for the nuclear energy system and equipment suppliers, owner/operators and energy end-user industries with many thousands of highly-skilled, high-paying jobs. This growth is good for industry and good for the U.S., North America and other countries that choose to participate and engage this technology. China is already underway with the deployment of their version of a modular HTGR design that may compete globally.

2. **Energy Price Stability** – The HTGR energy pricing is expected to be stable over an operational plant life of more than 60 years by virtue of the fact that <20% of the energy cost is tied directly to the fuel raw material. By supplanting natural gas and other fossil fuels for producing heat, the modular HTGR provides insulation from energy price variability.

3. **Alternative Uses for Indigenous Carbon Resources & Improving Energy Security** – HTGR technology provides an attractive path to take advantage of indigenous carbon (coal, pet coke, municipal solid waste, etc.) by gasifying the carbon with co-production of hydrogen, all using the modular HTGR technology, and ending-up with chemical feedstock or transportation fuels. As an example, if you matched-up about thirty-one 50,000 barrels-per-day carbon conversion plants with the annual coal production output of Kentucky, you could convert that coal to transportation fuels equivalent to about one fourth of the U.S. import demand today with minimal CO_2 emissions. This improves both energy security and independence.

4. **Minimizes Carbon Emissions** – Environmental factors range from incremental advantages associated with fuel utilization, waste management, land use and cooling water requirements. Unique within nuclear, the modular HTGR is the only carbon reducing game-changing technology on the foreseeable horizon for supplanting fossil fuels in the production of high temperature process heat. The end-user community that is driving the Alliance envisions a path that would eliminate as much as 80% of its carbon footprint with this technology. Substantially lower carbon footprints cannot be achieved without bold technology advances.

5. **Minimizes Water Usage** – The high thermal efficiency of modular HTGR technology can make use of dry cooling as an economic alternative in those areas where water is limited.

6. **Exports -** HTGRs may have a special potential in terms of export. Many of our U.S. industrial process heat users are also major U.S. based international companies. If those companies adopt HTGRs for their U.S. based facilities, they may then readily adopt them for one or more of their overseas facilities. Or alternatively, after HTGRs are licensed in the U.S., they may choose to adopt the reactors at one or more of their non-U.S. facilities first. Either way, this export pathway seems unique to HTGRs.