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Committee on Natural Resources
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Hearing on America's Helium Supply:
Options for Producing more Helium from Federal Lands

Chairman Lamborn, Ranking Member Holt, and members of the subcommittee: Thank you for the invitation and the honor to appear before you today. My name is Ramesh Bhave, and I am the Director of the Inorganic Membrane Technology Lab at Oak Ridge National Laboratory (ORNL) in Oak Ridge, TN. I am pleased to be here today to discuss ORNL's gas separations research and membrane technology development and its collaborative work with a small business to incorporate this technology into a system that can efficiently and cost-effectively separate helium from other gas streams.

The Helium Supply Problem

Helium (He) is a scarce, high value, inert gas with unique properties that is used in several high technology applications such as MRI machines, super-conductors, semi-conductor fabrication, fiber optic manufacturing and others. For the last century, the U.S. has dominated global helium supply with 2010 production estimated at 125 million cubic meters. Virtually all helium produced in the U.S. today is from a few "rich" natural gas deposits that contain sufficient helium to enable economic recovery. However U.S. production of helium is in rapid decline as these currently viable rich reserves are being depleted (Figure 1). This coupled with rising global demand has resulted in a shortage causing prices to rise (Figure 2). As is shown in Figure 2, the price of helium increased four-fold from 1998 to 2013.

A Possible Technology Solution

Helios-NRG, a small business located in Western New York, estimated that a substantial amount of helium, exceeding that in the "rich" fields used today, is present in lower-grade fields where the amount of energy required to extract helium is cost-prohibitive with current technology. In order to solve this problem, Helios-NRG set out to develop an advanced technology to cost-effectively recover helium from these vast but "low grade" sources.

In 2010, Helios-NRG received a DOE Small Business Technology Transfer (STTR) award to fund their efforts. They believed that a hybrid system that integrated membrane and non-membrane technologies would permit high purity helium production from marginal, low purity sources -- at costs comparable to the conventional technology used today to recover helium from helium-rich fields. Led by Dr. Ravi Prasad, the Helios team brings more than 30 years of technical and business experience in gas separations including helium recovery applications.

They found essential support at ORNL with its expertise in membrane separations, forming a team uniquely qualified to develop options for addressing the shortage of helium.

ORNL's Historical Research on Membrane Technologies

ORNL's recognized leadership in gas separation and selective enrichment technologies goes back more than 60 years and is rooted in the Manhattan project. In the past 30 years, ORNL has focused on research and development utilizing advanced membrane technologies to address challenges in many energy-intensive separation processes of national and commercial importance. Utilizing ORNL's state-of–the-art membrane fabrication, characterization and test facilities, ORNL's research team has made important contributions in several areas such as hydrogen recovery and separations, and post-combustion carbon dioxide capture and sequestration technologies. The team is also developing and improving advanced processes for lithium and rare earth metal extraction and is a leading member of the Department of Energy's (DOE) Critical Materials Institute.

ORNL Role in the Helios-NRG STTR Project

The primary role of ORNL in the Helios-NRG project is to develop and perfect the advanced gas separation membranes that are used as part of the hybrid system. More specifically, ORNL will provide research and development support for the development, demonstration, and deployment of molecular sieve membranes in the hybrid system being developed by Helios-NRG. ORNL molecular sieve membrane technology has wide applications to other important gas separations including hydrogen, carbon dioxide and noble gas separations, which are relevant to the clean-energy, petrochemical, and high-tech industries. Molecular sieve membranes enable the separation of helium based on the fact that the helium molecule is significantly smaller than molecules of all the other gases such as nitrogen and methane often present in the marginal helium sources. ORNL also has membrane fabrication expertise and facilities for larger scale prototype development and can support field demonstrations with private industry sponsors and partners.

Goals, Objectives, and Funding of the Helios-NRG STTR Project

The Helios-NRG—ORNL collaboration started in September 2010 with the award of the Phase 1 DOE STTR grant and continued to support research focused on helium recovery with a Phase 2 DOE STTR award in August 2011. Phase 1 and 2 goals, objectives and funding are summarized as follows.

<u>Phase 1</u>
The objective of Phase 1 was to demonstrate the feasibility of the concept at bench scale. Preferred membrane materials and fabrication techniques were identified and significant progress made towards commercial targets. Economic analysis was carried out and showed potential to produce helium from marginal sources using the new hybrid system at substantial cost advantage over the current commercial helium prices.

Phase 1 of the project was successfully completed in early 2011 and achieved all its technical objectives. The total Phase 1 DOE-STTR grant to Helios-NRG was approximately $100,000, out of which ORNL funding was approximately $43,000.

Phase 2

Phase 2 of the project builds on the progress made in Phase 1 and is intended to advance the technology to pilot scale. This will include further improvement in the membrane properties, scale-up of membrane fabrication, design/fabrication/testing of a scaled-up hybrid system and validation of process economics. It will lay the foundation for advancing the technology to demonstration stage.

Phase 2 funding was awarded in August 2011 and this phase of the work will be completed by the end of 2013. The total DOE-STTR funding to Helios-NRG is approximately $750,000 out of which ORNL funding was approximately $300,000.

Research Progress and Results

The project has made excellent progress and is on track to achieve all of its objectives. As I conclude, here are other highlights:

- Early in the project, advanced hybrid process cycles for helium recovery incorporating membranes and other separation processes were developed and used to establish quantitative targets for membrane development.
- Many membrane materials and fabrication techniques were tested and preferred combinations identified. Excellent progress has been made towards meeting or exceeding the ambitious performance targets. Substantial progress has been made in evaluating different types of helium recovery opportunities including a "standalone" case, intended for green-field applications.
- Economic analysis was carried out using the actual properties measured in the pilot unit showing potential to produce 99.99+% helium from marginal sources using the new hybrid system, with substantial economic advantage over the current commercial helium price.
- Helios-NRG completed the design and fabrication of a small test unit in August 2012. Testing of a single molecular sieve membrane tube module was completed in the first quarter of 2013. ORNL and Helios are exploring other, different membrane technologies that may further improve overall system performance. This work is ongoing in the second quarter of 2013. Pilot tests confirmed significantly better performance than project targets for both types of membranes.
- ORNL completed the design and assembly of a larger test module containing 8 membrane tubes which was shipped to Helios-NRG in June 2013. This is currently under evaluation at Helios-NRG facilities in New York.

Prospects and Timeline for Possible Commercialization

Helios-NRG and ORNL are well-positioned to continue the development of the hybrid system and membrane technologies for helium recovery to ensure a stable, reliable, competitively-priced supply of helium for several high technology and research applications. To further enable

commercialization, Phase 3 of this effort will focus on validation of the membrane technologies and the hybrid system in a field demonstration plant using actual raw gas bearing helium. Helios-NRG has had preliminary discussions with a global leader in helium production that has expressed interest in this system and hosting the field demonstration plant. The timeline for commercialization will depend on the availability of federal and private industry funding. It is estimated that based on the results to date, the field demonstration of the hybrid helium recovery system can be completed in 48 months, with the possibility for commercial deployment by 2020.

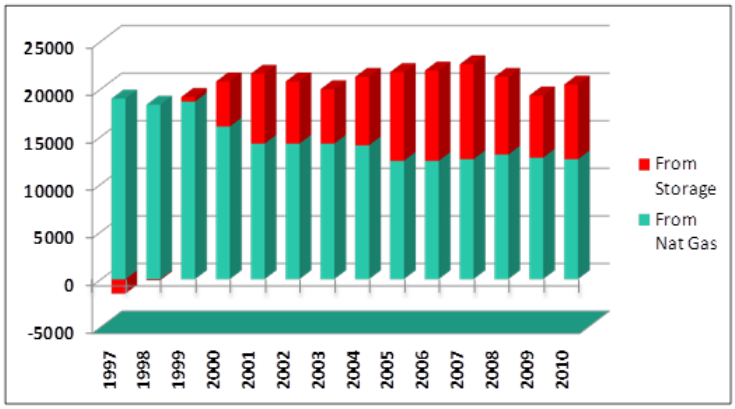

Figure 1. US Production from Natural Gas Wells and Government Storage (Courtesy Helios-NRG)

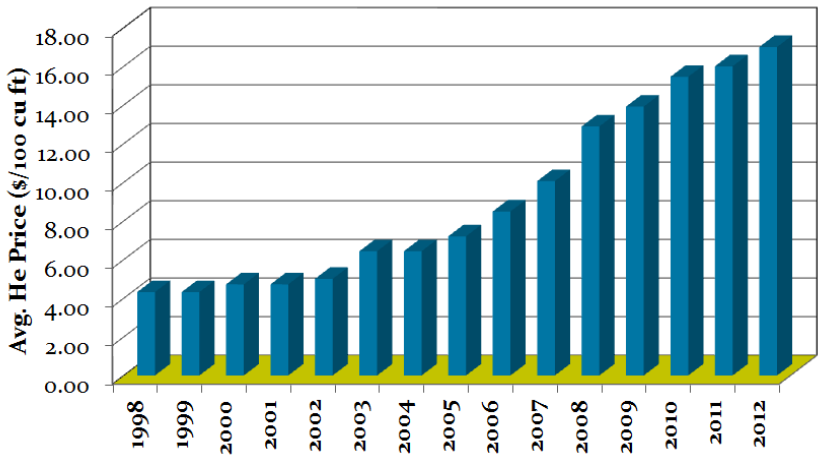

Figure 2. Average US Price for Grade A Helium (Courtesy Helios-NRG)