A brief history of more recent uranium enrichment technologies – part 2

(As published in The Oak Ridger's Historically Speaking column the week of February 26, 2018)

Bob Eby continues his excellent documentation of more recent uranium enrichment technologies.

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[This is part of a series on Advanced Uranium Isotope Separation processes. In the last article, we chronicled from gaseous diffusion through a peer review process that led DOE to select the Atomic Vapor Laser Isotope Separation process and terminate the government's gas centrifuge projects, and then the ultimate selection by the U. S. Enrichment Corporation, Inc., of the Advanced Gas Centrifuge process for near term deployment.]

Fifteen years earlier, it seemed that the gas centrifuge process was dead. Now, early in the new century, it had "new life" with USEC's decision for commercial deployment in the 2010s. USEC's intent was to operate a few of the "advanced" centrifuges at the Oak Ridge K-25 site in Building K-1600 while applying for and receiving first a license to operate a lead cascade and finally to obtain an Nuclear Regulatory Commission license for the American Centrifuge Plant a commercial plant for low enriched uranium supply.

Economics showed that the performance of these ACP machines needed to be greater than what was demonstrated during the Gas Centrifuge Enrichment Plant program in the GCEP days; however, with access to key members of the earlier program; i.e., Dean Waters, Bob Riepe, John Shaffer, Dave O'Kain and others, coupled with some very strong technical expertise from a new generation of exceptionally capable scientist and engineers, the expectation was that it would not take long to achieve the desired goals.

In 2004, USEC was granted the license from the NRC for a Lead Cascade to be deployed in the former GCEP building in Piketon, Ohio, which began operating in August of 2007. In April of 2007, the NRC issued a commercial operating license for the American Centrifuge Plant, paving the way for a commercial plant once USEC was satisfied with the performance and economics of the machine and plant and once funding was secured.

In the meantime, USEC continued to operate the Paducah Gaseous Diffusion Plant to meet order book requirements, albeit the economics of that process was turning south because of the high energy requirements of the gaseous diffusion process and rising energy costs.

For a commercial plant, the economics was obviously the key. The gas centrifuge developed by the government in the 70s and early 80s and selected for GCEP demonstrated the capability that was satisfactory at that time in Separative Work Units per machine for government deployment.

However, USEC's economic models showed that number needed to be greater to be economically viable in a purely commercial venture. So a concerted effort was initiated in the K-1600 building at the K-25 site to increase machine capacity while preparing and running a lead cascade in parallel in Piketon.

In 1999, USEC also entered into a Cooperative Research and Development Agreement with the Oak Ridge National Laboratory to access technical expertise of the Laboratory to support the project in specific areas of operations, electronics development, machine balancing and process modeling capabilities.

CRADAs are a joint program between private industry and a government agency to work together on research and development and bring the best capabilities to solve issues and enhance commercialization for future benefit of the nation.

The $336 million CRADA between USEC and ORNL was entirely funded by USEC. At the time this was the largest CRADA in the history of the Department of Energy and lasted more than a decade. More than 100 staff from the Laboratory supported the USEC program, with 30 full time employees working on it at its peak.

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USEC also recognized that a commercial plant would require a complete supply chain and manufacturing capability to build the carbon fiber rotors and machines at a high rate to meet production needs. The "Boeing" building in Oak Ridge (now on "Centrifuge Way") that had been used to build centrifuge machines in the 1980s program became available. USEC purchased the building and converted it to the Technology and Manufacturing Center (TMC).

USEC built a broad base of nationwide suppliers, including ATK, BWXT, Major Tool, Honeywell and Teledyne Brown to manufacture rotors, build the electronics, and connect the machines together to deliver the required U-235 enrichment capability.

The strategy and supply chain worked well and USEC personnel (old and new) were able to push the capacity of the machine and achieve the goal of about 320 SWUs per year per machine. As part of its agreement with the DOE, USEC had leased the GECP facilities in Piketon, and a demonstration cascade was built there in one of the buildings that would eventually house a segment of the commercial plant.

Testing of the demonstration cascade confirmed the performance of the machines in a plant environment, and USEC felt the machine was ready to be deployed in a commercial plant. However, that took capital.

The U.S. Government had just announced a new Loan Guarantee Program, and in 2009 USEC applied for the program with the hopes to have a plant operational in Piketon in 2012.

However, in July 2009 the DOE did not grant the $2B loan guarantee for USEC, stating the technology needed further demonstration in Piketon. The Department asked USEC to withdraw its request and negotiated an arrangement for $45M to conduct additional demonstration over the next 18 months.

In 2011, as USEC was expecting the Loan Guarantee process to reinvigorate, the disaster at Fukashima hit and the need for a new supply of enriched uranium to fuel commercial enrichment plants essentially halted because of the glut that was created from the reduction of commercial nuclear power worldwide.

Because of the continued high cost of the gaseous diffusion plant, USEC ceased operation of the last operating U.S. owned enrichment facility in Paducah in May 2013.

Finally, the perfect storm of events forced USEC's hand into filing Chapter 11 bankruptcy restructuring in early 2014.

A new successor company, Centrus Energy (Centrus), under the leadership of former Deputy Secretary Daniel Poneman emerged from that Chapter 11 filing. Centrus continued development of the AC100 machine, the machine designated by USEC as the centrifuge machine for future deployment.

In early 2016, Centrus completed a successful three-year demonstration of a full, 120 machine cascade at its Piketon, Ohio, facility, demonstrating the long-term performance and reliability of the machines under actual operating conditions.

The need for low enriched uranium (LEU) to fuel commercial nuclear power plants is obvious, and the supply of enriched uranium can be provided from many worldwide sources. However, because of treaty agreements, enriched uranium to fuel reactors; i.e,. Watts Bar Nuclear Plant, to produce tritium for use in maintaining the reliability of the U.S. nuclear stockpile must be only supplied from a U.S. origin source.

An October 2015 report by the U.S. Department of Energy found that Centrus' AC100 centrifuge is the "most technically advanced and lowest risk option" to meet the nation's long term national security needs. Since the American Centrifuge technology is currently the only viable available U.S. technology that can produce the low enriched uranium for this purpose, it is imperative that the U.S. Government maintain a semblance of capability in technical expertise to meet the need when it will be required or until some other U.S. based technology could replace it.

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However, recent reports from the U.S. Government has indicated the need for this LEU to supply fuel for Watts Bar will likely not occur for several years. Largely because of this need to maintain the capability, Centrus has entered into a series of contracts with ORNL since 2014.

Under the terms of the agreement, Centrus continues to perform engineering and testing work to preserve and advance U.S.-origin uranium enrichment technology to support future national security and energy security needs. Centrus experts stand by ready with a deployable centrifuge enrichment capability when the need once again arises.

In the meantime, armed with the knowledge from more than 15 years of centrifuge technology development work under USEC and Centrus led efforts, coupled with decades of centrifuge development from the U.S. Government's efforts during the 60s, 70s and 80s, Centrus scientists, engineers, and operators, are utilizing the Company's unique facilities in Tennessee to continue advancing the technology. This is being done by identifying further improvements to reduce costs, improve manufacturability, and enhance long-term reliability of its enrichment operations.

In parallel, ORNL also has a separate centrifuge effort and has developed a machine for supply of stable isotopes and is currently working on a machine for uranium isotope separation.

It is a difficult challenge to maintain a viable gas centrifuge capability in the face of such adverse market conditions that exist today. However, it is essential that the United States have an indigenous enrichment capability.

It is hoped that the work being done in Oak Ridge today at Centrus and ORNL will be strongly supported. That will ensure that critical U.S. expertise in centrifuge design, manufacturing, and operations will continue to advance and be prepared to support building new capacity in the future.

Oak Ridge was the key player in inventing and first deploying uranium enrichment. Now the nation's hopes for the future of uranium enrichment rest on the efforts here as well.

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Thanks Bob, excellent summarization of years of advancement in centrifuge technology and yes, Oak Ridge is right in the middle of it all!

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Bob Eby has spent his career in uranium enrichment and much of that focused on centrifuge technology making him a recognized expert in the field of uranium enrichment