A brief history of more recent uranium enrichment technologies – part 1

(As published in The Oak Ridger's Historically Speaking column the week of February 19, 2018)

At my request, Robert (Bob) Eby agreed to add to the information provided by Al Ekkebus on centrifuges.

Bob started his career as a co-op student in the Gaseous Diffusion Development Division at the K-25 site in 1971, and began full time work there upon graduation from UT in Chemical Engineering in 1974.

In the early 80s he was responsible for uranium processing aspects of the Molecular Laser Isotope Separation Program, the product and withdrawal program for the gas centrifuge program, and later led Martin Marietta's joint effort with Lawrence Livermore National Laboratory on the Atomic Vapor Laser Isotope Separation program in Oak Ridge and Livermore, Ca.

Upon his return from California to Oak Ridge in 1990, he became Plant Manager responsible for the cold and dark shutdown of the K-25 site and after other management responsibilities in the environmental management program. He returned to his uranium enrichment roots in 1976 and led United States Enrichment Corporation's centrifuge technology program for the American Centrifuge Machine for 10 years.

He is currently Executive Vice-President of Navarro Research and Engineering, Inc in Oak Ridge. He is the co-author of 3 patents in radiochemical process and lectured world-wide on uranium enrichment and other nuclear fuel processing and cleanup technologies.

I believe you will agree with me that Bob is a resident expert on uranium enrichment technologies. Enjoy his reflections on centrifuges.

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The 1970s began with an optimistic outlook for uranium enrichment in the U. S. All three gaseous diffusion plants – Paducah, KY, Portsmouth, OH, and Oak Ridge were operating at capacity with long-term contracts for their entire output. New enrichment plants were going to be needed to satisfy the growing demand, and the government adopted a policy that these new plants would be built by the private sector and closed its own order books.

But then in the mid-1970s, the legislation that would have enabled privatizing uranium enrichment failed, bolstering foreign enrichment projects, especially the European gas centrifuge projects of Urenco. In response, the U. S decided to build additional capacity with a government project at Portsmouth.

It was also decided to seek newer higher efficient methods for enriching uranium to meet commercial reactor needs for the future. During that time, an active program (as described in the earlier articles) on gas centrifuge was proceeding.

Gas centrifuge was approximately 10 times more efficient than gaseous diffusion when compared to the amount of energy it took to produce one Separative Work Unit. SWU was the commodity of interest in uranium enrichment.

Even though the gas centrifuge plant was being constructed at Portsmouth, there was a major effort in Oak Ridge. Over 500 people were involved in gas centrifuge Research & Development, under the leadership of Paul Vanstrum, Bill Wilcox, Dean Waters, Ernie Evans and their colleagues.

Percy Brewington managed the Gas Centrifuge Enrichment Plant organization and Gordon Fee led the Operating Contractors Project Office within the GCEP organization. Much of the engineering for the plant was done under the leadership of George Jasny and Pat Patton.

In addition, Boeing, one of the companies chosen to build the centrifuge machines, built a huge manufacturing facility in Oak Ridge. Centrifuge work was thriving here in town.

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While the centrifuge project was progressing, there were three other uranium enrichment technologies that were in early stages of development in the U. S. These were Molecular Laser Isotope Separation, Atomic Vapor Laser Isotope Separation, and the Plasma Separation Process.

These advanced technologies presented the opportunity for a factor of up to 10,000 higher separation factors than the gaseous diffusion process. Los Alamos National Laboratory had the lead to develop the base technology for MLIS,

Lawrence Livermore National Laboratory was responsible for AVLIS and TRW was in the lead for the PSP process. In conjunction, Oak Ridge, because of its overall uranium expertise, was involved in all these programs and was responsible for developing the uranium handling and processing aspects of these advanced technologies.

Oak Ridge also conducted technical and economic analyses of each of these processes. So, by the early 1980s, Oak Ridge had a thriving uranium enrichment technology effort, doing important R&D and technical support work on gaseous diffusion, the gas centrifuge, MLIS, AVLIS and PSP. All three Oak Ridge plants were involved in these efforts which were at that time under the direction of Dr. Robert ("Bob") Merriman.

After substantial investment in the development of MLIS, AVLIS and PSP, DOE elected to conduct an evaluation through a formalized peer review process and down-select one of these advanced processes for continued development. The goal was the selected process would continue to be developed and subsequently be evaluated against gaseous diffusion and gas centrifuge for further development as needed and eventual deployment to meet the needs of the future.

The peer review process was extensive and "brutal" at times, but at its end, the DOE selected the AVLIS process for future development and evaluation. (This process is a story in itself, in a future Historically Speaking series I hope to focus on the history of this competition review process and its political implications – Ray)

AVLIS uses lasers that are specifically tuned to the frequency of the desired uranium-235 isotope and not the non-fissionable U-238 isotope. By supplying sufficient energy specifically to the U-235 isotope, an electron can be driven off the U-235 atom and the resulting U-235 ion can be collected on a charged plate. That is why the process is so efficient because the lasers can be so precisely tuned to the isotope of interest.

Pumping the required energy into the atom while operating with uranium metal vapor presents challenges of its own. These challenges had to be overcome to make the AVLIS process economically viable. That was a major objective of the development program.

In the mid to early 80's, the DOE continued the development of both the gas centrifuge program in Oak Ridge and the AVLIS program in California and Oak Ridge. With experts from ORNL's Metals and Ceramics Division, uranium metal experts from Y-12, and uranium hexafluoride processing from the K-25 site, Oak Ridge had the responsibility to develop and prove the uranium metal based AVLIS separator unit and to test the uranium processing equipment to integrate a metal based AVLIS process into a world-wide fuel cycle.

The fuel cycle included commercial feed convertors and fuel fabricators who were established for commercial uranium enrichment processes that were based on uranium hexafluoride as the feed and withdrawal material of interest; i.e, gaseous diffusion and gas centrifuge processes.

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The next few years then continued the peer review evaluation process, only this time, it was AVLIS vs Gas Centrifuge. By then, an Advanced Gas Centrifuge was also being developed that was superior to the GCEP centrifuge. The AGC had been advocated by Dean Waters, Bob Merriman and others in Oak Ridge and showed great promise.

However, during that same time frame the market for U. S. uranium enrichment was collapsing. The U. S. nuclear program had not recovered from Three Mile Island in 1979 and was in the wake of problems and delays in nuclear power plants and growing competition from foreign enrichment competitors.

The large government outlays for uranium enrichment now longer aligned with market realities. In response, DOE decided to close the Oak Ridge gaseous diffusion plant and terminate the GCEP construction project. DOE also decided that the AVLIS process would be its technology of the future and the gas centrifuge R&D work was also ended. These were crushing times for Oak Ridge, where uranium enrichment had originated.

One further decision that was made was that the Oak Ridge Martin Marietta AVLIS program would be consolidated with LLNL in a joint effort to be centered in Livermore, Ca. Twenty eight East Tennessee families originally moved to California in the 1986-1987 timeframe and more followed later to carry on Oak Ridge's tradition of playing key roles in the advancement of uranium enrichment processes.

Oak Ridge people who relocated to Livermore remained in key roles responsible for the separator and uranium processing development, but also had key roles in program management of the program as well as managing the copper vapor laser development and demonstration effort.

The program was truly a joint program between the LLNL and Oak Ridge with the "best athlete" concept for people in key roles. Oak Ridge technologists surely held up their end of the effort. DOE-ORO retained an oversight role as did the DOE-SAN office out of Oakland, CA.

In 1987, in recognition of his work in the nuclear fuel cycle, including leadership in gaseous diffusion, gas centrifuge, and laser technologies for uranium enrichment, Bob Merriman was awarded the EO Lawrence Award by DOE, and subsequently, The Robert E Wilson Award, presented by the Nuclear Engineering Division of the American Institute of Engineers.

AVLIS development continued at the LLNL, and in 1992 the Energy Policy Act created the United States Enrichment Corporation, a government corporation to eventually fully privatize uranium enrichment for commercial use. In 1994, the AVLIS process was transferred out of primary control of the National Laboratory to USEC who continued the development effort.

USEC went through its own commercial evaluation and determined that the gas centrifuge program was the most likely technology that could be deployed commercially within the company's business case. As a result, USEC cancelled the AVLIS program in 1999. Many of the Oak Ridge personnel who moved out to Livermore to support the AVLIS program came back to the area and some even went to work for USEC on the centrifuge program.

In about 2003, USEC began to re-established a team of gas centrifuge experts to deploy a commercial gas centrifuge enrichment plant. That will be the subject of the next in the series of articles.

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Wow, what a great summary of the history of Gas Centrifuge Uranium Enrichment as well as the Atomic Vapor Laser Isotope Separation technology. Thanks Bob, and readers, the next installment is forthcoming…stay tuned!

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Bob Merriman, recognized leader of enrichment technologies who received a number of prestigious awards for his work in the nuclear fuel cycle