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Statement of
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Before the
Committee on Science and Technology
Subcommittee on Energy Research and Production
U. S. House of Representatives
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ADVANCED URANIUM ENRICHMENT TECHNOLOGIES

Madam Chairman, members of the Committee, it is a pleasure for me to be here today and describe the advanced technologies the United States is pursuing for uranium enrichment. These are the Advanced Gas Centrifuge (AGC) and Atomic Vapor Laser Isotope Separation (AVLIS) methods. These programs have excellent momentum and potential, and they comprise an important element of the United States' uranium enrichment business.

Looking broadly at the U.S. enrichment activities today, the Gas Centrifuge Enrichment Plant (GCEP) construction project continues to proceed very well. Private industry has now invested over \$100 million in centrifuge manufacturing facilities. A new initiative has been taken in the AGC program to begin a major effort to deploy in GCEP high-performance centrifuges made from advanced materials. The AVLIS process was selected for full-scale development and demonstration in the Advanced Isotope Separation (AIS) program competition, and a revised proposal for demonstration and deployment of AVLIS has been submitted. Meanwhile, important cost savings are being realized in the operation of the gaseous diffusion complex via some cost-reduction/productivity improvement programs. These actions are reflected in the recent announcement that there will be no increase for this pricing period in the cost of U.S. enrichment services.

The last several months have seen some significant events in the uranium enrichment business climate as well. The projected demand for U.S. enrichment services has exhibited some additional shrinkage due to continued curtailments in nuclear programs and aggressive competition. In this regard, competition from non-U.S. enrichers, notably Eurodif, has become more intense; and worldwide oversubscription of enriching services has created a secondary market which is adding to the competitive pressures. Today the U.S. enrichment program is fighting loss of market share from strong price competition in an arena where worldwide capacity exceeds projected demand. We understand the U.S. objective to be to protect and, to the extent possible, expand this \$2-3 billion/yr U.S. business, one-third of which has a positive impact on our balance of payments picture and which enhances U.S. influence in the nuclear fuel cycle. While we need to ensure long-term flexibility to respond to shifts in requirements, our current focus is not so much on more SWUs for the 1990s, as it was in the mid-1970s when the gaseous diffusion capacity expansion was under way and GCEP was started, but on cheaper SWUs for the 1990s. We are concerned that we cannot remain competitive in the marketplace so long as our production is exclusively provided by energy-intensive gaseous diffusion plants.

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Therefore, we see the DOE program being geared toward displacing gaseous diffusion capacity with more cost-effective production methods. Our major tools in this competition are the traditional ones where the U.S. enrichment program has always excelled: advanced uranium enrichment technologies. Today there are two very attractive technologies--AGC and AVLIS.

I am pleased to have this opportunity to describe the AGC and AVLIS programs for you. As requested, I will summarize the status and potential of the technologies, outline the programs, briefly note the economic incentives as we see them today, and describe how the advanced technologies, once demonstrated, might be deployed so that SWU costs in the 1990s can be significantly reduced.

THE ADVANCED GAS CENTRIFUGE PROGRAM

The objective of the AGC program is to develop, demonstrate, and deploy machines having separative capacities well above that of the initial Gas Centrifuge Enrichment Plant (GCEP) machine on a schedule which will permit their use in GCEP to achieve a reduction in U.S. SWU costs. The initial GCEP machine, the Set III machine, represents a demonstrated technology, which was targeted to be more economic than gaseous diffusion when deployed on a commercial scale. While the purpose of this statement is to summarize the AGC and AVLIS programs, a brief comment on the status of the Set III machine will provide a useful point of departure.

The gas centrifuge program achieved a major milestone in September 1982, when the Centrifuge Plant Demonstration Facility (CPDF) was placed in operation in Oak Ridge. The CPDF is a unit cascade of Set III machines which will be replicated many times in GCEP; i.e., it is the basic GCEP building block. All of the machines and most of the other hardware were procured from industrial firms. Since the start-up, cascade operation has been continuous with only short interruptions. To date, the cascade has operated above the GCEP design levels of performance and availability. The reliabilities of the cascade and the machines have so far exceeded the expectations projected for the Portsmouth plant. This accomplishment confirms the commercial readiness of the centrifuge machine and plant equipment and of the industrial manufacturing capability. A view of the CPDF cascade is shown in Chart 1. The CPDF is operating well, providing important data, and producing SWUs.

The key component of a gas centrifuge is its rotor. In general, separative capacity is increased and the cost of SWUs is decreased by building long rotors and spinning them as fast as possible. Practically speaking, the length is limited by the ability to balance and stably operate high-speed machines which pass through flexural criticals as they are driven up to operating speed. The speed is limited by materials physical properties, coupled with design/manufacturing practicalities.

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CPDF-THE CENTRIFUGE PLANT DEMONSTRATION FACILITY

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Chart No. 1

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The two primary objectives of the AGC program are to exploit the potential capabilities of the current GCEP rotor material and of advanced materials:

1. One objective is to operate in 1983, and thoroughly demonstrate in 1984, a machine design (Set IV) which has a capacity of 1.5 times that of the Set III machine.
2. A second objective is to demonstrate in the 1986/1987 time frame a machine (Set V) which has a capacity of two to three times that of the Set III machine. This machine will employ advanced materials. An in-depth technical and economic assessment of this program in 1984 will be used to reevaluate this objective and to help define the most advantageous deployment scenario for the Set V machines.

These machines are being designed to be used in GCEP as initial fill and/or retrofit units.

The AGC program is a joint effort involving the entire U.S. centrifuge development/commercialization community, i.e., Union Carbide Corporation, Nuclear Division (UCC-ND), the University of Virginia (UVa), Boeing Engineering and Construction Southeast, Inc. (BECSI), Goodyear Aerospace Corporation (GAC), AiResearch Manufacturing Company (AMC), and Electro-Nucleonics, Inc (ENI). These organizations all have many years of experience in the gas centrifuge program. UCC-ND has been selected by DOE as the lead contractor for the AGC technical effort and as the AGC machine design integrator.

Set IV Program

The primary thrust of the Set IV program is to take full advantage of the capability of the current rotor material mainly by increasing the speed. Machines have already operated at 1.4 times the Set III performance level. The dynamic behavior and balance of the Set IV rotors already tested have been satisfactory.

We are well into the concept demonstration phase of the program and are essentially at the point where the final geometry and features of the Set IV machine will be chosen and integrated into a design package for use in fabricating the design verification machines for the Set IV demonstration in 1984. The next step toward deployment of Set IV machines would be reliability testing, which is scheduled to begin in 1985.

In summary, significant progress has been made in achieving the Set IV performance target, and the program is progressing well as it moves into the demonstration phase. Because of the substantial experience with rotors of this type, there is high confidence in the success of the Set IV effort.

Set V Program

Advanced materials which are now available offer the potential for significantly improving the performance of gas centrifuges. Recognizing

this potential, UCC-ND, AMC, BECSI, GAC, and UVa submitted a joint program proposal directed toward exploiting this potential to DOE in September 1982. This proposal is based on the consensus judgment that " . . . these are the materials of the future for the centrifuge." Key elements of the proposal are a strong, aggressive basic materials technology and advanced centrifuge machine technology effort by UCC-ND in concert with parallel development of alternative rotor manufacturing techniques by the three centrifuge manufacturers. Key milestones include verifying the basic potential of achieving target speeds in 1983 (which has been accomplished), building and operating both short- and full-sized rotors manufactured using different candidate approaches in 1983 and 1984, acquiring sufficient technical and performance information by 1984 to permit an in-depth assessment of deployment potential and options, and demonstration of Set V machines in the 1986/1987 time frame.

In December 1982, DOE approved the program. Good progress is already being made by each participant. While the development program will be technically challenging, especially during the next 2 yr, the potential benefits justify the effort, and confidence in a successful Set V demonstration in 1986/1987 is high.

THE ATOMIC VAPOR LASER ISOTOPE SEPARATION PROGRAM

The objective of the AVLIS program is development, demonstration, and deployment of a version of this technology capable of meeting the DOE AIS program target of providing process costs $\leq \$40/\text{SWU}$. AVLIS was one of three AIS processes pursued competitively by DOE in the 1970s. In April 1982, AVLIS was selected by the DOE Process Evaluation Board (PEB) as having the best potential for and least risk in meeting the AIS program objectives. The high selectivity of AVLIS distinguishes it fundamentally from either the gaseous diffusion or gas centrifuge process. The use of uranium rather than UF_6 as the process working medium is, of course, another difference.

The AVLIS program is being implemented by an integrated joint team comprised of representatives from the Lawrence Livermore National Laboratory (LLNL) and UCC-ND. LLNL is currently the lead laboratory. These two organizations have collaborated on AVLIS development since the inception of the program in the mid-1970s.

The two major hardware assemblies of the AVLIS process are the separator and laser subsystems. Independent development and demonstration facilities for each of these subsystems are now reaching the point where work is proceeding or can soon proceed on production scale systems. Chart 2 illustrates some of the key separator and laser systems and facilities now in the program.

In selecting AVLIS, the DOE PEB stated that " . . . there is reasonable probability that the AVLIS process can achieve enrichment costs at less

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SOME AVLIS FACILITIES

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(A)

(B)

(C)

(D)

- (A) THE MATERIALS HANDLING DEMONSTRATION MODULE
- (B) A PLANT-SCALE COPPER VAPOR LASER
- (C) DIAGRAM OF THE HIGH POWER LASER FACILITY
- (D) THE SIS LABORATORY

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than the economic goals set for the AIS program," but noted a significant concern with "... the thermal control performance of the liquid uranium collector." Since process selection, significant progress has been made in resolving the thermal control issue. Also, advances in laser technology and engineering have continued. In addition, AVLIS is being supported within the defense program area for Special Isotope Separation (SIS). Included in the SIS program is construction of a laboratory facility at Livermore (SISL) and the funding of lasers, both of which have basic applicability to uranium isotope separation.

Considering these factors, in January 1983, LLNL and UCC-ND submitted a joint proposal to DOE for rapid demonstration and deployment of AVLIS.

The previous AVLIS program plan was based on the construction of a Development and Demonstration Module (DDM) beginning in FY 1984, with full-scale demonstration and engineering technology confirmation scheduled for 1990. The new proposal combines the most important engineering design features from the DDM in SISL, which is now under construction, to perform technology and engineering demonstration by the 1986/1987 time frame, which is about 3 yr earlier than in the previous plan. The SISL demonstration will be roughly equivalent from a technical standpoint to the demonstration that would have been done in the DDM. In combination with off-line life tests and subsystem prototype facilities and with the detailed production plant engineering design which is also planned, (beginning now with conceptual studies for the next 2 yr and progressing then to formal detailed design), this demonstration will confirm technology performance and establish associated economic parameters, permitting a good deployment decision. The detailed production facility design will not only help guide the technical efforts and provide the necessary cost information but would also expedite deployment.

To sum up, the key AVLIS milestone in the recently proposed program is a process demonstration using production scale hardware which is accompanied by a good engineering basis in 1986/1987. This demonstration package, if successful, could give DOE the opportunity to deploy AVLIS in the early 1990s. We believe these goals are achievable, and that the benefits justify the proposed effort.

POTENTIAL ECONOMIC IMPACTS OF AGC AND AVLIS

Both the AGC and AVLIS programs are pointed toward significant technical demonstrations and detailed economic evaluations in the 1986/1987 period. This will enable decisions about deployment of either (or both) of these advanced processes. In looking ahead, it is useful to consider the economic incentives for these new technologies, to help guide our programs and our allocation of resources.

Present gaseous diffusion costs are on the order of \$100/SWU, most of which reflect electric energy costs. (Present U.S. SWU prices are ~\$140 to 150/SWU since other items, such as imputed interest on stockpiles and construction funds, are included.) With significant competition in the

\$100 to 125/SWU range, the benefits of the advanced technologies seem evident. We believe that the AGC and AVLIS technologies offer the potential of cutting our costs by a factor of 2 to 3, relative to gaseous diffusion, and this provides a good basis, we think, for their emphasis. The U.S. program, therefore, is faced with achieving a transition from gaseous diffusion production to more cost effective processes. The present DOE program includes emphasis on cost reduction in gaseous diffusion operation, phasing in of GCEP, and demonstration of AGC and AVLIS. This is potentially the most powerful competitive package in the world, but care must be taken in managing the transition. This will require, in my view, continuing an open, constructive, cooperative effort by the technologists, industry, the Administration, and the Congress. It would not be prudent to shut down gaseous diffusion plants until sufficient operational experience is gained with the "next" process. Similarly, it would not be prudent to stop the present GCEP project without a hard-nosed demonstration of AGC and/or AVLIS of the types proposed in those two program plans. On the other hand, it would also be unwise to put such low emphasis on AGC and AVLIS that their potential impact in the marketplace is preempted. We are fortunate to have an opportunity to make good decisions now since there is no compelling market situation which is currently driving us toward more capacity.

SUMMARY

In this very complex picture, which will require continuing evaluation over the next several years, there are no simple answers. In this vein, the following concluding comments are offered:

1. Heavy competition in a reduced SWU market emphasizes the need to assure low-cost SWU production for the 1990s, not necessarily more SWUs. The current market situation does not compel us to add new capacity, so that there is an opportunity to evaluate all our options carefully.
2. The gaseous diffusion process represents a solid, reliable technology, but its high demand for power makes it less economically attractive for the longer term. The transition away from gaseous diffusion should, however, be a deliberate one.
3. The ability to install and to retrofit improved centrifuges in GCEP enhances its economic attractiveness. Gas centrifuge technology has significant potential for improvement which can be exploited in this manner. GCEP, with a full complement of Set IV machines, will result in a long-term reduction in SWU cost relative to gaseous diffusion. For these reasons, construction of GCEP should be continued in a manner which preserves a good capability to continue to deploy advanced gas centrifuges.
4. The Set V AGC, if deployed in GCEP, appears now to offer potential for reducing even further the cost of SWUs from GCEP. Accordingly, the AGC development and demonstration program should continue to be fully supported. To the extent possible, near-term GCEP project

decisions should be made that will leave open the option of rapid AGC deployment if warranted on the basis of the planned 1986/1987 Set V demonstration.

5. Although the AVLIS process is at an earlier stage than the gas centrifuge, it appears to offer the best potential for further reducing SWU prices in the 1990s if successfully demonstrated. Fundamentally, we believe that this process, when demonstrated and deployed, will not be matched by our competitors in this century. Therefore, the AVLIS demonstration program, including both the SISL performance demonstration and the detailed production plant engineering design necessary to establish process economics and expedite deployment, should be fully supported.
6. Neither AGC (Set V) nor AVLIS is sufficiently developed and demonstrated at this time to warrant commitment to production. However, both the AGC and the AVLIS technology development programs are structured to emphasize obtaining sufficient key technology evaluation data by the 1986/1987 period to allow a firm assessment of their real-world performance capabilities and attractiveness for production use in the early 1990s. The data acquired in the next few years will provide the bases for choosing between the two technologies and for directing emphasis to provide the lowest practical SWU prices in the early 1990s. We believe the key to cost effective, competitive enrichment in the 1990s and beyond lies in the exploitation of our advanced enrichment technologies. Therefore, it is important that these efforts be very strongly supported at least through the 1986/1987 demonstration.