SIGMA: THE NOVEL APPROACH OF A NEW NON-PROLIFERATING URANIUM ENRICHMENT TECHNOLOGY

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Abstract

The SIGMA concept, under development by Argentina, represents the evolution of the Uranium Enrichment Gaseous Diffusion technology, updated to face the challenge of the new economic-based and competitive world frame.

The Enrichment technology has been historically considered as a highly proliferating activity in the nuclear field, and central countries limited the access of the developing countries to this technology.

The SIGMA concept incorporates innovative proliferation resistant criteria at the beginning of the design process, and inherits all the non-proliferation features of the gaseous diffusion plants (GDPs). The radical new proliferation resistance approach of the SIGMA technology suggests a new kind of global control of the uranium enrichment market, where some developing countries might access an Enrichment plant without access to the technology itself.

In this paper, we investigate the economy of the SIGMA plants, and the implications of this technology on the Uranium Global Market.

Introduction

It is a well known issue that in the future, a strong demand for nuclear energy will be focused in developing countries, and the enrichment demand of these countries will produce a political interference between natural market forces and political constrains.

Market forces in developing countries usually try to move commercial activities with high capital requirements to demand centers (developing countries too for nuclear energy). Then proliferation issues will be under strong pressure to take into account that present projections predicts for the year 2040 nuclear energy in developing counties will be higher than in developed countries.

This issue could evolve in the worst case scenario due to technology evolution.

Present commercial Uranium enrichment technologies were developed for military Highly Enriched Uranium (HEU) production. Ultracentrifuges came from Russian HEU technology, GDP came from US HEU production, and laser AVLIS technology came from the PuAVLIS US project. All the designers, trying to improve the economics for the new generation of enrichment technologies, look to increase the separative factor and reduce the Uranium hold up, increasing the potential proliferation risk of all these future technologies.

Gaseous diffusions plants

Construction of GDPs was started during World War II to produce enriched uranium for defense purposes. These plants were used primarily for this purpose through 1964. From 1959 through 1968, uranium enrichment production shifted primarily to supply the nuclear power industry.

Increase in capital charge, electric power supply and interest rates, shifted competitiveness to centrifuge enrichment plants.

This economic behavior is mainly produced by the component scale economy and the decrease of compressor efficiency at low flow stages. A GDP cascade has thousand of stages in series, in which higher enrichments have lower mass flow. The smallest flow stages are the most expensive per SWU (higher component costs with less compressor efficiency). Thus a GDP will be competitive when the smallest stages are competitive. This usually happens in GDP cascade configuration for a 3 MSWU/year capacity.

This behavior could be seen as a cascade paradigm, because it is generated for the cascade concept itself, with small dependence on technology.

SIGMA Concept

At present, the excellent experience in gaseous diffusion cannot be used for new plants due to the strong capital restrictions of large economical plants and the relative flexibility of ultracentrifuge technologies. Then, in order to obtain a competitive gaseous diffusion technology, efforts must be focused on capital cost reduction and economy at low scales production, short construction time, and lower energy consumption.

The SIGMA concept solves all these targets introducing several technological solutions, but using the well-known gaseous diffusion experience. It overcomes the problem of large volumes needed to obtain good economic performance at the smallest stage sizes (the cascade paradigm). A new modular design is able to manufacture, assemble and commission into a proper installation, to be finally send to the final site. The SIGMA concept allows optimum size for major component standardization.

For the SIGMA approach, reduction of the proliferation risk is a central issue in the future nuclear energy market and then has been included in the design. The Gaseous Diffusion Technology has low potential attractiveness for HEU production, but relatively high diversion capabilities of high LEU mass. The SIGMA concept has been developed in order to easily reduce the proliferation risk to a near-zero value. The design includes a low cost detector for total neutron count and an optimized geometry for gamma-neutron detection. A commercial scale module is designed to obtain a maximum enrichment grade of 5%, so it could not be used for HEU production.