SIEMENS

TECHNOLOGY TRANSFER AND COOPERATION IN THE NUCLEAR FUEL AREA

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ABSTRACT

Siemens is a full-range supplier in the area of nuclear power generation with broad experience and activities in the field of nuclear fuel.

Siemens has developed advanced fuel technology for all types of fuel assemblies used throughout the world and has significant experience worldwide in technology transfer in the field of nuclear fuel. Technology transfer and cooperation has ranged between the provision of mechanical design advice for a specific fuel design and the erection of complete fabrication plants for commercial operation in 3 countries.

In the following the wide range of Siemens' technology transfer activities for both fuel design and fuel fabrication technologies are shown.

ÖZET

Siemens, nükleer yakıt sahasındaki geniş tecrübesi ve faaliyetleri ile nükleer güç üretimi alanında büyük çaplı bir satıcıdır.

Siemens, dünyada kullanılan bütün yakıt elemanı tipleri için, ileri yakıt teknolojisi geliştirmiş ve nükleer yakıt alanında teknoloji transferi konusunda engin bir tecrübeye sahiptir. Üç ülkeye, spesifik yakıt dizaynı için mekanik dizayn danışmanlığı sağlanması ve ticari amaçlı komple yakıt üretim tesisi alanlarında teknoloji transferi ve işbirliği sağlanmıştır.

Bu bildiride, yukarıda bahsedilen Siemens'in teknoloji transferi faaliyetlerinden yakıt dizaynı ve yakıt üretimi teknolojileri gösterilmiştir.

1. Introduction

150 years of Siemens - 40 years of Nuclear Power in Germany: From the beginning the peaceful use of nuclear power in Germany is closely connected with the name of Siemens. That means Siemens has been leading in the supply of Nuclear Power Plants for safe and economic generation of electric power.

And from the beginning of the peaceful use of nuclear power one of the typical features of the nuclear business has been cooperation which also means transfer of know-how in mutual trust. In the fifties know-how on nuclear power for commercial use was transferred from USA to Europe. Since then it has spread more and more over the world: Cooperation is a keyword in the area of nuclear power.

2. Siemens as a worldwide Cooperation Partner

Among the world's largest electrical companies with international nuclear activities the Siemens AG ranks behind General Electric but far ahead of Westinghouse or the ABB-CE Group as shown in Fig. 1. The Siemens AG with an order volume of more than one hundred billion DM is divided into 16 groups or business units as outlined in Fig. 2. Each unit is solely responsible for their respective business area and acts independently as a profit center.

One of these 16 business units is Power Generation KWU presently with an order volume of about 10 billion DM per year. Historically, Kraftwerk Union AG was founded on April 1, 1969 by merging the power plant engineering departments and the turbine and generator manufacturing plants of the Siemens AG with these of the Allgemeine Elektricitäts-Gesellschaft AEG. On January 1, 1977 the Siemens AG acquired all of AEG's shares in KWU AG, and on October 1, 1987 KWU was fully integrated into the Siemens AG. The KWU Group has built or has on order a total of 36 nuclear power plants with a total capacity of 32,800 MW. All of these plants with the exception of three have been supplied under turnkey contracts.

The KWU Group's business areas are outlined in Fig. 3 and comprise the supply of power plants and facilities of all types for the production of electricity, district heating and process heat using nuclear, fossil and renewable energy sources. The scope of services covers customer consulting, supply of components and subsystems, erection and commissioning, up to turnkey erection of power plants.

The business areas of the KWU Power Generation Group are:

- Conventional Power Plants for fossil energy sources, e.g. combined-cycle (steam and gas turbine) power plants
- Conventional Power Plants for renewable power sources
- Nuclear Power Plants
- Nuclear Fuel Cycle including back-end
- Power Plant Components, in-house manufactured and externally manufactured
- Power Plant Services for nuclear and fossil installations

Among the business areas of Power Generation KWU the Nuclear Fuel Cycle Division plays an important role. The Nuclear Fuel Cycle Division is one of the three world leaders in Uranium fuel fabrication and has a considerable share also in the fabrication of Mixed Oxide Fuel. The Products and Services are shown in Fig. 4 and Fig. 5. The present market share is outlined in Fig. 6.

The Nuclear Fuel Cycle Division has an international reputation and experience in the area of Technology Transfer to and Cooperation with partners all over the world. In this area many projects have been or are very successful in efficiently transferring and implementing nuclear

fuel technology in various countries as outlined in Fig. 7. Needless to say that in all cases international regulations and safeguards agreements have been observed.

3. The Concept for Technology Transfer and Cooperation

Technology Transfer and Cooperation covers the areas of nuclear fuel element design and engineering, in-core fuel management and respective safety analysis for the complete power plant, the supply of fuel assembly components as well as fuel manufacturing technology, supply of fabrication equipment and design, erection and start-up services for a fuel fabrication plant as outlined in Fig. 8. Based on the specific interests and needs of the partner the scope, the time period and the contractual concept of a Cooperation agreement are jointly defined and agreed upon.

3.1 Technology Transfer for Fuel Fabrication

The technology transfer can cover all areas of fuel fabrication and will be outlined in the following on a typical Cooperation scheme for the erection, start-up and operation of a fuel fabrication plant. For such a technology transfer the following elements are available:

3.1.1 Erection of a fuel fabrication plant

The erection of a fuel fabrication plant can be divided into the Basic Engineering and the Detailed Engineering phases:

In the frame of the Basic Engineering phase Siemens provides the plant layout for the required capacity, the equipment lists for powder production, pelletizing, fuel rod production, fuel assembly assembling, spacer and structural component manufacture and the respective laboratory and test equipment as well as engineering services for the civil construction and the supply systems.

During the Detailed Engineering phase engineering services for the procurement of the fuel fabrication equipment, the definition of local equipment, meaning equipment procured within the receiving country, and foreign equipment, meaning the equipment procured outside the receiving country, are performed. This Detailed Engineering phase usually also covers the erection and installation services for the foreign and local equipment, the start-up of the plant and the field tests and the commissioning and licensing assistance.

The cooperation partner is responsible for the provision of the site, the performance of the civil construction, the infrastructure for the power supplies, the provision of local equipment, local erection and installation services and the selection and provision of the plant management and operating staff.

The main activities for fuel fabrication technology transfer and localization is shown in Fig. 9.

3.1.2 Training of Personnel

Based on the experience of the recruited personnel a training program covering class room training, training on the job in Siemens fuel fabrication facilities and thereafter at the equipment within the newly erected plant during the installation and start-up phase in fuel fabrication the necessary quality control and maintenance and, if requested, over a longer time interval after start of production is defined together with the plant operator. Such training programs range from a few man-years up to 60 man-years of training time.

3.1.3 Transfer of Documents and Technical Assistance

The technology transfer is supported by the provision of all documents needed for a quality determined and economic fuel fabrication. It comprises e.g. the process descriptions, the manufacturing and quality control instructions, associated quality management documents and maintenance instructions and documents.

Technical assistance services offered as well cover the complete area of possible topics. The scope of services in detail can be agreed upon depending on the specific requirements of the cooperation partner.

3.1.4 Contractual Arrangements

For such a fuel fabrication plant project typically the following contracts are agreed upon

- Engineering Services Contract covering the Basic and Detailed Engineering Services
- Equipment Supply Contract for foreign equipment
- Technical Information Contract covering the transfer of documents and the training services

Naturally these contractual arrangements are adapted to the specific needs and requirements of the cooperation partner.

3.2 Technology Transfer for Design and Engineering

The range of Siemens fuel designs extends from 14x14 to 18x18 lattice configurations for PWR and from 6x6 to 10x10 lattice configurations for BWR. These varied designs reflect on the one hand the continuing development of Siemens fuel technology and on the other hand the customers' diverse and different requirements which can be met by a tailor-made fuel design.

Siemens most advanced fuel designs stand out due to their excellent operating performance in the past and are most suited for the present and the future burnup range economically achievable. In general, Siemens designs exhibit failure rates considerably below the standard in the nuclear industry worldwide today as outlined in Fig. 10. This record is based on a continuously high R&D effort in most cases performed in in-house facilities thus securing timely performance of R&D tasks in accordance with the actual needs.

Extensive know-how gained and used worldwide as well as broad experience in licensing fuel assemblies and performing safety analyses form the basis for being an attractive partner in the area of technology transfer and cooperation

Based on this background Siemens offers Technology Transfer for nuclear fuel covering the areas of

- mechanical design and engineering
- nuclear design
- thermal-hydraulic design
- in-core fuel management
- safety analysis
- joint R&D programs

The transfer of know-how can be performed via

- class room training
- on the job training
- transfer of documents
- joint design work
- technical assistance services

Class room training, as well as on the job training, covers all the above areas of fuel design technology.

With respect to the range of know-how to be transferred the transfer of documents includes a wide-spread range of data carriers such as drawings, specifications, quality management procedures, interface instructions for the fabrication of fuel rods and the fuel assembly, the fuel rod and fuel assembly components, transport instructions for fuel assemblies, repair procedures and inspection procedures, technical reports such as fuel rod design reports, fuel assembly design reports, nuclear design reports, fuel management reports, safety analysis reports, topical reports, verification reports, computer codes including the respective manuals etc. etc.

A highly efficient way of design technology transfer is the Joint Design of fuel assemblies: By means of the Joint Design, partners' engineers participate in all design activities for a specific project at Siemens in Erlangen under Siemens' responsibility. This work can be divided into two steps: During the first step - the Preliminary Joint Design (within about two years) - all manufacture-related documents and licensing reports (e.g. topical reports, verification reports, fuel design reports, reload transition safety reports) are completed. In the second step - the Final Joint Design - all plant- and cycle-specific documents, e.g. nuclear design report, reload safety evaluation report etc. are prepared jointly by Siemens and partners' engineers, based on the documents generated in the first phase. During the whole Joint Design phase the partners' engineers become thoroughly familiar with Siemens' proven design tools and methodology.

Thus the cooperation partner gets able to start independent design work on fuel assemblies while Siemens assists in reviewing the independent design work results for a period of time if required: These technical assistance services are defined according to the needs of the cooperation partner.

The scope of technology transfer in this area is carefully defined together with the customer and usually a Technical Information Contract for the transfer of the documents, for training services or joint design work including technical assistance is concluded. Joint R&D programs are covered under separate agreements.

4. Technology Transfer and Cooperation Partners

The Technology transfer schemes as outlined in chapter 3 have been successfully applied to numerous cooperation agreements all over the world as already highlighted in Fig. 6. With partners like CNEA in Argentina, INB and NUCLEN in Brazil, KNFC and KAERI in Korea, ABB in Sweden, B&W in USA and NFI in Japan successfully implemented cooperation agreements have so far led to the transfer of millions of pages of technical documents, to nearly 150 man-years of training in the area of design and engineering of nuclear fuel, to more than 50 man-years of training in the fuel fabrication area and to joint design work for 6 Nuclear Power Plants.

5. Conclusions

Siemens Nuclear Fuel Cycle Division offers concepts for Technology Transfer and Cooperation which are tailor-made to the needs of the respective partner worldwide. The experience so far with these concepts shows a positive record and satisfaction at the side of the partners. Siemens Nuclear Fuel Cycle Division is prepared to continue to be a partner for technology transfer and is open to enter new agreements.

World's Largest Companies with International Activities in the Nuclear Fuel Cycle

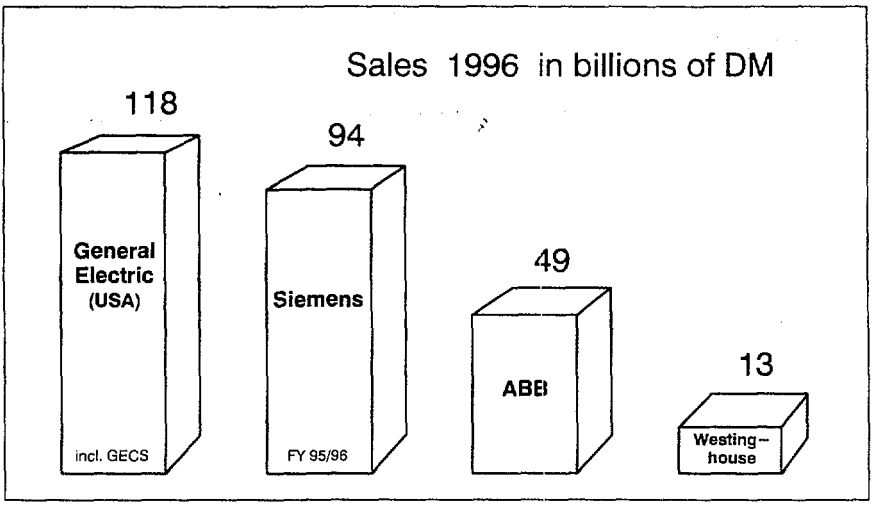

Fig. 1: The Big Four

BVA/Ro/1997/07/010E

Customer-oriented organization

Managing Board

Groups

Power Generation (KWU)	Power Transmission and Distribution (EV)	Industrial and Building Systems (ANL)	Drives and Standard Products (ASI)	
Automation (AUT)	Public Communication Networks (ÖN)	Private Communication Systems (PN)	Defence Electronics (SI)	
Transportation Systems (VT)	Automotive Systems (AT)	Medical Engineering (Med)	Semiconductors (HL)	
		Separate legal units		
Passive Components and Electron Tubes (PR)	Electromechanical Components (EC)	Siemens Nixdorf Informationssysteme AG (SNI)	Osram GmbH	

Corporate departments

- Finance (ZF)
- Human Ressources (ZP)
- Technology (ZT)
- Planning and Development (ZU)
- Corporate Communications (UK)
- Economics and Corporate Relations (WPA)
- Corporate Purchasing and Logistic (EL)
- Infrastructure Services (ID)

as of January 1, 1997

Regional organization International Siemens companies, regional offices, sales companies, representative offices, agencies

Fig. 2: Siemens - The Company '97

3 · 97

Outline of Product Spectrum

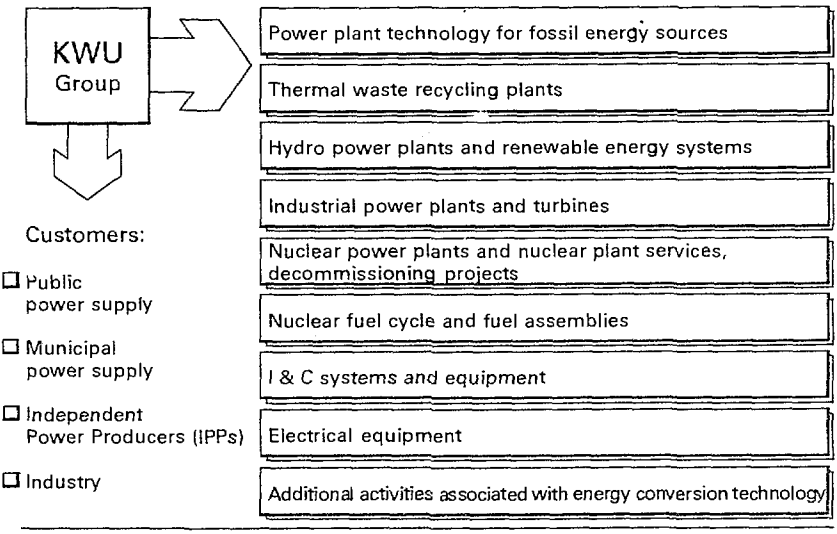

Fig. 3: KWU Group Products

KWU 970016e

Nuclear Fuel Cycle and Fuel Assemblies

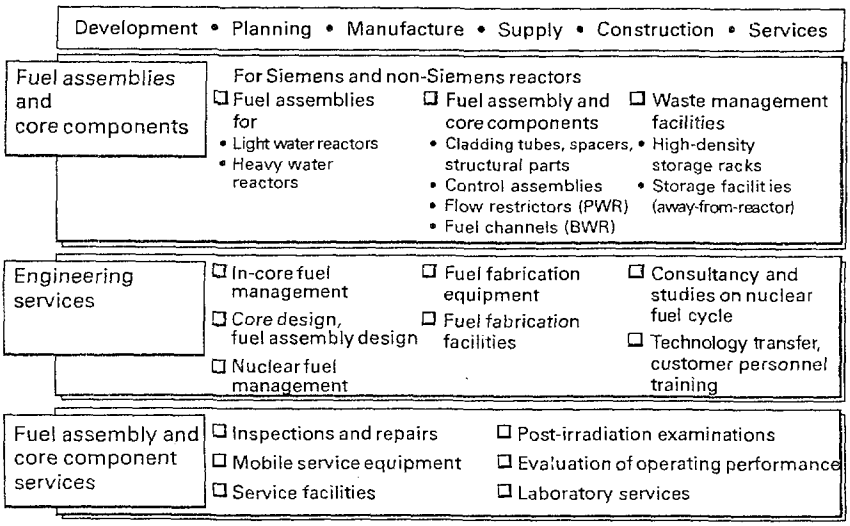

Fig. 4: KWU Group Products

KWU 970031e

Siemens Fuel Assembly Technology Worldwide

119 Nuclear Power Plants in 16 Countries

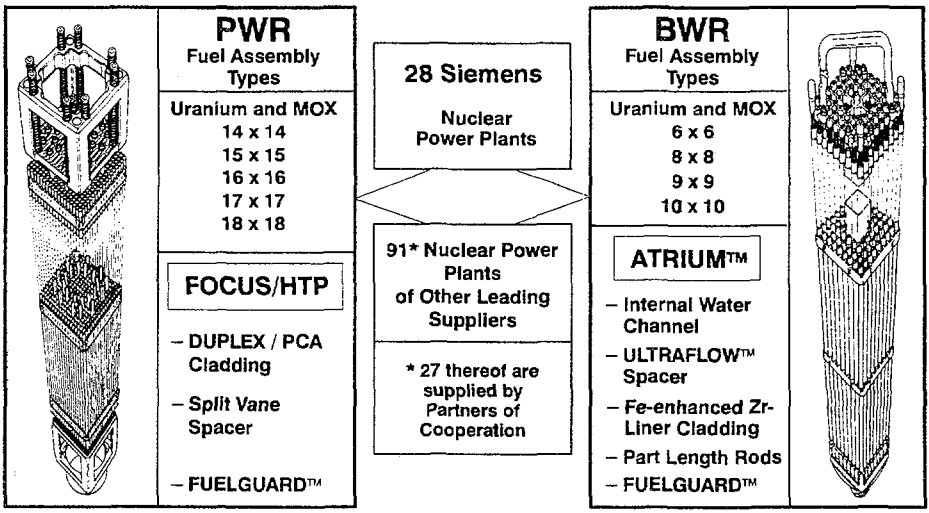

Fig. 5: Siemens Fuel Technology

BV1/Re/1995/08/002aE

Siemens is worldwide the No. 2 (FY95/96)

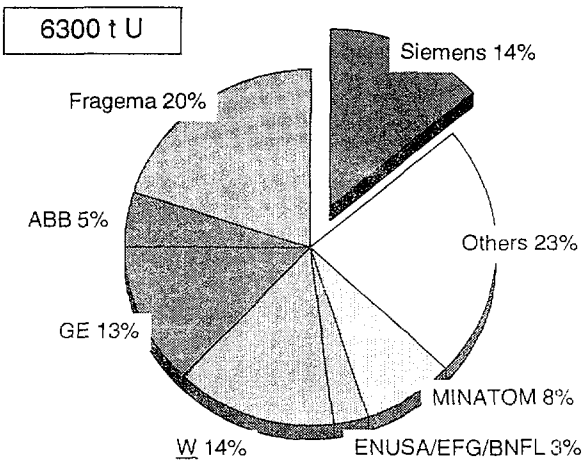

Fig. 6: Market Shares

BVA/A&M
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International Cooperation

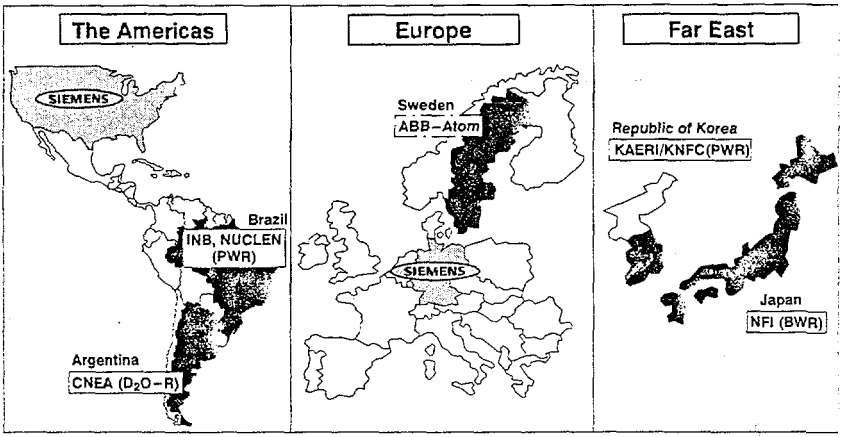

Fig. 7: Cooperation Projects

Know–How Transfer and Cooperation

Nuclear Fuel and Core Components

Software	Manufacturing	Erection of Fuel Fabrication Plants
– Design and Engineering for Fuel Rods, Fuel Assemblies and Core Components – Nuclear Core Design – Safety Analysis – Transfer of Documents and Codes – Quality Assurance – Joint R&D Programs	– Training of Personnel – Supply of Components – Transfer of Documents	– Basic Engineering – Detailed Engineering – Erection and Start–up Services

Fig. 8: Areas of Know–How Transfer and Cooperation

Fuel Fabrication Technology Transfer and Localization

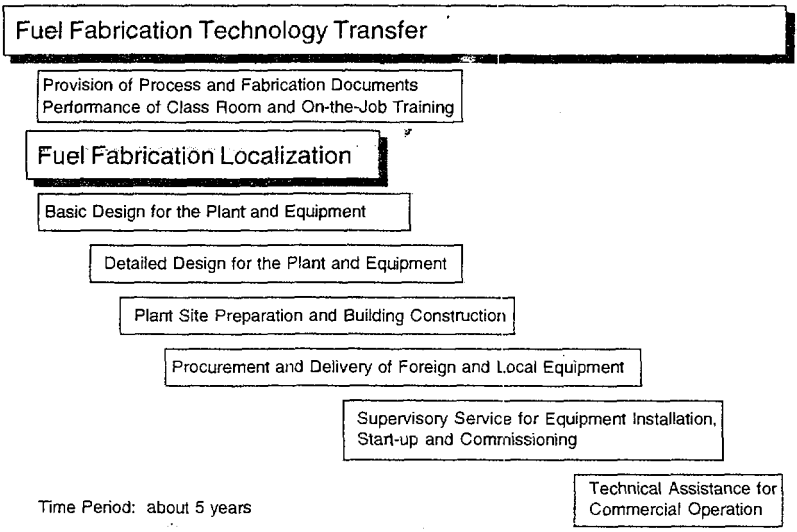

Fig. 9: Main Activities in a Fuel Localization Project

Operational Performance of Siemens Fuel

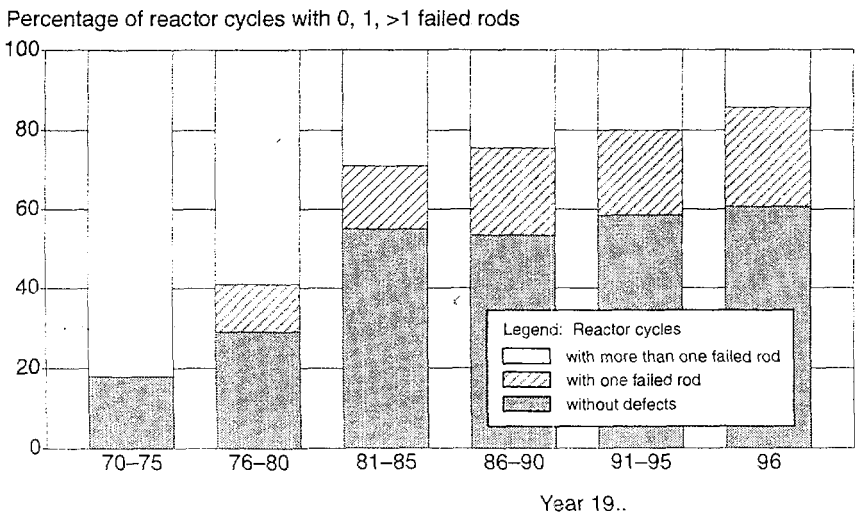

Fig. 10