D.6. THE EUROPEAN COMMUNITY PROJECTS

D.6.1. IMPACT OF ACCELERATOR BASED TECHNOLOGIES ON NUCLEAR FISSION SAFETY - SHARE COST PROJECT OF THE EUROPEAN COMMUNITY

D.6.1.1. INTRODUCTION

Over the last few years the interest in ADS has grown in many European countries. As a result of this some European institutes have decided to establish a shared cost project in the framework of the European Community. The overall objective of this project is to make a European assessment of the possibilities of accelerator-driven hybrid reactor systems from the point of view of safe energy production, minimum waste production and transmutation capabilities. In particular:

a) **to perform system studies on accelerator driven hybrid systems**

b) **to assess the accelerator technology**

c) **to study the radiotoxicity of the fuel cycle for ADS and its nonproliferation aspects**

d) **to provide basic nuclear and material data for ADS by means of evaluation and experiments**

The final objective is to concentrate and coordinate different efforts from member states to create a European scientific and technological basis for further projects aimed at developing environmentally friendly, more publicly acceptable and safer nuclear fission energy sources. The final results will be models, tools, validated routines and some new experimental data for future experimental activity on a larger scale.

D.6.1.2. WORK CONTENTS

This project is divided into 4 tasks presented in Fig. 1:

1. system studies on the accelerator driven hybrid
2. assessment of the accelerator technology
3. basic nuclear and material data
4. studies of the fuel cycle for ADS

Task 1: System studies of an accelerator driven hybrid

System studies will be focused on the following systems :

a) Energy production using the Thorium fuel cycle

b) Energy production using LWR spent fuel and burning of TransUranium elements

c) Dedicated Plutonium burning with energy production

d) Transmutation of fission products combined with burning of TransUranium elements

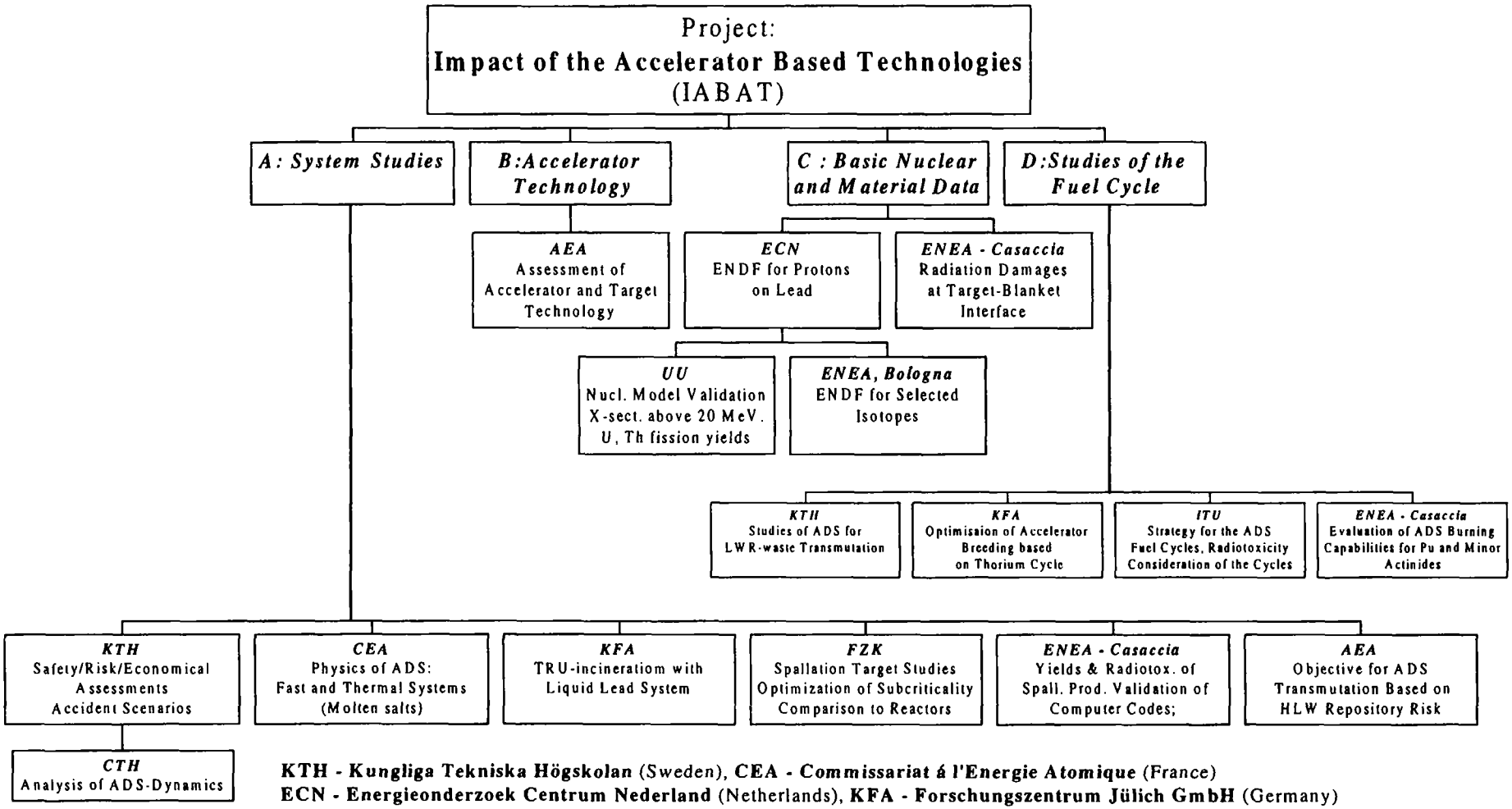

FIG. 1 Task structure of the European project: Impact of the Accelerator Based Technologies on Nuclear Fission Safety

These studies will be performed for thermal, fast and intermediate neutron energies to optimize the performance of the system. The neutron energy range strongly determines the choice of the materials used for the coolant and reflectors/moderators and requires multidimensional optimization which has to be performed in respect of material compatibility, engineering aspects, corrosion, safety, economy and other factors.

In Europe large quantities of Pu from reprocessed spent LWR fuel are available. These can be recycled to some extent in existing LWRs using the MOX option, or by using fast reactors. However, multiple recycling of MOX in thermal reactors is not very efficient in LWRs. The possibilities of using recycled Pu in hybrid systems will be investigated.

It is also very important for Europe to monitor and, if required, to help to destroy excess Russian weapons Plutonium. Therefore the potential of **ADS** to efficiently burn weapon Plutonium with a simultaneous energy production has to be investigated.

The spallation target will be chosen and optimized with respect to proton energy, neutron production, thermodynamics and radiotoxicity of spallation products.

The safety/risk assessment of the different ADS will be performed and reference scenarios for severe accidents will be worked out for these different systems. Optimization of the subcriticality level with respect to safety and efficiency will be investigated. Transient behaviours of the ADS will be investigated.

The environmental and economical impact of the ADS on the geological repository of HLW will be estimated.

A preliminary economic assessment, based on the results of studies in this project, will be made in order to estimate the feasibility of these ideas as well as to validate the results.

Task 2: Assessment of the accelerator technology

Accelerator technology will be assessed with respect to: construction (cyclotron vs linac), proton current and energy levels. These results will strongly influence the economical aspects of the system studies.

Task 3: Basic nuclear and material data

A relatively high yield of neutrons up to several hundreds of MeV is produced by the proton interactions in the thick, heavy element ADS target. Nuclear reaction calculations will be performed and experimental data will be collected in order to create an evaluated data file.

Nuclear model codes will be validated for basic nuclear reaction cross section data of importance for ADS neutronic calculations. The validation is based on a number of protons and neutrons induced cross section measurements performed at the The Svedberg Laboratory, Uppsala in the energy range 50 to 200 MeV. Measurements will also be made of the thermal fission yield for ^{233}U and the fast fission yield for ^{232}Th.

Task 4: Studies of the fuel cycle for ADS

The use of the Thorium cycle for energy production seems to be extremely attractive due to the breeding potential generated by the excess neutrons in the system. Apart from operating in a self-sufficient mode supplying large amounts of energy, there is simultaneous production of fissile material and negligible production of TRU-elements.

A combined Th and LWR-spent fuel cycle is another attractive option opening new possibilities for synergetic coexistence of conventional nuclear reactors and ADS. Generic aspects of the Th-cycle will be studied in the framework of another project entitled "Thorium cycles, a nuclear waste management option",

coordinated by W.M.P. Franken, ECN. In our project we shall only concentrate on specific aspects of the hybrid systems and the studies will be coordinated with ECN.

The following fuel options will be investigated:

- inert matrix using liquid Lead as a carrier/cooling material
- inert matrix using molten salt (fluoride, chloride) as a carrier/cooling material
- aqueous systems with heavy water
- oxide fuels
- metallic fuel

The proliferation and radiotoxicity characteristics of the different fuel cycles and fuel options will be investigated. The efficiency and costs of fission products transmutation will also be assessed.

D.6.1.2. EXPECTED BENEFITS

The strategic aim of the project is to **broaden the nuclear power option** and to make it **more attractive and acceptable to the general public, for the benefit of present and future generations**. By addressing some of the most important problems of nuclear power, namely improving safety and reducing the burden of the waste radiotoxicity, we may significantly contribute to the permanent solution of the world long term energy supply. The strategic studies planned in this project will result in the comparison of different options in the form of the cost/benefit impact of accelerator based transmutation on different strategies such as: direct geological disposal of irradiated fuel, with or without reprocessing and Pu recycling in reactors etc. Up to now, individual studies have been very difficult to compare due to the significant differences in hypothesis, method and data. This difficulty has been compounded when comparisons have been attempted on the use of different fuel cycles and/or different neutron spectra for transmutation. This project will prepare the platform for future analysis of diverse nuclear power systems.

In the frame of this project, the problems of **weighting the long-term low-level risks versus short-term higher-level risks will be addressed for comparison of geological repositories with the transmutation option**.

Many questions have also been raised concerning the economic costs of introducing accelerators into nuclear power. Even at this very early stage it is necessary to make a **preliminary economic assessment to prepare the ground for future decisions concerning the eventual construction of such systems**. This project addresses these issues.

In conclusion, the project will result in the following benefits:

1. preparation of the platform for future analysis of diverse nuclear power systems
2. grounds for weighting the long-term low-level risks versus short-term higher-level risks for comparison of geological repositories with the transmutation option
3. preliminary economic assessment to prepare the ground for future decisions concerning the eventual construction of accelerator driven systems
4. a framework for future international collaboration aimed at performing an ADS integral experiment will be prepared.