Nuclear Data and the Industry

During the last two decades, there has been a growing interest of the nuclear industry for improved nuclear data. As an example, the following statements on the impact of nuclear data improvement on the different "components" of the full nuclear fuel cycle were made at the Nuclear Data Conference in Trieste (1997) by S.Ion, at the time Director of Research at BNFL (UK):

FRONT END OF THE CYCLE (mining, conversion, enrichment, fuel fabrication)
Good nuclear data does have the potential for significant impact in fuel fabrication. Based on a pessimistic world nuclear capacity of 400 Gwe, the capital cost allocation for fuel fabrication is estimated at $250m/year. A saving of just 1% on the capital cost attributable to better nuclear data would equate to a benefit of several million $ per year.

REACTORS
Based on an assessment of operating margins to cover uncertainties, better nuclear data could well have the potential to allow at least a 2% uprating in the current generation of LWRs.
This equates to a potential increase in generation worth $3bn/year for 400 Gwe capacity

BACK-END OF THE FUEL CYCLE (reprocessing, waste management)
The total value of the back-end services for a 400 Gwe programme is in the region of $5-10bn per year. Even a 1% saving in capital and operating costs attributable to improved nuclear data, could amount to a benefit of $50-100m per year.
Besides its economical value, nuclear data has an important defensive role to play for the back-end of the cycle; issues of regulatory and public acceptance are especially dependent on being able to present a sound technical case with the minimum of uncertainty.

Nuclear Data and innovative nuclear systems

The two attached Journal papers address the issues of a) nuclear data uncertainties impact on the design and fuel cycle performances of innovative nuclear systems (Generation-IV, GNEP, Accelerator Driven Systems), and b) priority needs to improve specific nuclear data (via experiments and/or theory) in order to meet target design accuracies (in principle as defined by industry/designers).
A classical physics approach is used:
1) Define nuclear data uncertainties (variance/covariance matrices) by isotope, nuclear reaction type, energy range
2) Perform extensive sensitivity analysis for a large number of integral quantities which characterize both a reactor (criticality, safety-related quantities etc) and its associated fuel cycle (decay heat at reactor shut-down and in a repository, neutron sources at fuel fabrication, neutron doses in a repository etc). The analysis is performed for the selected systems of interest.
3) Using 1) and 2), perform integral parameter uncertainty evaluation
4) Define "design target accuracies"
5) Evaluate required accuracies in nuclear data to meet target accuracies, as defined in 4), and
6) Assess priority needs for specific nuclear data uncertainty reduction.

These six steps underline the following relevant research fields:

1) The research field of nuclear data covariance assessment is a major one. Several methods have been proposed and are still in an exploratory stage (e.g. based on the use of experimental uncertainties, or based on nuclear reaction model codes, or a combination of both, etc).
2) Sensitivity analysis is also a growing field of interest. The specific feature of nuclear systems (i.e. non-conservative systems) requires specific adjoint-based methods as well as Monte Carlo-based methods
3) The selection of appropriate integral parameters needs a close interaction of reactor and nuclear physicists, reactor and fuel cycle designers and industry people
4) Target accuracies definition is a crucial field of interaction of the same communities as for 3).
5) and 6) require the interaction with nuclear physics experimentalists and the performance of high accuracy experiments. In some cases, innovative experiments and techniques are needed, in order to meet the very high accuracy requirements, or to allow measurements with tiny amounts of very high mass actinides (e.g. the use of Accelerator Mass Spectrometry could be worth investigating).

International collaboration

The Nuclear Science Committee of the OECD Nuclear Energy Agency is active since five decades in the field of nuclear data. A specific working group (WPEC) coordinates international activities in the fields of nuclear data evaluation and nuclear data measurements. Recently (2005) the WPEC has established a Subgroup on “Nuclear Data needs for advanced reactor systems” with the following scope and objectives:

Scope

A systematic approach to define data needs for Gen-IV and, in general, for advanced reactor systems is needed in order to harmonize requests coming from different communities, to establish priorities and credible quantitative goals and timeframes, to define the respective and complementary roles of new data evaluations and of differential and integral experiments. A strong interaction and synergy among reactor designers, reactor physicists and nuclear physicists is a necessary prerequisite of this activity.

Objectives

The objectives of the subgroup are
-Compilation of an agreed set target accuracies on relevant design parameters for the Gen-IV concepts. Required target accuracies should be justified in terms of impact on different phases of a specific design (feasibility, preconceptual and conceptual design etc.)-Definition of a set of data uncertainties and covariance data. These data should be as complete as possible. At this stage, it is not expected to have a “final” set, in particular of covariance data, but an agreed “first iteration” set.
-Production of a set of quantitative data needs by isotope, reaction type, energy range.
-Proposal for an approach to meet the needs and relative timeframe

The Subgroup has agreed to use the physics approach outlined previously and first actions have been completed (e.g. definition of internationally agreed design target accuracies, sensitivity methods, preliminary covariance data etc). This initiative offers a potential frame for wider international collaboration with nuclear physics groups in Europe, Japan and Russia.