

ACTIVITIES OF OECD/NEA IN THE FRAME OF P&T

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Abstract

Back in 1989, the OECD/NEA started a comprehensive programme of work in the field of partitioning and transmutation (P&T). This programme was initiated by a request from the Japanese government who was launching a programme on P&T (OMEGA project) and invited the OECD/NEA to coordinate an international information exchange programme on P&T.

This OECD/NEA Information Exchange Programme has since then resulted in several activities, among them the Information Exchange Meetings and two state-of-the-art systems studies next to scientific aspects being handled by the Nuclear Science Committee.

The Nuclear Science Committee covers a wide range of scientific aspects of P&T. Aspects ranging from accelerators, nuclear data and integral experiments, chemical partitioning, issues on fuels and materials, and physics and safety of transmutation systems. This paper will overview the activities of the past ten years and will give insight in the ongoing projects, the results, and the perceived future activities.

1. Introduction

Back in 1989, the OECD/NEA started a comprehensive programme of work in the field of partitioning and transmutation (P&T). This programme was initiated by a request from the Japanese government who was launching a programme on P&T (OMEGA project) and invited the OECD/NEA to co-ordinate an international information exchange programme on P&T.

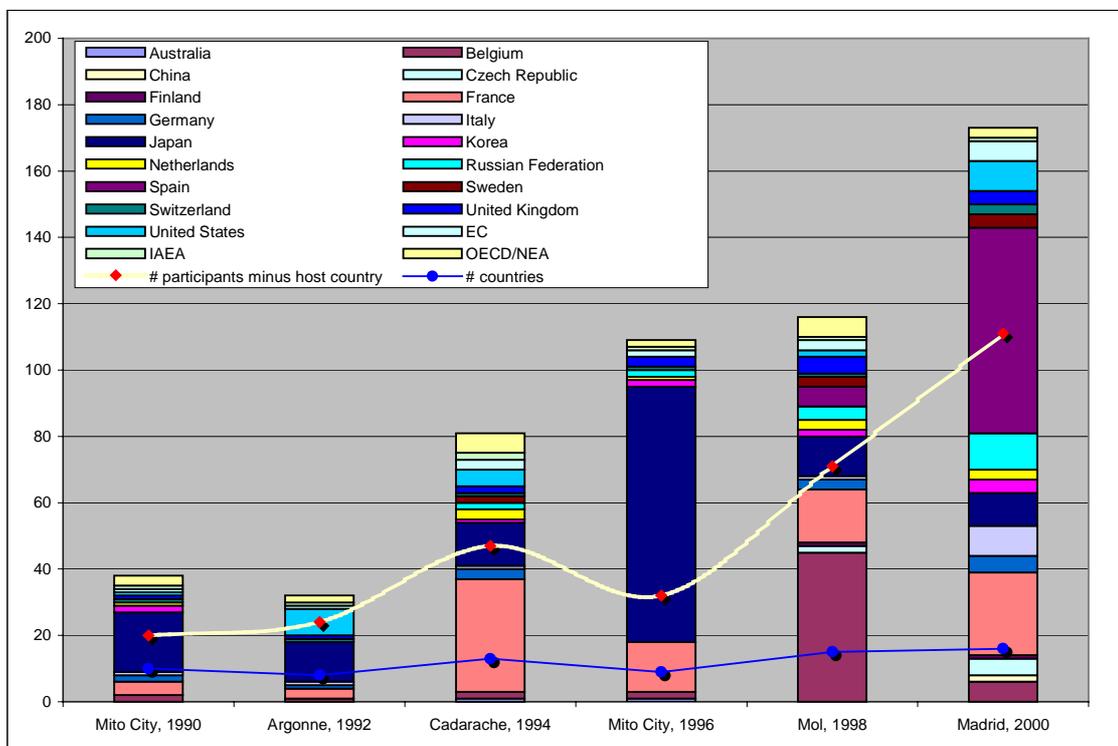
This OECD/NEA Information Exchange Programme has since then emerged in several activities, among them the Information Exchange Meetings and two state-of-the-art systems studies.

Since the NEA was invited to take up this topic in 1988, the interest in it has grown in several of our Member countries. The task is one of long-term scientific research, but it is recognised that certain short- or medium-term benefits could also be derived. There is quite a rich network of bilateral agreements on P&T between OECD Member countries. However, judging from the number of participants who have come a long way to the Information Exchange Meetings and the different workshops, there is a clear view that substantial benefits can be achieved from wider international activities and co-operation.

NEA has recently reorganised the P&T activities as a horizontal project between the Nuclear Development and Nuclear Science Committees and a restructuring of the science programme under the umbrella of a new working party on scientific issues in P&T has recently been started.

Figure 1 shows, for general information, the past increasing interest and participation in the Information Exchange Meetings. The shown trends let us also reflect on the future character of these meetings.

Figure 1. **Historic overview of participation to the OECD/NEA Information Exchange Meetings**



2. The previous 10 years

The activities of OECD/NEA in the field of P&T were initiated in 1989 by the proposal from the Japanese Government to conduct an international Information Exchange Programme under the umbrella of the Nuclear Development Committee. The objective of this OECD/NEA Information Exchange Programme on Actinide and Fission Product Partitioning and Transmutation were defined as to enhance the value of basic research in the subject by facilitating the exchange of information on and discussion of programmes, experimental procedures and results. The Information Exchange Meetings are integral part of this Programme intending to bring a biannual review of the state-of-the-art of P&T and is co-organised by the Secretariat and major laboratories in Member countries. Next to this Information Exchange Programme, other activities under the umbrella of the Nuclear Science Committee are undertaken and will be detailed in following section.

The first Information Exchange Meeting was held at Mito City (Japan) in November 1990 [1]. Various scientific and policy aspects of P&T were addressed and highlighted several disparate approaches which had been taken, covering a variety of aqueous and non-aqueous chemical procedures and a number of different reactor and accelerator based transmutation schemes. As this meeting stressed the need to have some small specialists meetings on suitable topics, OECD/NEA organised two of those specialists meetings. The first one handled on partitioning technologies (Mito City, Japan, November 1991) [2] where the second one focused on the topic of accelerator-based transmutation (PSI, Switzerland, March 1992) [3].

In November 1992, the Argonne National Laboratory hosted the second Information Exchange Meeting [4]. The papers presented indicated that one common thread was the need for some means of taking an integrated view of the expected benefits and possible disadvantages of including P&T in the nuclear fuel cycle. Among other results of such an approach would be guidance on research needs. A number of emerging important issues were identified during the meeting, including the legal background, the incentives and the implications for the whole fuel cycle in different countries. One of the main conclusions was that a comparison of system studies in the field of P&T, some of them already in progress, should form the central part of the P&T activities under the umbrella of the Nuclear Development Committee of the OECD/NEA.

These views were carried forward at the third meeting, hosted by CEA at its Cadarache site in December 1994 [5]. Several participants from 11 countries, together with Russia, the IAEA and the European Commission attended the meeting that primarily focused on P&T strategic systems studies. The meeting provided a solid basis for approaching a more co-ordinated NEA project, which was started in early 1996, on the benefits and penalties of adding P&T to the nuclear fuel cycle. This meeting also concluded that there was a clear need to define objectives against to which to measure the potential benefits of P&T. However, the discussion at the Cadarache meeting indicated that a final set could not yet be established.

The fourth meeting was hosted by STA, JAERI, JNC and CRIEPI and was held again in Mito City, Japan, in September 1996 [6]. The goals for P&T were set clearer during this meeting, i.e. P&T would not replace geological disposal, the potential hazard reduction was mainly associated with TRU elements, and reduction of the dose impact to man would come from mobile fission product radionuclides such as ^{129}I and ^{135}Cs . The main motivation for P&T was considered being based on ethical reasons for the future generations and public claims concerning geological waste disposal sites. The meeting also indicated that there was a need to better define the performance evaluation by the use of criteria. Those criteria would relate to the feasibility and credibility of the achievable reductions in mass and toxicity reduction, the corresponding cut-off period, the best way for industrial implementation and to a reasonable level of extra costs. Achievement of this kind of evaluations

would need the continuation of technical studies and of systems and strategic studies including the necessary economical evaluations.

The Fifth Information Exchange Meeting [7], hosted by the Belgian Nuclear Research Centre SCK•CEN and co-organised by the European Commission, was held in November 1998 at Mol (Belgium) with more than 130 participants from 15 countries and 3 international organisations. This meeting could be characterised by two main directions; first of all, a more integrative view on partitioning and transmutation was observed where consensus on the way to perform P&T was achieved but where questions were raised on the added-value of P&T in the nuclear fuel cycle (and the most appropriate way to achieve it). Secondly, the breakthrough in partitioning of minor actinides was achieved on laboratory scale at pre-set performances.

3. Systems studies

In response to the discussions and conclusions of these meetings, two systems studies were conducted by the NDC. Both aiming at a comprehensive authoritative state-of-the-art and assessment report on the role, feasibility and developments of P&T.

The first report, entitled *Status and Assessment Report of Actinide and Fission Product Partitioning and Transmutation*, was published in 1999 [8] and was the result of a two-year's work by an expert group. The report investigates different options to decrease the final radiotoxicity and provides a limited systems analysis of the main options as a step towards clarifying choices among this complex set of possible alternatives. The preliminary systems analysis starts from the present technical state of the art in the fuel cycle and points to some possible developments in P&T technologies which would result in an advanced fuel cycle with an overall reduction of the radiotoxic inventory and a reduced impact on the biosphere. The main general conclusions of this report state:

- Fundamental R&D for the implementation of P&T needs long lead-times and requires large investments in dedicated fast neutron spectrum devices, extension of reprocessing plants, and construction of remotely manipulated fuel and target fabrication plants.
- Partitioning methods for long-lived radiotoxic elements have been developed on a laboratory scale.
- Recycling of plutonium and minor actinides could stabilise the transuranium nuclides inventory of a nuclear power park. Multiple recycling of transuranium nuclides is a long-term venture that may take decades to reach equilibrium of inventories.
- Conditioning of separated long-lived nuclides in appropriate matrices which are much less soluble than glass in geological media, or which could serve as irradiation matrix in a delayed transmutation option, is a possible outcome for future decades.
- P&T will not replace the need for appropriate geological disposal of high level waste, irradiated transuranium concentrates, and residual spent fuel loads from a composite reactor park.

The ongoing systems study on “Comparative Study of ADS and FR in Advanced Nuclear Fuel Cycles” complements this first study by looking to the role of P&T in different nuclear fuel cycle schemes and the specific role of accelerator-driven systems (ADS) versus fast reactors (FR). In addition, the technological status and issues in developing these ADS or FR including the needed developments in the fuel cycle, and finally a cost/benefit analysis and the R&D-issues related to P&T are part of the study's scope. An international expert group has been set-up and will finalise its analysis by mid-2001.

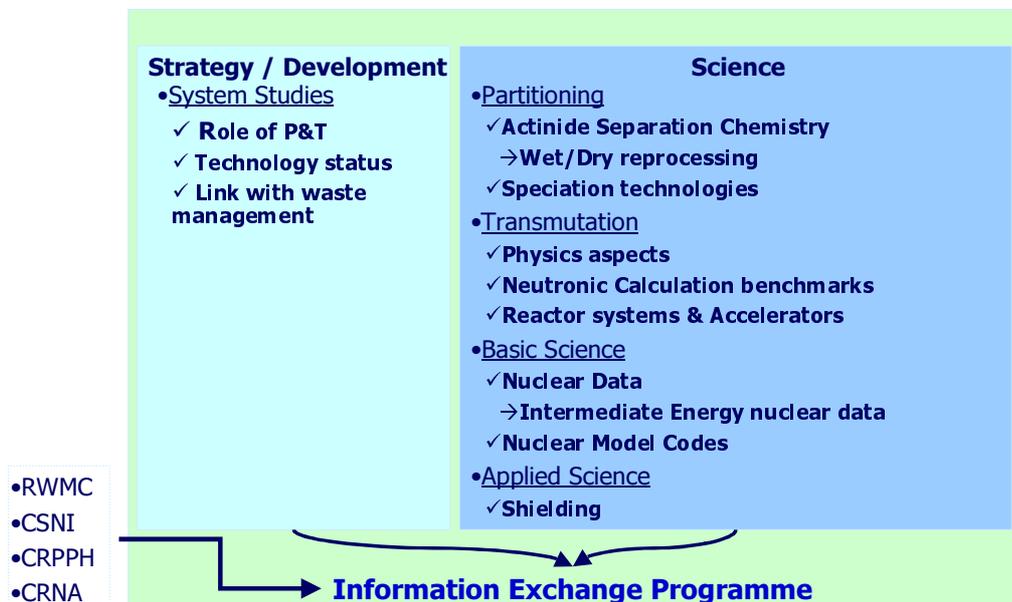
4. Scientific issues of P&T

In parallel with the activities on P&T of the Nuclear Development Division the Nuclear Science Committee (NSC) covers various scientific issues in response to the perceived need expressed during the Information Exchange Meetings.

Where, in principle, the NSC focuses a rather broad field of topics, its initial activities related to P&T were in essence oriented towards two substantial aspects, i.e. the creation of data bases and the organisation of inter laboratory comparison exercises. Later, these activities were expanded to include also other aspects of P&T, e.g. radiochemistry, accelerators, and others.

Today, the programme of work of the NSC in the frame of P&T comprises scientific aspects studied by its working parties and expert groups (or task forces), the NEA Data Bank activities on nuclear data and computer programmes, and finally the organisation of workshops (see Figure 2).

Figure 2. Overview of today's OECD/NEA's activities within the frame of P&T



A Task Force to investigate the physics aspects of different transmutation concepts was set-up in the early 1990s. The resulting overview report, published in 1994 [9], described the basic features of a number of different transmutation concepts.

In addition, the Working Party on Evaluation Co-operation (WPEC) worked previously on the High Priority List of Measurements which covers a list of actinides needing further measurement activity, especially in the above 20-MeV part of the neutron energy-range [10]. Co-ordination of differential nuclear data measurements was undertaken as well as an effort was started on intermediate energy nuclear data measurements, evaluation and nuclear model codes development and benchmarking.

In 1996, the NSC Expert Group on Physics Aspects of Different Transmutation Concepts organised a benchmark exercise to investigate the physics of complex fuel cycles involving reprocessing of spent PWR reactor fuel and its subsequent reuse in different reactor types: PWRs, fast reactors and an accelerator-driven system. The results of the comparison of the calculated activities for

individual isotopes as a function of time for different plutonium and minor actinide transmutation scenarios in different reactor systems can be found in reference [11].

New activities were launched since 1998 and included workshops on high power accelerators reliability [12]. The first of this kind was held in October 1998 aiming the exchange of information between the accelerator and nuclear community in the light of accelerator driven systems for P&T purposes. The NSC conducted the second workshop on high-reliability accelerators in France at 23-27 November 1999 [13].

A speciation technology workshop was held in 1999 [14] and a workshop on pyrochemistry has recently been organised in October 2000. The NSC also reviewed in 1998 current and developing actinide separation chemistry via a workshop and a report by an expert group [15].

The NSC and Data Bank continue to fulfil their role to provide physics tools and data that enable improved transmutation calculations to be performed. Ongoing activities relate to:

- Nuclear data and benchmark calculations.
 - Activities were conducted in the field of intermediate energy nuclear data. Three studies were completed in the early '90s:
 - ❖ One on the availability of experimental data and nuclear model codes.
 - ❖ A second on the requirements for an evaluated nuclear data file.
 - ❖ The third study was an international comparison of the performance of computer codes used in intermediate energy calculations. The results of this exercise were published in 1994 [16]. It was followed by a specialist's meeting in June 1994 [17], which recommended the systematic compilation of experimental intermediate energy data to assist the theoreticians and evaluators in their work. The Data Bank started to compile these data into the internationally maintained EXFOR database [18].
 - A co-operative project on an evaluated intermediate energy nuclear data file, through its Working Party on International Evaluation Co-operation.
 - Related activities involved a specialist's meeting in 1997 on the optical model dealing with higher energies required in accelerator-driven technologies [19].
 - Benchmark exercises were undertaken and reported in 1997 on the predictive power of nuclear reaction models and codes for calculation of activation yields in the intermediate energy range (up to 5 GeV) [20].
- Shielding aspects of accelerators, targets and irradiation facilities [21].
- Criticality (including sub-criticality) benchmarks.
- A neutronic benchmark of an accelerator-driven minor actinide burner has performed. A summary of the results is presented in this meeting [22] and the final report of the benchmark will be issued in mid-2001

Recently, the NSC meeting of June 2000 endorsed the creation of the Working Party on Scientific Issues in Partitioning and Transmutation (WPPT) in order to guide the P&T-related activities of NSC in the future.

This Working Party will envelop the scientific aspects of P&T and comprises four sub-groups:

- Group on Accelerator Utilisation and Reliability:
 - This group emerges from the previous workshops on Accelerator Utilisation and Reliability, will synthesise the improvements made and draw conclusions from each workshop held and continue to organise such workshops. The group will also deal with target and window performances, for instance, issues on spallation products and thermal stress and radiation damage, respectively.
- Group on Chemical Partitioning:
 - The existing expert group on Pyrochemistry moves under this WPPT where this subgroup will first focus on the drafting of a state-of-the-art report on Pyrochemistry. Despite its name, the group will also look into aqueous processing issues.
- Group on Fuels and Materials, as the new proposed transmutation systems will demand specific materials to be validated or developed for use in more challenging irradiation conditions.
- Group on Physics and Safety of Transmutations Systems:
 - This group will organise theoretical and experiment-based benchmarks to validate nuclear data as well as calculation tools needed for simulating advanced transmutation systems, and investigate safety aspects of transmutation systems such as the beam trip problem of ADS.

5. Other committees

Contacts with the Radioactive Waste Management Committee (RWMC) guarantee that an exchange of resulting information is shared among the related committees. The RWMC issued a statement on P&T in 1992 [23] primarily to emphasise the point that actinide P&T cannot be considered as an alternative to geologic disposal. The RWMC continues general studies related to the development of geologic repositories but there are no activities specifically directed at P&T.

In early 2000, the NEA Steering Committee and Committee of Standing Technical Chairs decided to extend the Information Exchange Programme as a horizontal activity within OECD/NEA, emphasising the multi-disciplinary character of P&T and also responding to a more transparent structure of NEA's activities in this field. Therefore, both the NDC and NSC will co-organise this Programme and input from other committees, especially the Radioactive Waste Management Committee, would be searched for. A new web page has also been launched as a joint activity [24].

6. Possible future activities

Beyond the known NEA activities related to P&T, it is noted that confident decisions or actions regarding a P&T fuel cycle requires significant extensions of existing technology throughout the back-end of the fuel cycle. However, examination of the historical literature reveals a number of important areas of technology that have received relatively little or dispersed attention.

Therefore, while there is continuing need for improved data and analyses on a broad front to provide the basis for governmental decisions, the following areas are perceived as deserving particular attention in the future and appropriate OECD/NEA activities are considered in the future:

- *Repository analysis*: one of the primary benefits of P&T is believed to be a reduction in risk from the geologic repository. Despite this, there have been very few studies to quantify the extent and uncertainty of the risk reduction. Most of the historical studies have used hazard or toxicity indexes that do not properly account for the migration of various radionuclides. The recently published first phase report [9] covered into some extent the impacts of P&T on the long-term repository risk. However, there remains a pressing need to analyse these impacts of P&T on long-term repository risk in all future work and this will again be addressed within the ongoing second phase P&T systems study. Such analysis will request the collaborative effort from RWMC.
- *Fuel cycle impacts*: recycling MAs results in significant changes in the composition of the fuel or targets that contain them. However, the impacts of these changes on the out-of-reactor fuel cycle (e.g. design of facilities and transportation casks, safety impacts) are not yet fully documented and were only partially covered in previous assessment studies. Further detailed studies in this area are needed and are partially included in the second phase study on P&T.
- *Systems analyses*: despite the many studies that have been conducted over decades, the number of systems studies that comprehensively compare the advantages and disadvantages of standard and P&T fuel cycles is small. Such an analysis should be a key component of NEA recommendations to member governments and, as such, constitutes a major need. The first and second phase of NEA's P&T systems studies and the specific NSC-activities have been targeted to cope with this specific demand.
- *Safety of P&T related installations*: the current renewed interest in ADSs and also in FRs for P&T purposes has been evolving such that currently small-scale or demonstration facilities are proposed. Despite the still long-term venture for P&T activities and construction of specific installations, one should already consider basic studies on safety related issues and especially on the ADS related aspects. Some of these aspects have been covered by existing or ongoing systems studies but input of specific expertise could be welcome.
- *Nuclear data*: whilst overall assessment studies are important, the need for basic nuclear data to perform the underlying neutronic calculations are of very high importance. Especially the move to harder neutron spectra in fast reactor systems and accelerator-driven systems, in addition to the specific aspects of spallation neutron spectra and the increasing contents of minor actinides in the fuel, support the need for a continuous and increased need for validated nuclear data files. Specific effort is needed in the intermediate energy domain and NSC-Data Bank has conducted work on this since the early 1990s.
- *Materials science*: the new proposed transmutation systems will demand specific materials to be validated or developed for use in more challenging irradiation conditions. This materials science domain including not only structural materials but also target and fuel materials becomes more dominant in such P&T schemes. Increased effort in experience exchange is needed and has already partially been covered by the NSC International Fuel Performance Experiments (IFPE) database. Activities on a Material Damage Database and a report on the correlation between dpa-calculations and real damage are planned within NSC.
- *Separation chemistry*, being a very important part of any P&T scheme, needs continuous development especially in the light of new developments in aqueous as well as in dry separation methods. NEA's activities cover the follow-up of recent developments and needs.

- *Demonstration Experimental Programme*: while different Member countries study P&T and plan to conduct or are conducting an experimental programme aiming the scientific and technological demonstration of P&T and especially ADS, there is scope for an international co-ordinated joint project in this domain. This joint undertaking would supplement the Information Exchange Programme and aim rationalisation of the different international initiatives in order to support collaborative development in the domain.

7. Conclusions

OECD/NEA has organised a structured programme of work during the past ten years. The two main committees involved in this programme are currently pursuing system studies, nuclear data evaluations and benchmarks, and organise specific workshops on scientific aspects of P&T.

The increasing interest in P&T has brought the OECD/NEA to regroup some of its scientific activities in a new working party WPPT in order to respond better to the perceived needs of the P&T-community and governments.

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