The objective of the panel discussion 'Radioactive Waste Management – Burn or Bury' was to instigate a lively debate about the various options dealing with the waste management for sustainability of nuclear power and to seek synergy between geological disposal and partitioning and transmutation technologies. The debate became interesting and lively by drawing parallels from the back-end of the human life-cycle in which the custom of 'burning' and 'burying' of human-waste in different communities was put forward as a point of animated reference.

After a brief introduction by the chairman the panellists were invited to make a '2-slide introductory presentation' outlining briefly their views on this topic. Subsequently, the floor was open for discussion with questions from the audience and answers from the panel members.

Following is a brief summary of the introductory remarks by the panellists:

Mr Benamati, a member of the Italian parliament, pointed out that the European public opinion is divided 50-50, for and against nuclear energy. Most importantly, 39% of the sampled people that are against nuclear energy could change their opinion if a permanent and safe solution for nuclear waste could be found. He pointed out that the European public, in general, was not well informed of different possibilities of waste management. He said that the public opinion could look quite differently at the problem if the nuclear waste is transmuted (burned) to decrease its half-life before disposal. He believes that politicians should be better informed about the merits of nuclear energy and composite waste management solutions. Personally, he believes that a strong synergy between the “burn and bury” lobby is the best way forward. He said that he is committed to promote the research in the field of partitioning and transmutation at national level supporting the efforts of the EU, in order to positively complement the R&D activity on geological disposal. The combined results of those two technologies could be very fruitful for the pacific use of nuclear energy.

Mr Boullis first outlined the principles of 'The 2006 French Act' concerning the nuclear waste management, namely (i) continue recycling to decrease the amount of nuclear waste, radio-toxic inventory etc., (ii) establish a retrievable geological repository as the reference option for the final waste management and (iii) the year 2012 as a time point for reassessment of industrial potential of
diverse options of P&T leading to a prototype of the selected process by 2020 and (iv) definition of a repository by 2015 with a view to its operation by 2025. He also pointed out the options that can be considered for adoption in future: (i) U and Pu recycled with fission products (FP) where minor actinides (MA) are destined for geological disposal (GD), (ii) Heterogeneous recycling of MA and U+Pu where FP are destined for GD, (iii) Homogenous recycling of MA and U+Pu where FP are destined for GD, (iv) Co-extraction and recycling of U and Pu where FP and MA are destined for GD and (v) the double strata approach where U and Pu are recycled in conventional reactors and MA are transmuted in a dedicated accelerator driven system (ADS) where FP and residual MA are destined for GD. Selection of an option is scheduled in 2012. Mr Boulis presented a scenario of French nuclear power plants (NPP) up to 2060 involving life extension techniques of present-day Gen II plants, operation of Gen III NPPs from 2012, operation of Gen III+ NPPs from 2020 and Gen IV fast NPPs from 2040. He warned that the solution of the back-end of the nuclear fuel-cycle must be considered with urgency otherwise one risks accumulating huge stockpiles of the spent fuel. In this regard he alluded to the establishment of new pilot facilities at La Hague (FR) site for quantities of fast reactor MOX fuel fabrication (tons) and MA pins (kgs).

Mr González emphasised the need to consult the public when developing waste-management policies that incorporate P&T. This requires developing new technological options involving significant financial and manpower resources. However, each country will have to consider its own constraints for deployment of these technologies if their overall nuclear policy so permits. He highlighted the importance of detailed planning in erecting and utilisation of advanced facilities so that best results are obtained. He also reiterated that public acceptance of nuclear requires the participation of all stakeholders in decision-making.

Mr Lalieux shed some light on the key elements of the spent fuel that drive the geological disposal community. These are (i) decay heat (fission products: ~150 y, actinides: <1000 y), (ii) radiological risk affecting the dose to the environment (fission products: >10000 y) and (iii) radio-toxic inventory of the nuclear material in the waste (actinides: for more than 10000 y). He believes that the contribution of P&T in reducing the long-term burden of repositories is limited if it is restricted to actinide management. Benefits of separation of heat bearing elements to aid in increasing the repository capacity should be matched with the risk of the generation of secondary waste and occupational doses to technicians. He recognised the role of P&T in sustainability of nuclear energy but this in itself should not impact on delaying the geological disposal related decisions by public authorities.

There were many questions that were posed by the audience for panellists to discuss. Mr Miguel Cuñado of ENRESA, Spain was critical of P&T and warned of possible activation products which may be more harmful if appropriate measures are not taken in selecting appropriate materials. He was also unhappy that reprocessing plants are releasing iodine into the sea though it is done under the purview of regulatory authorities in a controlled manner and within the limits set for such releases. Mr Jan Marivoet of SCK-CEN (BE) said that P&T offers a number of very interesting perspectives for waste management of future fuel cycles. He also indicated that the interaction between P&T community and waste management organisations is highly desirable. Mr Jordi Bruno of Spain said that we are not two scientific communities that are in confrontation (although we are chasing the same funding) but politicians are using P&T to drag their feet, and they appear to take a lifetime to make up their minds in approving the geological repositories. The panellist Mr Lalieux added that it is important to balance the role of P&T and to avoid delaying disposal-related decisions.
In the chairman’s view, the progress and prospects, challenges and recommendations for P&T discussed during the P&T session can be summarized as follows:

- **Progress and Prospects:**
  - Separation of main heavy metals (U, Pu) and heat bearing components (e.g. Cs, Sr, Am) before disposal increases the repository capacity (3-100 times) in certain geological media.
  - Storage of Cs and Sr for 100-300 years in specialized (calcinated) waste forms is recommended. Due to the long-lived Cs-135 isotope, after storage, disposal of this waste form would also be required.
  - Transmutation/burning of separated MA (in ADS or FR) reduces the ‘long-term burden’ on repositories. This may aid the GD community in securing a ‘broadly agreed political consensus’ of waste disposal in geological repositories.
  - Transmutation of MA has also a favorable impact in the unlikely occurrence of ‘human intrusion scenarios’.
  - The maximum eventual dose to human beings from a geological repository in ‘normal scenarios’ is likely to be due to fission products though evidence is appearing that MA also can be mobile under certain conditions.

- **Challenges:**
  - Advanced partitioning processes are to be reinforced towards pilot and test facilities for optimized separation processes leading ultimately to industrial facilities requiring strong political support and huge financial and human resources.
  - Dedicated efforts have to be made in developing and selecting low activation materials in reducing the intermediate level waste and reducing secondary waste streams in the processes of P&T so that it does not put undue burden on the safe disposal of additional secondary waste produced.
  - A close cooperation between the two (P&T and GD) communities in defining unified and coherent systems for effective waste management is highly desirable.

- **Recommendations:**
  - The GD community should take into account the requirements and accommodate the waste streams emanating from the advanced (MA) reprocessing systems and support development of appropriate waste forms for geological disposal.
  - Keeping in mind the natural decay of nuclear waste, a careful roadmap and planning (taking account of the time needed e.g. for regulatory authority approvals) should be made so that there is no mismatch between the schedules of partitioning, transmutation and disposal technologies.

In conclusion, P&T is essential for the sustainability of nuclear energy. GD is indispensable for radioactive waste management. Both communities should work together for the future of nuclear energy.
References
[1] Gianluca Benamati: Member of Italian Parliament, Heavy-liquid-metal technologists turned politician since 2007, a former director of ENEA, Brasimone Nuclear Centre, Italy.


[3] Enrique Gonzalez: Head of Nuclear Division, CIEMAT, Spanish Energy, Environmental and Technological Research Centre. Experimentalist in Nuclear data and neutronics of Fast systems, Leader of some of the Nuclear data experiments at CERN and of the Nuclear data Domain in FP6-Eurotrans project.