Nuclear Fuel Cycles Issues and Challenges
2004 IAEA Scientific Forum

Session 2 – *Waste and Spent Fuel Management Issues*
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Title of the Notes- P&T An option for spent fuel and waste management using a Double Strata Fuel Cycle with a dedicated Waste Burner Reactor

Notes

- The present time commercial reactors (LWR, CANDU, etc.) operate in a Once Through Fuel Cycle OTC, and based in a feed of uranium. From around 400 operating reactors a large stock pile of radioactive waste are being produced, mainly long lived TRU- Plutonium, MA(Am, Np, Cm), and Long Lived Fission Products,LLFP, such as I-129, Tc- 99, Cs-135 etc. It is estimated around 300,000 t of the spent fuel be produced in this decade, with 1% of Pu (3,000 tons), 0.1% MA, 300t, and 400tons of LLFP.
- The build up of radioactive stock piles, besides the concern of waste disposal(radio toxicity), also brings the issue of proliferation. To overcome these issues, the next generations of nuclear reactors are considering concepts that coupled with a closed fuel cycles in many new iniatiatives, such as GIF and INPRO. This is main point I which to note, that is P&T is sustainable option for spent fuel and HLW management, considering the renascence of Nuclear Energy for the next decades. Some issues such as safety, economics had already been almost solved. Also the contribution of nuclear energy to avoid the threat of global warming due to CO_2 emissions in short term is also a positive point. So the only point which still remain as a controversy issue for a complete acceptance of Nuclear Energy, is what is going to be done with the HLW (long term hazard). We need to give answers acceptable for the public, and as establhied in the Joint Convention for Safety Spent Fuel Management and Radioactive Waste Managen to protect the people, the society, and the environment presently and in the future in such way that the needs from present generation be satisfied without compromising the future needs of the future generations.
- The scheme illustrated in the slide, summarizes almost all possibilities of waste and spent fuel management. First we notice that in a present OTC cycle, only uranium is being used as a fuel. So a first point we wish to make is that the utilization of thorium based fuel cycle is an option to reduce long lived radio toxicity and constrain plutonium even in a present time reactors (LWR, CANDU), or in the concepts under development such as Molten Salt Reactors, Gas Cooled Fast Reactors, HTR, considered in INPRO and GIF initiatives. In fact initiaves to utilize thorium as fuel in several cycles had been studied and proposed all around the world, as the Radowisk Light Water Thorium Nuclear Reactor Concept (seed blanket fuel element), and the utilization in CANDU Reactors. The IAEA, has promoted several technical meetings, coordinated research projects related with Thorium utilization, as reported in the recent TECDOC-1319, Thorium Fuel

Utilization (2003), and TECDOC-1349, Potential of thorium based fuel cycle to constrain plutonium and reduce long lived waste toxicity (2003).

- The second point, I wish to make is that OTC assumes that the final solution for HLW is the geological repository for thousand of years(>10,000 y). Although this solution looks as the most attractive and economical competitive, and adopt by countries like USA (Yucca Mountain), Sweden, Finland, still a lot of controversies still remain, and the acceptability by the public is still an unsolved issue. First some questions need to be answered, such as i) is possible to control physically by engineering design and natural barriers for such long period of time (10,000-100,000 y), ii) the security is possible for such long time period. We must realize that 10,000 y is the time of man history, and from the time man start civilization in history to now empires, nations, culture, social organization etc have changed, and it is impossible to predict how society is going to be 10,000 y from now (there are prognostics that a new glacial age could start 15,000 y from now). Also, for instance in the USA, Yucca was designed to accept 70,000 HM, and if there is a renaissance or even the present time reactors have its life extended, probably new repositories is going to be constructed. This paradox is also true for other countries. So to have a sustainable nuclear energy development for the centuries to come, a hundred folds should reduce the time of confinement. That is the Advanced Fuel Cycle, or P&T has to give as an answer.
- The second fuel cycle option, already implemented or in planning by countries like France, Japan, Russia, etc. Is the aqueous reprocessing fuel cycle with vitrification of HLW. In fact LWR-MOX is already in use in Western in Europe (France, German, Switzerland and Belgium) in LWR(the advanced EPR will use MOX fuel), and are a first step in a global closed fuel cycle scenario. The PUREX aqueous process is well established, and reprocessing of Plutonium and uranium is available in France, UK, Japan, India, Russia, and China., and the recycling of these major actinides(U,Pu- 99.9% are extracted). For the innovative reactors under consideration RFC is an option, and if we include in cycle the possibility to separate MA(pyroreprocess), and burn in fast reactors than the goal to reduce the requirement in the repository by a hundred fold could be achieved. I would like to add, the possibility to use thorium in a closed fuel cycle with aqueous reprocessing(THOREX), with Fast Reactors, as also an option to reduce the burden in the repository, besides to increase the utilization of natural resources(thorium is 3 times more abundant than U in the earth crust, 6.000 ppb), in a sustainable nuclear energy scenario.
- Finally, the Advanced Fuel Cycle with Partining of MA could be a sustainable option for spent fuel and HLW management. So P&T objective is to reduce the LONG TERM HAZARD of spent fuel or HLW by transforming long lived radio nuclides(MA, LLFP) into short lived nuclides and reduce the radio toxicity by a factor of 100. Of course P&T demands a lot of development in dry processing(pyro), fuel fabrication, and new innovative dedicated transmute reactor. Accelerator Driven System(ADS), Thorium fueled(Th-TRU), Helium or lead bismuth cooled could be such reactor. In fact a lot of R&D effort are being put in P&T in all technical aspects, pyro processing, fuel fabrication, ADS concepts using solid or fluid fuels(MSR). The European Community, the USA, Russia, China, Republic of

Korea, France etc. are involved in P&T, and have programs in it. The IAEA through the technical Working Group of Fast Reactors have reported several technical documents related with P&T, such as IAEA TECDOC 1365(2003)- Review of National ADS programs for P&T. A NEA OECD 2003 report (Comparative Study on ADS and FR in Advanced Nuclear Fuel Cycles), made an excellent and consistent study comparing the sustainability(cost effectiness, environmental friendly, resource efficiency) of several fuel cycles scheme(Pu Burning in LWR-FR, Heterogeneous MA recycling LWR-FR, TRU burning in FR , TRU burning in ADS, MOX recycling LWR-ADS, Double Strata LWR-FR-ADS, only FR), using U-Pu-MA solid fuels, and compare with OTC. The main conclusions were that? 1) P&T WILL NOT REPLACE THE NEED FOR APPROPRIATE GEOLOGICAL DISPOSAL OF HLW THE CLOSED FUEL CYCLE WITH P&T, USING ADS OR FR, WILL REDUCE IN A HUNDRED FOLD THE TIME REQUIREMENT FOR THE REPOSITORY, 2) THE COST OF ELETRICITY IN SUCH CYCLES WILL INCREASE 10-20%, 3) NEEDS A R&D EFFORT FOR THE DEVELOPMENT OF THE NECESSARY TECHNOLOGY.

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P&T: An option for Spent Fuel and Waste Management using a Double Strata Fuel Cycle with a dedicated waste burner reactor (ADS)

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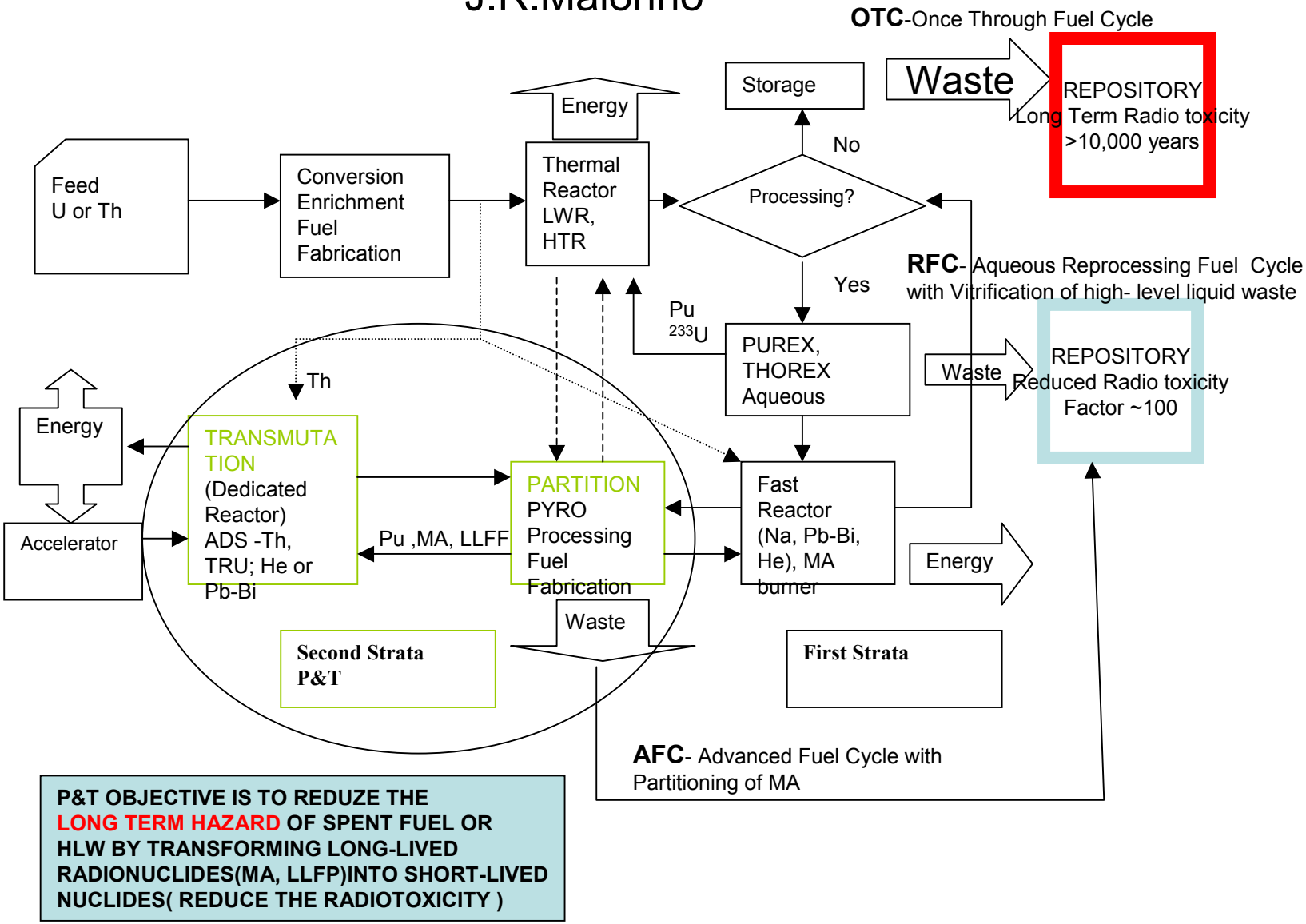

P&T OBJECTIVE IS TO REDUZE THE LONG TERM HAZARD OF SPENT FUEL OR HLW BY TRANSFORMING LONG-LIVED RADIONUCLIDES(MA, LLFP)INTO SHORT-LIVED NUCLIDES(REDUCE THE RADIOTOXICITY)