SERVICE PLATFORM IN NUCLEAR FUEL CYCLE: PRACTICAL SOLUTION FOR THE USED NUCLEAR FUEL FROM POWER REACTOR ISSUES AND SECURING OF THE FUEL SUPPLY

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Abstract

The obligation of used nuclear fuel (UNF) management lies with the NPP operator, and further – with the country which origins it. International Agreements like IAEA Joint Convention and the EU Directive 2011/70/Euratom all state that final wastes should be disposed of in the country where it is generated. Therefore, the ultimate responsibility for the management of radioactive waste (RW) lies with each member country. In many cases for the sole country and especially the sole NPP operator it is not easy to keep that responsibility: for example, for countries with small nuclear programmes it will be difficult to have enough resources available for managing spent fuel and radioactive wastes. In certain circumstances, safe and efficient management of UNF and RW might be fostered through agreement among countries to use facilities in one of them for the benefit of the others.

Another potential approach to be considered is to put responsibility for UNF disposal on the fuel supplier in the model of fuel leasing. The ability to transfer responsibility for all the fuel issues including supply of the fresh one and treatment of the irradiated one is a long-standing desire of the most NPP operators1, since the main task for the operator is safe and economically effective electricity production. And other tasks seem to be forced or indirect. But this desire can be hardly realized for some reasons. One of them is RW return issue: desired leasing scheme does not include the return of any RW after UNF reprocessing to the country where this UNF is generated, which, as a rule, is unacceptable for political reasons.

History knows cases when, despite to the above restrictions, the nuclear fuel leasing was implemented (for example take-back service between the USSR and Eastern Europe countries, when the used fuel of power reactors came back to USSR from GDR, Hungary, Bulgaria etc). However, these cases are the exception rather than the rule.

At the same time, the leasing concept has a number of undeniable advantages, the most important of which is the focus on the service nature in the cooperation between the supplier and the customer. The report describes how the service principle may be implemented to the fuel supply and UNF management, taking into account the current capabilities and limitations.

It is important to note that the paper does not propose any new technical solutions and inventions, but concentrates on the model that could integrate currently existing and developing solutions to be attractive to the UNF owner.

1. PREREQUISITES, CONTENT AND LIMITATIONS OF THE NUCLEAR FUEL LEASING CONCEPT

One of the cornerstone task for NNP operators is ensuring security of supply of fresh fuel to feed reactor operation. Such a supply should be reliable and cost-reasonable. Equality of technological levels of the main stages of the nuclear fuel cycle (NFC) was completed with the transition of all the world's enrichment service providers to the gas centrifuge technology and corresponding alignment of the prices for nuclear fuel. It led to a situation where non-price factors became more and more important: the reliability and warranty of supplies, financial flexibility, as well as the variety and quality of services provided including unique and supplementary services.

Another obligatory task for NPP operators is the management of used nuclear fuel (UNF). It should meet all the requirements for the long-term safety and should be cost-reasonable as well. One of the option for UNF management is its recycling through reprocessing to recover fissile materials.

Since recycling connects UNF management with the fuel supply it is reasonable to look for the model where these two components of the NFC are integrated. Such an integration promises benefits in NFC economy first. And it seems to be attractive for NPP operator (UNF owner) as it rids off the headache of the long-term processes related to the UNF management. Thus such a model could be useful to close the gaps both in fresh fuel supply and UNF management like gradual exhaustion of cheap fields of uranium, the growing transportation

[1] It is considered that NPP operators are not the final responsible body for SNF and RW management (disposal). The final responsible body in the majority of the countries is the government. Nevertheless, NPP operator keeps important part of the total responsibilities especially when the government could not point the exact date of the final SNF disposal facility availability.

cost, lack of UNF deep geological disposals etc. Some of these gaps (e.g. cheap natural uranium availability) is not obvious today, but strategically it should be envisaged.

In the past, attempts have been made to combine NFC front-end and back-end and to make the so-called "nuclear fuel leasing" scheme, in which it was supposed to transfer fresh nuclear fuel to the NPP operator and return UNF back to the supplier. However, this concept in the versions of the late 1990-ies and early 2000-ies was unrealizable for the following reasons:

— Association of the leasing scheme as the option of UNF management, which does not involve the return of radioactive waste (RW) from UNF reprocessing to the country of origin, which was unacceptable for political reasons;
— The need to transfer ownership to the fuel receiver, which leads to the impossibility of leasing;
— Different characteristics of fresh fuel and UNF, which does not allow to justify the leasing of the same material;
— Impossibility of application the zero VAT rate (reduction of transaction efficiency).

At the same time, the leasing concept has a number of valuable marketing ideas, which can be implemented taking into account the current opportunities. The main advantage of this concept is a combination of NFC front-end and back-end components supported by flexible financial mode when, for example, NPP operator receives a comprehensive service (fresh fuel with subsequent UNF return and the option of its recycling), and makes payments evenly at the stage of generation and sale of electricity. In this case, in target version of fuel leasing NPP operator saves on:

— Using recycled fuel materials instead of natural ones;
— Securing fresh fuel supply with avoiding of the fuel-related procurement procedures;
— Riding off all the unf management issues: interim storage, inspections, social pressure and even fund fees (in case when radioactive waste is to be disposed by npp operator);
— Reduced amount of npp radioactive waste to be finally disposed (rw conditioning is to be included into the scope of service);
— Reducing the financial burden associated with the presence of unf on the balance sheet.

The updated concept, so called NFC Service Platform, is adapted to modern market conditions and represents a model that try to overcome the restrictions for the aim of the benefits listed above.

2. NFC SERVICE PLATFORM DESCRIPTION

The objective of the NFC Service Platform is to provide a comprehensive service throughout the whole NFC supplemented by the option of attractive financing and advanced logistics. Thus there are three main components of the Platform: product line, finance and logistics.

Product line includes a full range of NFC products and services. The integral parts of the service could be natural/reprocessed uranium, services for its purification, conversion, enrichment and fabrication, as well as UNF management: packaging, transportation, interim storage, reprocessing, fissile materials recycling, high level waste partitioning and conditioning[2] for final disposal.

Not all the parts of the product line are ready to be delivered up to now. The following services are to be improved or developed to be commercially attractive: fabrication of appropriate MOX fuels from UNF recovered materials, partitioning of radioactive waste, minor actinides transmutation[3], processing residuals to be disposed near-surface etc. These services are being finalized and can be brought to market as soon as they are ready. At the same time traditional supply of uranium separate work units (SWU) along with medium-term

[2] In fact HLW partitioning and conditioning is a kind of radiochemistry technique which is broadly used at SNF reprocessing plant. It is based on liquid extraction approach and the only challenge there is to find the most effective extractant: there are very many lab tested ones, so, the authors predict availability of the certain services in the nearest future.

[3] High Level Waste partitioning and minor actinides transmutation are obligatory parts of the NFC Service Platform in option when NPP owner would like to avoid deep geological repository. Residuals in this option could be stored for ~300-350 years in the casks and then to be disposed near-surface. In case when it is made within the NPP site, all the obligations concerned to the SNF and RW treatment could be realized by NPP operator without creation of the National SNF fund.

lending is possible to supplied now, and customer could pay for the SWU from income of electricity sale. This component could be considered as a starting point for the NFC Service Platform development.

Financial component involves a variety of payment options services: increasing the terms of payment under the contract, installment payment, phased payment, etc. The target option is a phased payment for a comprehensive service during the irradiation of fuel in the reactor simultaneously with the generation and sale of electricity by the NPP operator.

The set of logistics components includes various delivery conditions, the choice of optimal transportation routes, the provision of transport equipment from its own fleet, washing empty containers, the use of a system of material accounts for uranium products. The development of the logistics component provides for the opening of new transport routes, the creation and international certification of the domestic fleet of transport containers for UNF. In addition, the establishment of a system of material accounts with UNF reprocessing enterprises (Russia, France, China, Japan and India) may be considered.

Complex fuel solution can be selected individually for each customer depending on its needs. The target NFC Service Platform should allow to the NPP owner to concentrate on the NPP safe operation and electricity production and trading: all the fuel issues will be addressed to the NFC Service Platform provider(s) with the corresponding redistribution of the financial and other risks in favor of provider(s).

NFC Service Platform may be started to be implemented instantly on the basis of available opportunities and existing services, and then to be complemented with other services to be developed together with customer, like the product line, financing tools and legislation. Thus the further development of the NFC Service Platform could be financed by the service itself.

3. ISSUES TO BE ADDRESSED

The target NFC service platform requires solution of number of issues related to:

- Technologies of RW management (minor actinides transmutation in fast neutron reactors, intermediate level waste storage, method of RW conditioning, MOX fuel application in PWR type reactors etc.),
- Economy of the process (services in the NFC back-end for the customer should not lead to an increase in payments compared to the current levels of contributions to the funds for the UNF treatment),
- Legal agreements between the countries on different aspects like UNF title transfer, minor actinides services, radioactive waste return, new routes for nuclear materials transportation etc.

Thus, the NFC Service Platform development seems to be a challenge not only for the service provider and the customer. Broad support of the initiative by international community is crucial for the initiative.

4. SUMMARY AND CONCLUSIONS

The concept of fuel leasing 1990-2000s is not realizable in its pure form but can be adapted to modern realities in the format of a NFC service platform.

NFC service platform includes three components: product line, financing, logistics service. Certain number of services could be gathered individually with the inclusion of components depending on customer's needs and limitations.

The essence of NFC service platform seems to be very attractive environmentally, socially and economically: it significantly reduces the volume and activity of the nuclear waste to be disposed, it makes easier the waste management by the NPP operator, it could be covered by the direct payment from electricity selling etc. In its target state NFC Service Platform could it can simplify national infrastructure of the address with SNF and RW.

Some components of the NFC service platform are ready to be provided right now. Other are to be developed. The platform could be improved in step-by-step mode, starting with existing techniques and services and then complimented by the new ones.

International community support of the NFC service platform conception is crucial. One of the task there is to find a legal mechanism how it could be implemented in the frame of the Joint Convention obligations.