Drivers and impediments for the international cooperation in the Nuclear Fuel Cycle’s Back End

Leonid Yanko

JSC TVEL
The unleashed power of the atom has changed everything save our modes of thinking. Thus we drift towards unparalleled catastrophe. The solution to this problem lies in the heart of mankind.

*Albert Einstein, 1948*

International cooperation, multilateralism is indispensable.

*Hans Blix, 1998*

The only thing that will redeem mankind is cooperation.

*Bertrand Russell*
Drivers and Examples

**Common objective.**
E.g. ecological safety at Fukushima.

Different objectives but **Coincident tasks.**
E.g. INPRO: sustainability of the existing nuclear fuel cycle for one party, development scenarios for another, and modelling of the systems as a common task.

**Mutual benefits.**
E.g. joint researching of the granite SNF storage characteristics in Äspö Hard Rock Laboratory.

**Scientific interest.**
E.g. R&D projects on spent fuel melting.
How to Use the Drivers
Assumptions

Common objective.
E.g. ecological safety at Fukushima.

Different objectives but Coincident tasks.
E.g. INPRO: sustainability of the existing nuclear fuel cycle for one party, development scenarios for another, and modelling of the systems as a common task.

Mutual benefits.
E.g. joint researching of the granite SNF storage characteristics in Äspö Hard Rock Laboratory.

Scientific interest.
E.g. R&D projects on spent fuel melting.

Find the common objectives.
E.g. ecological safety, utilization of the reprocessed materials etc.

Find the coincident tasks.
E.g. sustainable national Nuclear Fuel Cycle, necessity of the modern type facilities for SNF storage etc.

Find the mutual benefits.
E.g. developing of the recycling technologies etc.

Find the scientific enthusiasts.
Impediments and Examples

Different consideration on SNF status. Some Countries consider it as waste vs. some other consider as value.

Diversity of the legal requirements. There offers to create a multilateral SNF storage vs. Europe insists on national responsibility.

Political restrictions. Influence of unsettled issues of political nature

Lack of resources. Some Countries can not consider reprocessing due to high price of reprocessing.

Lack of responsibilities. Some Countries limit its responsibilities concerning the fuel exported to the foreign NPPs and can not cooperate when this fuel is spent.
How to Overcome the Impediments

Options

Different consideration on SNF status. Some Countries consider it as waste vs. some other consider as value.

Diversity of the legal requirements. There offers to create a multilateral SNF storage vs. Europe insists on national responsibility.

Political restrictions. Influence of unsettled issues of political nature

Lack of resources. Some Countries can not consider reprocessing due to high price of reprocessing.

Lack of responsibilities. Some Countries limit its responsibilities concerning the fuel exported to the foreign NPPs and can not cooperate when this fuel is spent.

Balance the interests. E.g. underground disposal is useful both for SNF and vitrified HLRW.

Study the legislation (and find the solution). E.g. Europe allows to export SNF when all the parties could secure the long-time safety.

Conclude an alliance. E.g. German back-end enterprises restricted for abroad activities conclude the alliances with the joint ventures.

Show the long-time benefits. E.g. La Hague reprocessing plant was developed due to considerable international cooperation.

Take responsibility upon yourselves.
Recipe for the ideal project
for the international cooperation in Back End

Find the common objectives.
Find the coincident tasks.
Find the mutual benefits.
Find the scientific enthusiasts.
Balance the interests.
Study the legislation (and find the solution).
Conclude an alliance.
Show the long-time benefits.
Take responsibility upon yourselves.
Integrated approach
Set of NF Front End + Back End services: Advantages

Set of NFC services

Set of NFC services’ advantages

✓ Non-proliferation
Non-proliferation of Nuclear Dual-Use Technology and Materials

✓ Safety
Extensive expertise in SNF/Radwaste management

✓ Ecology
Efficient use of natural resources
Reduction of radwastes volume and number of hazardous objects

✓ Economy
No requirement of FC Back End establishment
Integrated offer
Two main options

«Once-through cycle»

NF supply

SNF TPS fabrication

SNF removal

SNF reprocessing

Wastes/Pu disposal
RepU / MOX SNF disposal*

RepU / MOX fabrication & supply

* In the second cycle: RepU SNF and MOX SNF

«Wait-and-see» policy

NF supply

SNF TPS fabrication

SNF removal

SNF long-term storage (>100 years)
Possible approaches to the international cooperation in the area of Back End of Nuclear Fuel Cycle
REMIX Nuclear Fuel Cycle
How it looks like

• After irradiation in the NPP fuel is stored for the certain time in the reactor pool, and then goes to the reprocessing.
• During reprocessing all the remaining uranium and plutonium are recovered, and the fission products are vitrified and disposed.
• REMIX-fuel is produced of the uranium-plutonium mix recovered with the adding of the natural uranium enriched up to 17% by U-235. Weight of the feed is about 20% of the whole fuel weight.
• Thus, fresh REMIX fuel contains about 4% of U-235 and about 1% of Pu. For the thermal neutron reactor like VVER/PWR such the composition is usual and does not require reactor modification (no capital investment).
• After irradiation REMIX-fuel is reprocessed again. Uranium and plutonium are again recovered and go to the fresh REMIX-fuel fabrication. Compensation accumulated even isotopes of U and Pu by the natural uranium feeding allows to perform at least 5 recycles.
REMIX Nuclear Fuel Cycle
Fission Materials Recycling

REMIX Fuel Assembly
1% $^{239}\text{Pu}$ + 4% $^{235}\text{U}$

100% charging
of the reactor core;
4-years company

NPP Irradiation

(U-Pu)$_2$O$_2$ based
Fuel Fabrication

Enriched uranium
(up to 17% by $^{235}\text{U}$)

Burnup level –
up to 50 Gt·day/tU

Spent Fuel
Cooling

Non-separated
U-Pu mixture

Radioisotopes
for medicine
and industry

Spent REMIX Fuel
2% $^{239}\text{Pu}$ + 1% $^{235}\text{U}$

Spent Fuel Reprocessing

Vitrified HLW
Disposal

U and Pu Recycling

Approx. 5 years
REMIX Technology
Multicycle Nuclear Fuel Lease

NPP operator as a Customer

Provider = Fuel Fabricator + SNF Utilizer

Fuel irradiation

Fresh Fuel

Fuel Fabrication

SNF cooling on-site

Spent Fuel

SNF Reprocessing

No need for the Customer to develop Back End infrastructure and service.
REMIX Nuclear Fuel Cycle for the international cooperation in Back End

Sustainable Fuel Cycle for all the parties.
Fuel Supply.
Work load; Specialization.
Interesting scientific tasks included.
Minimization of the RW to be disposed.
Reduce governmental concern about SNF.
Everybody are welcome.
NPP to be provided with the same fuel for its lifetime.
ROSATOM already develops REMIX.

Find the common objectives.
Find the coincident tasks.
Find the mutual benefits.
Find the scientific enthusiasts.
Balance the interests.
Study the legislation (and find the solution).
Conclude an alliance.
Show the long-time benefits.
Take responsibility upon yourselves.
Reprocessed Uranium Recycling
How it looks like

• RepU is a product of the Spent Nuclear Fuel reprocessing.

• There is a multi-decade experience in purification, enrichment and using of RepU as the NPP fuel (France, Germany, Switzerland, Russia, etc).

• Involvement of the RepU in the Nuclear Fuel Cycle looks like comprehensive and sustainable approach to the fuel cycle management.

• RepU inventory grows approximately over 1000tU per year, raising the risk of demonstrating an exit for this material on the long-term and, consequently, having to treat this material as a waste and not as being recoverable.
Reprocessed Uranium Recycling
General Overview of the industrial services

Reprocessing Plant → Oxides storage → Dissolution and purification → Fluorination → Enrichment → Re-conversion → Tails → UF6 storage → Waste management → Waste disposal

Customer: 
- Oxides storage: U3O8
- Dissolution and purification: RW
- Fluorination: UN
- Enrichment: UF6
- Re-conversion: UF6e
- Tails

Provider:

NPP → Fabrication
- Fuel Assemblies
- UO2 powder
RepU processing for NF fabrication for Russian RBMKs and in cooperation with AREVA

NF for RBMK fabricated by our technology does not require modification of the reactor core. In the future RepU VVER fuel will be fabricated by blending scheme⇒ also no core modifications for VVERs
Reprocessed Uranium Recycling for the international cooperation in Back End

Sustainable Fuel Cycle for all the parties.
Find the common objectives.

Fuel Supply.
Find the coincident tasks.

Work load; Specialization.
Find the mutual benefits.

Very interesting scientific tasks included.
Find the scientific enthusiasts.

Minimization of the RW to be disposed.
Balance the interests.

Reduce governmental concern about SNF.
Study the legislation (and find the solution).

Everybody are welcome.
Conclude an alliance.

NPP to be provided with the fuel for its whole lifetime.
Show the long-time benefits.
Proven reliable technology, long-term experience in cooperation
Take responsibility upon yourselves.
Conclusions

• International cooperation in Back End is quite essential.
• There are obvious drivers and also impediments for such the cooperation.
• Analysis of drivers and impediments could be a matter of a Back End project realization.
• REMIX and RepU projects seem to be able to use the drivers and overcome the impediments.
Every kind of peaceful cooperation among men is primarily based on mutual trust and only secondarily on institutions such as courts of justice and police.

*Albert Einstein*