IBR™

Reprocessed Uranium Utilization in Russia

Analytical Study

International Business Relations, LLC

Moscow, 2022

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Project Team

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- Selected experts from state & private institutions

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RepU	reprocessed uranium
ERU	enriched reprocessed uranium
EUP	enriched uranium product
FA	fuel assembly
FAEA	Federal Atomic Energy Agency of Russian Federation (presently State Corporation “Rosatom”)
GC	gas centrifuge
ISUB	irradiated special uranium blocks (for Pu-production reactors)
HEU	highly enriched uranium
MEU	medium enriched uranium
NU	natural uranium
LEU	low enriched uranium
LTC	long-term contracts
RCF	reactivity compensation factor
RS material	reprocessed uranium recovered from spent nuclear fuel of ADE (Pu-production) reactors
SCC	JSC “Siberian Chemical Combine”
MSZ	JSC “Machine Building Plant” (JSC MSZ)
SNF	spent nuclear fuel
tHM	ton heavy metal (usually uranium)
tU	ton of uranium (as pure metal) = 2,600 lb. U_3O_8

Part 1. Introduction in RepU Utilization Business

1.1 Structure of the report

For many years RepU has been a relatively small but stable secondary uranium supply source. Rising prices for natural uranium in 2020-2021 increased the interest to the RepU utilization. The certain interest to the RepU utilization from the side of fuel assemblies (FA) manufacturers and nuclear utilities has been kept on the following reasons:

- ✓ It is obviously to the nuclear community, that the prices for NU will be increasing in the future and RepU utilization will be economically reasonable;
- ✓ The significant volumes of RepU are storing in the storages and nuclear utilities spent money for the RepU storage;
- ✓ Significant part of nuclear utilities have the concept of closed nuclear fuel cycle, so the new volumes of RepU will be generated as result of SNF reprocessing and it will require the new expenses for RepU storage in case the RepU will be not utilized.

In these circumstances comparative technology & economic analysis of RepU use for production of nuclear fuel is especially important and timely, because both the producers of nuclear fuel and their clients should have clear understanding of the economic expediency of investing in the development of RepU processing (radiochemical purification, conversion, enrichment) and fuel fabrication technologies and in the RepU fuel utilization in commercial nuclear reactors.

Nowadays Russia and France are the only countries where production of enriched reprocessed uranium (ERU) has become an industrial scale process. In the study, IBR concentrated on the current state and prospects of RepU utilization in Russia because, on IBR's opinion, the leading role of the Russian nuclear industry in this field will remain unchanged in the near future.

There are two principal technologies for RepU enrichment, namely:

- ✓ Enrichment of reprocessed uranium to a higher content of ^{235}U in a gas centrifuge cascades, which is called in this study the <u>direct enrichment technology</u>.

- ✓ Mixing of reprocessed uranium with uranium of higher enrichment (e.g. 10-20 percent or higher of ^{235}U), which is called in this study the <u>mixing technology</u>.

For the manufacture of some products, both techologies have been and are used.

In the study, IBR considered the state and prospects of both approaches to RepU enrichment in Russia. The second Part of this report is dedicated to the direct enrichment technology and the third Part is dedicated to the mixing technology. In order to introduce the reader to the whole system of RepU business currently existing in Russia, IBR provided the Part 1.

1.2 General outline of the current state of RepU business in Russia

Reprocessed uranium (RepU) utilization has been a rather complex and significant part of nuclear fuel cycle activities in Russia for many years. At present, RepU utilization projects both current and prospective are interconnected to some extent because all of them utilize the same industrial and technological basis of Russian nuclear fuel cycle enterprises. That is why it seems reasonable to provide a concise overview of the current state of RepU business in Russia and only then present more detailed discussions of particular RepU projects and technological processes.

A diagram presenting key players in RepU business and their interrelations is shown at the Figure 1.1.

There are some current and prospect RepU utilization projects in Russia:

1. Cooperation between Framatome GmbH (former AREVA GmbH) and JSC Machine Building Plant (MSZ)[1].

   Framatome GmbH (former AREVA GmbH):

   - ✓ Deliveries RepU in the form of U_3O_8 from the European Union (EU) to MSZ;
   - ✓ Provides German-made parts (tubes, spacer grids etc.) for the fuel assemblies (FA) manufacturing at MSZ;
   - ✓ Manufactures FA for PWR / BWR using fuel pellets made from ERU at MSZ (MSZ delivers to Framatome GmbH (former AREVA GmbH) certain percent of fuel in the form of the fuel pellets, not in the form of FA);
   - ✓ Deliveries FA for PWR / BWR to customers in European Unioun (EU).

   JSC Machine Building Plant (MSZ):

   - ✓ Deliveries through FC TVEL to JSC Siberian Chemical Combine (SCC) for radiochemical purification / conversion / direct enrichment the certain volume of RepU in the form of U_3O_8 that was supplied by Framatome GmbH (former AREVA GmbH) from the European Union (EU), and then receives back the enriched reprocessed uranium (ERU). The delivered to JSC Siberian Chemical Combine (SCC) RepU can be mixed preliminary or after direct enrichment with NU / EUP to limit the concetration of ^{232}U and / or ^{236}U in intermediate product;
   - ✓ Purchases through FC TVEL at Federal State Unitary Enterprise Production Assocoation Mayak (PA Mayak) medium-enriched RepU, ~ 14-17% ^{235}U;
   - ✓ Purchases from FC TVEL the certain volume of EUP that is resulted of NU enrichment;
   - ✓ Reconverts to oxides ERU and EUP that have been supplied by JSC Siberian Chemical Combine (SCC), other uranium enterprises and PA Mayak;
   - ✓ Mixes the available type of fuels to receive the final fuel with required isotope contents and/or with limitations for concentrations of certain isotopes;
   - ✓ Manufactures fuel pellets and fuel assemblies;
   - ✓ Deliveries fuel pellets and fuel assemblies to Framatome GmbH (former AREVA GmbH).

2. EDF orders RepU radiochemical purification, conversion and enrichment services from TENEX (RepU processing is actually done at SCC) and has, in the framework of a general fuel supply contract, a special contract with Framatome SAS (former AREVA SAS) for a package of services for ERU fuel fabrication. In 2018 was signed the new contract between EdF and TENEX devoted to purification, conversion and enrichment of RepU in 2023-2032. The sum of new contact is about $ 1 bln. The dtailes of this contract are described in Part 2.

3. Fabrication of ERU fuel for Russian NPPs. FC TVEL purchases RepU from PA Mayak and sells FA with ERU fuel to the Russian nuclear power utility JSC Rosenergoatom. Earlier about 40-60 tU of ERU fuel was used to manufacture the FA for VVER-440 and VVER-1000 reactors to demostrate the opportunity of nucelar unit safety operation and recieve the certain experiance for the future. At present only RBMK fuel is produced with the use of ERU fuel.

4. In 2013-2016 years, some Japanese companies expressed their interest in the cooperation with Russia concerning RepU of Japanese origin processing (radiochemical purification, conversion, enrichment) in Russia. But, the negotiations between FC TVEL and Japanese companies are not enough extensive. IBR

[1] This plant is formally called “Mashinostroitelnyi zavod” in Russian that means “Machine building plant”. It also has a rarely used alias “Elemash” from “Electrostalsky mashinostroitelnyi zavod”. We used MSZ or “Machine Building Plant” in this study.

proposes that Japanese nuclear utilities will come to the agreement concerning RepU of Japanease origin utilization for nuclear fuel manufacture utill 2027-2030.

5. In 2016, one of US's utilities expressed their interest to the cooperation with Russia concerning RepU of US origin processing (radiochemical purification, conversion, enrichment) in Russia. The details of US's utility interest were unclear. However, IBR may propose, that US's utility is interested in processing (radiochemical purification, conversion and direct enrichment) of DOE owned low irradiated uranium resulted from industrial (Pu production) nuclear reactors. Taking into account Russian-US political relations IBR dpesn't aware the progress in this direction.

6. Nuclear Fuel Complex (NFC) of India. Though until now NFC of India has been purchasing nuclear fuel, more precisely, fuel pellets made from LEU and NU it is quite probable that in the near future RepU-based fuel will also be supplied from Russia to India.

7. In 2017, JSC MSZ & FC TVEL came back to the negotiations with SNC Lavalin concerning the CANDU fuel bundles manufacture with the use of RepU fuel at MSZ. There were no positive results until the end 2021.

8. JSC MSZ & FC TVEL look for opportunity of delivery fuel made on the base of RepU already in bundles for loading in heavy water reactors. The nuclear fuel equivalent enrichment for heavy water reactors can be higher that enrichment of natural uranium to extend the fuel company and to increase the fuel efficiency. At the end of 2021 FC TVEL decided to intensificate the negotiations with all utilities operate CANDU type reactors.

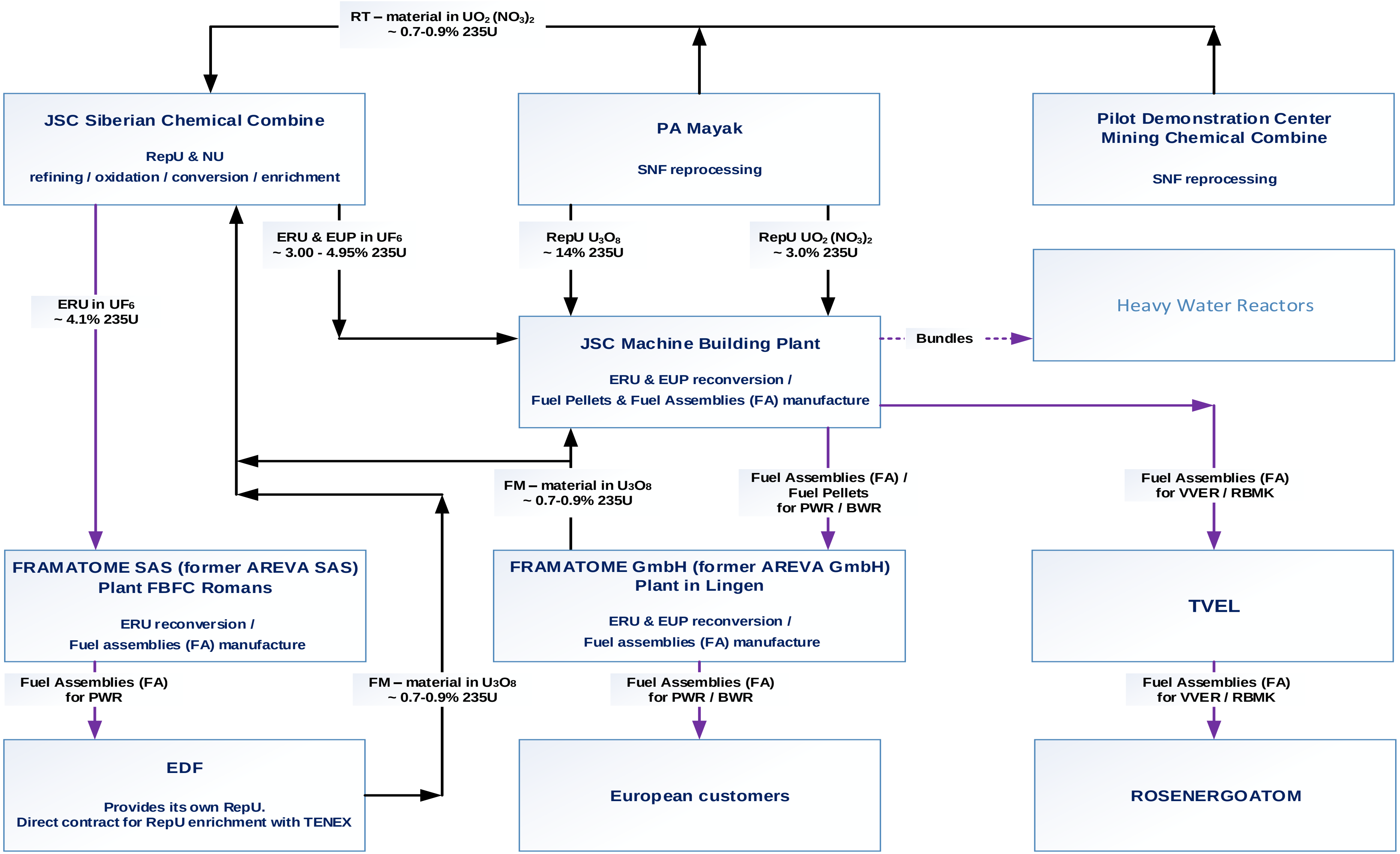


Figure 1.1. Schematic diagram of current RepU utilization activities in Russia

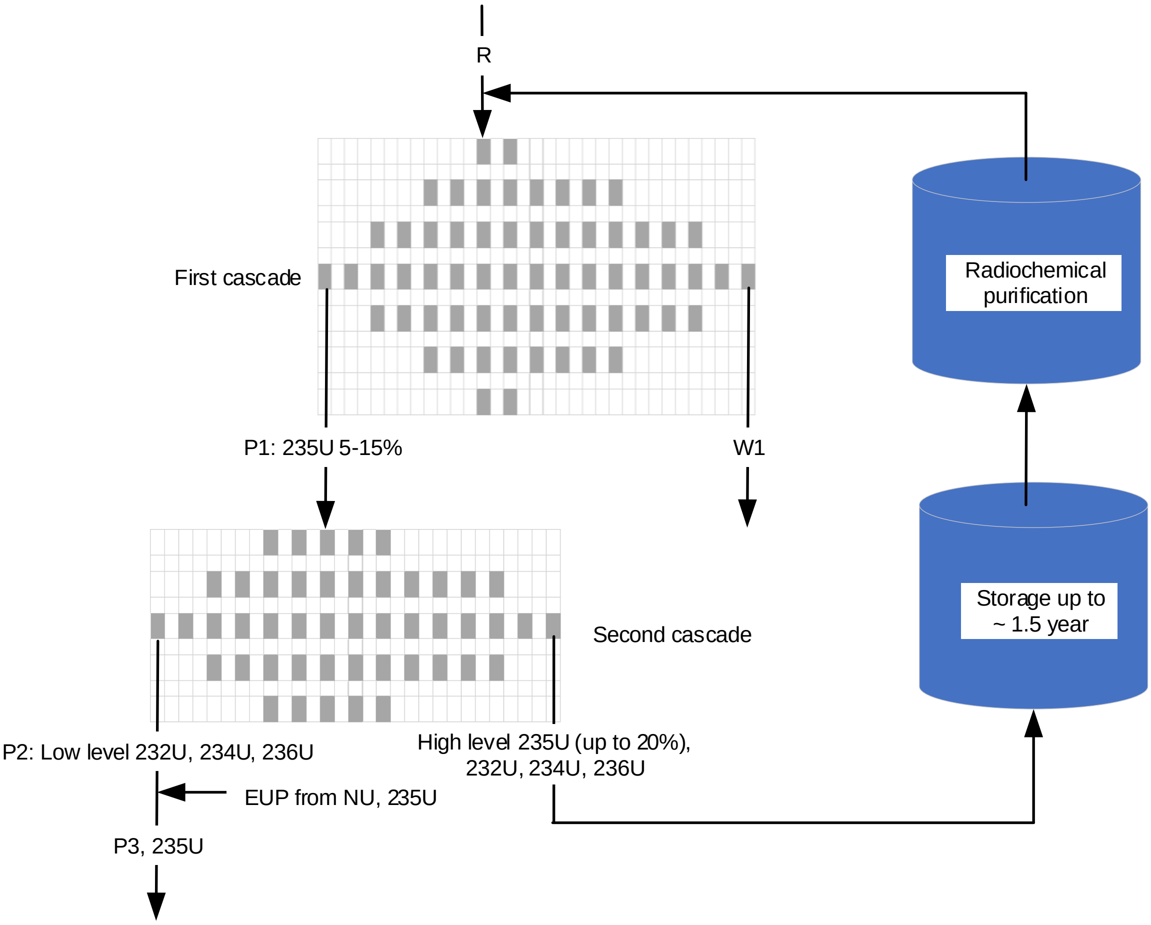
Table 2.1 IBR forecast of Russian uranium enrichment industry in UF6 of natural quality demands and sources of supplies, tU

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Russian Enrichment Industry demands in UF6, tU	16 451	16 794	17 069	17 414	17 691	17 828	17 207	17 758	17 551	18 034	17 895	18 240	18 721	18 721	19 547	18 652
UF6 of NU quality supplies, tU, including:	16 451	16 794	17 069	17 414	17 691	17 828	17 207	17 758	17 551	18 034	17 895	18 240	18 721	18 721	19 547	18 652
▪ Tails enrichment, tU	3 061	3 486	3 715	4 452	4 264	3 601	3 895	3 764	4 223	4 223	4 517	4 255	3 633	3 306	2 357	3 208
▪ Import & reservs as UF6, tU	1 200	1 200	1 000	800	200	0	0	0	0	0	0	0	0	0	0	0
▪ Russian Conversion Industry, tU	**12 190**	**12 108**	**12 354**	**12 162**	**13 227**	**14 227**	**13 311**	**13 994**	**13 328**	**13 811**	**13 378**	**13 984**	**15 087**	**15 415**	**17 190**	**15 444**

Remarks:

- ✓ The source of data (natural quality UF_6 supply & demand, natural quality UF_6 resulted from tails re-enrichment) – IBR Russian uranium enrichment industry. State & forecast. 2020.
- ✓ Import as UF6 does not mean only every year import of UF_6. It means too the using of UF6 of natural quality from reserves established by imported UF_6 in former times. Mainly, the reserves of UF_6 of natural quality that had been formed as result of import of ~ 27,000 tU in the form of UF_6 of natural quality to Russia by TENEX in terms of HEU-LEU project.
- ✓ The UF6 of natural quality includes RepU with the enrichment ~ 0.7% ^{235}U.

In 2012, SCC registered patent No. RU 2497210 “Method for isotopic reduction of regenerated uranium” describing variants of Diagram (4). The formula of the invention: A method of isotopic reduction of regenerated uranium for reuse in a nuclear reactor, consisting in the fact that in the hexafluoride of regenerated uranium the content of the U-235 isotope is increased to a specified value in the range of 2.0 ÷ 5.0 wt.% And the relative concentration of the isotope is reduced U-232 in a mixture of uranium isotopes, including the direct enrichment of regenerated uranium hexafluoride with the U-235 isotope in a two-stage installation from separating stages of gas centrifuges, characterized in that in the first cascade, regenerated uranium is enriched with the U-235 isotope to 5.0 ÷ 10.0 wt .% while maintaining the ratio of mass flow rates of the dump flow and the cascade withdrawal flow in the range (6.9 ÷ 18.4): 1, the dump and first cascade withdrawal flows are fed to the second cascade, while the isotopically reduced regenerated uranium is taken from the separating stage of gas centrifuges in the central part of the second cascade. The method, characterized in that the isotopically reduced regenerated uranium is taken in an amount not exceeding 0.13 of the mass fraction of the external feed stream of the two- cascade installation.



R - RepU, P - Product, W - Waste

In 2019, the Federal State Budgetary Institution "National Research Center" Kurchatov Institute "registered patent No. RU 2702620" Method for isotopic reduction of regenerated uranium "describing variants of Diagram (4). This patent almost completely repeats the ideas published in patent No. RU 2497210. Claim of invention: The method of isotopic reduction of regenerated uranium provides for an increase in the ^{235}U isotope content up to 3-5 wt.% In regenerated uranium with a decrease in the absolute and / or relative concentration of even uranium isotopes, with the separation of isotopes of the raw uranium uranium regenerate in an installation of two successive gas centrifuge cascades. uranium regenerate based on the fissile isotope uranium-235 in the first gas centrifuge ordinary cascade to a content of 5-15 wt%. natural origin and concentration of ^{235}U 3-5 wt. %, and the selected stream of the second cascade enriched in ^{235}U up to 20 wt. % is sent to a storage container. After aging and radiochemical purification, it is mixed with the regenerated uranium of the next batch at the inlet of the first gas centrifuge cascade. The technical result is the elimination of dangerous high concentrations of the fissile isotope ^{235}U no more than 20% for the ^{235}U isotope at any stages of the process, ensuring the complete return of the regenerated uranium to the fuel breeding due to the absence of unused regenerate sent for long-term storage.

Table 2.10 Composition of ERU product obtained from RepU if it is directly enriched in a single cascade without admixing of natural uranium

	Concentration, %			
235-U in standard fuel (made of enriched NU)	**3.7**	**4.0**	**4.5**	**4.95**
235-U in ERU[19]	4.25	4.59	5.12	5.66
232-U in ERU	13.7E-07	14.9E-07	16.8E-07	18.6E-07
234-U in ERU	0.0989	0.1071	0.1207	0.133
236-U in ERU	1.841	1.965	2.171	2.355

For IBR's calculations, we assumed that the final product should correspond to fuel with 4.5 % concentration of ^{235}U produced from natural uranium. As it has been mentioned above, fuel from RepU should have a higher content of ^{235}U to compensate for neutron absorption by ^{236}U and ^{234}U[20]. In the table above we took the value of reactivity compensation factor (RCF) equal to 0.3[21] that is an approximate value most frequently used in practice. We also decided to neglect the influence of ^{234}U concentration on reactivity compensation in IBR's calculations because it is usually done so in practice.

2.3.4 Calculation of the products' prices

This section is devoted to a comparative economic analysis of various options for the production of fresh nuclear fuel, including using RepU. The initial price for the owner of the RepU stored in warehouses or just received from the reprocessing of spent nuclear fuel is assumed to be zero. RepU gains some price only after being processed into ERU and its price is included in the ERU price.

The calculations of comparative prices of products with equal properties (from final consumer's point of view) were made for the following eight options (see below).

I. Product (1) – FA with enriched uranium as UO_2 (**4.5% ^{235}U**), **made from natural uranium** whose price corresponds to average world market prices. Uranium conversion and enrichment are made at the average market prices of world producers **(Western Europe / US prices,** see item 2.3.3).

II. Product (2) – FA with enriched uranium as UO_2 (**4.5% ^{235}U**), **made from natural uranium** whose price corresponds to average world market prices. Uranium conversion and enrichment are made at the FC TVEL under "transfer" or "internal" prices **(FC TVEL "transfer" or "internal" prices** see item 2.3.3).

III. Product (3) – FA with enriched uranium as UO_2 (equivalent to **4.5% ^{235}U** made from NU), made from natural uranium, whose price corresponds to average world market prices, with addition of some amount of RepU. Radiochemical purification, conversion and enrichment of RepU are made at the FC TVEL under "transfer" or "internal" prices **(FC TVEL "transfer" or "internal" prices,** see item 2.3.3). Enrichment is carried out under the **single-cascade flow diagram with dilution of RepU with natural uranium to keep ^{232}U concentration in ERU equal to 5·10^{-7}%**. This diagram includes a cascade where practically all ^{232}U concentrates along with ^{235}U and gets into the enriched product with 4.5 percent concentration of ^{235}U. Consequently, the amount of natural uranium to be added to the cascade for diluting RepU depends on the admissible concentration of ^{232}U in the product. It is most probable that it should be lower than or equal to the concentration of ^{232}U in the source RepU, though, as it was mentioned above, different counties have elaborated own safety regulations concerning admissible ^{232}U concentration in uranium for fuel assemblies fabrication and these specifications may change in the future. Nowadays 2·10^{-7}% is the level that is usually considered maximum for enriched UF_6. IBR took decision to consider the best case for the single cascade technology when in the near future admissible concentration of ^{232}U in enriched product will be higher than today and amount to 5·10^{-7}%. If this is the case and ^{232}U concentration in source RepU is equal to 2·10^{-7}%, the RepU flow to enrichment is approximately 2.5 times higher than and the enriched product flows and 4-4.5 times lower than the natural uranium feed flow. In other words, RepU makes

[19] Reactivity compensation factor (RCF) was taken equal to 0.3.
[20] At the beginning of the fuel company, the ^{234}U isotope plays a negative role by capturing neutrons and converting into ^{235}U, which is a fissile isotope.
[21] For uranium-graphite reactors, RCF is less and amounts to 0.2.

only a very limited part of uranium feeded to the cascade. In this case, the concentration of ^{236}U in the product will be almost the same as in the source RepU, i.e. 0.4 %. It was assumed that in this case the concentration of ^{235}U in the product should be the same as in the fuel made of natural uranium - 4.5 percent (in other words reactivity compensation was neglected due to its small value in this particular case). It should be noted that in the calculations IBR took RepU price equal to zero.

IV. Product (4) – FA with enriched uranium as UO_2 **(ERU ~ 5.15% ^{235}U that equivalents to 4.5% ^{235}U made from NU)**, made from RepU in a single **cascade without addition of natural uranium**. Radiochemical purification, conversion, and enrichment of RepU are made at the FC TVEL under "transfer" or "internal" prices (**FC TVEL "transfer" or "internal" prices,** see item 2.3.3). In this case concentration of even isotopes of uranium in the product (ERU) will be very high. At present only Framatome Romans plant can make nuclear fuel from such material and even this plant has licensed limit on content of ^{232}U in ERU equal to $16 \cdot 10^{-7}$%. This option corresponds to the current cooperation of EDF with JSC SCC but enrichment of ERU ordered by EDF is significantly lower (4.1-4.2%) than the enrichment (5.1%) considered in our calculation. It should be noted that in our calculations we took RepU price equal to zero.

V. Product (5) – FA with enriched uranium as UO_2 **(ERU ~ 5.15% ^{235}U that equivalents to 4.5% ^{235}U made from NU)**, made from RepU without addition of natural uranium in a **double cascade (with purification from ^{232}U to level $2 \cdot 10^{-7}$% in ERU)**. Radiochemical purification, conversion, and enrichment of RepU are made at the **FC TVEL under "transfer" or "internal" prices,** see item 2.3.3. Double-cascade flow diagrams allow RepU enrichment without adding natural uranium and concentrate ^{232}U in a small volume of high-level wastes. Cascade 1 in diagram 4 (see above) concentrates ^{235}U to 5.6 %; in cascade 2, the product is purified from ^{232}U. The final concentration of ^{235}U in the product is 5.1 percent. A calculation of optimal parameters for the double-cascade diagram is a complex technical task. Still, after taking a number of assumptions, it is possible to assess general economic parameters of the isotope separation process. For the first cascade SWU were calculated taking into account the necessity to enrich to higher ^{235}U concentration in the first cascade and this SWU value was used as a base for price calculation. Influence of the second cascade on the price was also taken into account using factor 1.1 to account for minimum ~ 15% of additional separative work in the second cascade. Double cascade technology needs more feed RepU than single cascade because part of ^{235}U is lost with waste flow from the second cascade. This fact was also taken into account (about 10% of ^{235}U is lost in the second cascade with radioactive waste). It should be noted that in our calculations we took RepU price equal to zero.

VI. Product (6) – FA with enriched uranium as UO_2 (**equivalent to 4.5% made from NU)**, made from natural uranium, whose price corresponds to average world market prices, with addition of some amount of RepU bought on the market. Radiochemical purification, conversion, and enrichment of RepU are made under the world market prices **(World market prices prices,** see item 2.3.3) Enrichment is carried out under the **single-cascade flow diagram with dilution of RepU with natural uranium to keep ^{232}U concentration in ERU equal to $5 \cdot 10^{-7}$%**.

VII. Product (7) – FA with enriched uranium as UO_2 (~ **5.15%**), made from RepU in a single **cascade without addition of natural uranium**. Radiochemical purification, conversion, and enrichment of RepU are made under the the world market prices). In this case concentration of even isotopes of uranium in the product (ERU) will be very high. At present only AREVA Romans plant can make nuclear fuel from such material and even this plant has licensed limit on content of ^{232}U in ERU equal to $16 \cdot 10^{-7}$%. This option corresponds to the current cooperation of EDF with JSC SCC but enrichment of ERU ordered by EDF is significantly lower (4.1-4.2%) than the enrichment (5.1%) considered in our calculation. It should be noted that in our calculations we took RepU price equal to zero.

VIII. Product (8) – FA with enriched uranium as UF_6 (~ **5.15%**), made from RepU without addition of natural uranium in a **double cascade (with purification from ^{232}U to level $2 \cdot 10^{-7}$% in ERU)**. Radiochemical purification, conversion, and enrichment of RepU are made under the world market prices (**World market prices,** see item 2.3.3).

The following tables and a plot show the summary of results obtained in calculations i.e. the estimated price cost of the product (specific price of FA in terms of $ per kgU) for all the eight options described above and its breakdown.

Table 2.11 Products' identification

Products	Equivalent to enriched NU, 4.5% ^{235}U	Processing technologies	Limit of ^{232}U in the product, %	Price formation base.
Product (1)	Yes	Conversion & enrichment in single cascade	NU conversion & enrichment	NU, conversion, enrichment – world market prices.
Product (2)	Yes	Conversion & enrichment in single cascade	NU conversion & enrichment	NU – world market prices. Conversion, enrichment – Russian "transfer" or "internal" prices.
Product (3)	Yes	RepU purification & conversion. NU conversion. RepU & NU mixing and enrichment in single cascade.	$5\cdot10^{-7}$%	NU– world market prices. Purification, conversion, enrichment – Russian "transfer" or "internal" prices.
Product (4)	Yes	RepU purification & conversion & enrichment in single cascade.	No limit.	Purification, conversion, enrichment – Russian "transfer" or "internal" prices.
Product (5)	Yes	RepU purification & conversion & enrichment in double cascade.	$2\cdot10^{-7}$%	Purification, conversion, enrichment – Russian "transfer" or "internal" prices.
Product (6)	Yes	RepU purification & conversion. NU conversion. RepU & NU mixing and enrichment in single cascade.	$5\cdot10^{-7}$%	NU – world market prices. Purification, conversion, enrichment – Western prices.
Product (7)	Yes	RepU purification & conversion & enrichment in single cascade.	No limit.	Purification, conversion, enrichment – Western prices.
Product (8)	Yes	RepU purification & conversion & enrichment in double cascade.	$2\cdot10^{-7}$%	Purification, conversion, enrichment – Western prices.

Table 2.12 Comparison of prices of enriched UF_6 produced from natural and reprocessed uranium, \$/kgEUP, equivalent to enriched NU, 4.5% ^{235}U

Products	Year																			
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
Product (1)	1 804	1 850	1 887	1 935	1 992	2 076	2 172	2 288	2 329	2 377	2 412	2 446	2 484	2 512	2 546	2554	2576	2597	2636	2 675
Product (2)	1 348	1 374	1 407	1 441	1 476	1 516	1 555	1 630	1 646	1 666	1 688	1 708	1 736	1 757	1 790	1839	1881	1923	1963	2 000
Product (3)	1 210	1 227	1 250	1 271	1 294	1 320	1 350	1 404	1 415	1 436	1 451	1 468	1 489	1 506	1 528	1566	1604	1637	1667	1 695
Product (4)	740	741	743	741	743	745	753	758	764	772	780	789	796	804	811	823	836	844	851	854
Product (5)	796	798	800	798	799	801	811	817	823	834	843	853	861	870	878	893	908	917	925	930
Product (6)	1 681	1 722	1 748	1 789	1 817	1 873	1 939	2 059	2 104	2 149	2 194	2 228	2 263	2 289	2 320	2 361	2 356	2 368	2 380	2 409
Product (7)	1 239	1 261	1 256	1 269	1 264	1 293	1 334	1 409	1 455	1 495	1 534	1 558	1 577	1 593	1 607	1 620	1 576	1 554	1 535	1 535
Product (8)	1 393	1 418	1 412	1 428	1 424	1 460	1 510	1 596	1 651	1 699	1 745	1 774	1 798	1 817	1 835	1 851	1 800	1775	1751	1 751

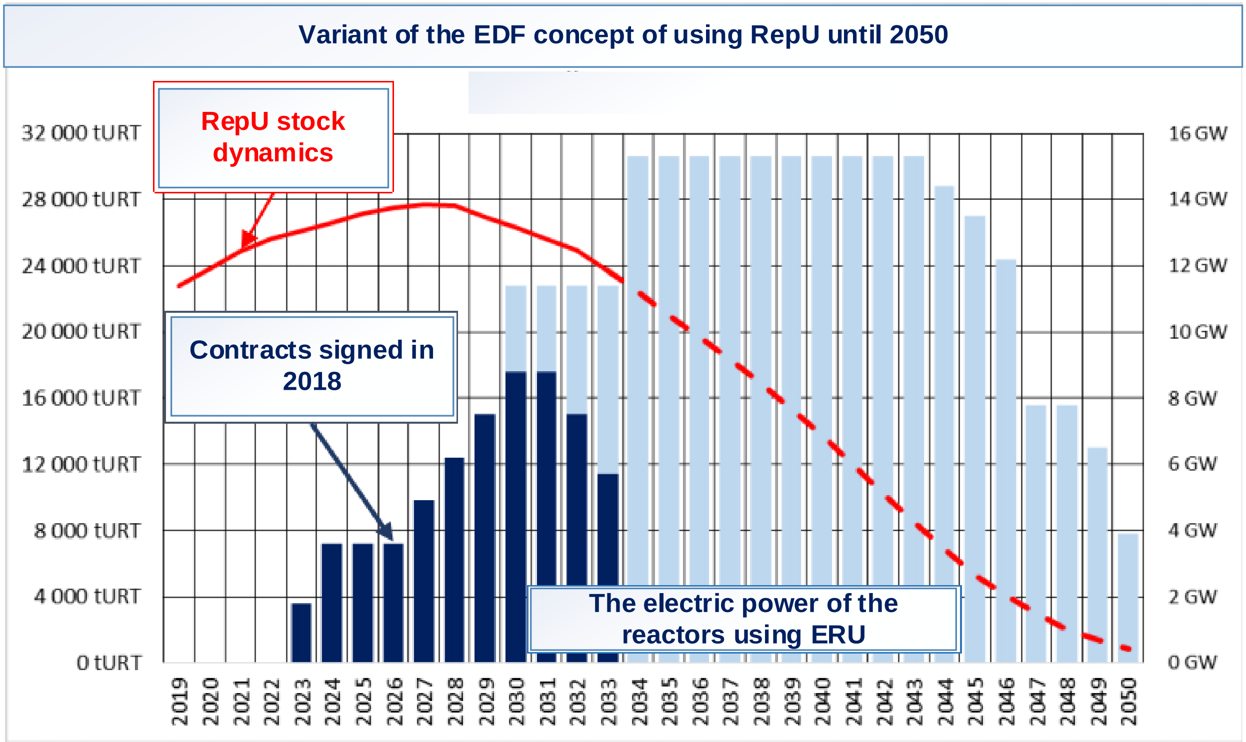


Figure 2.8 Variant of the EDF concept of using RepU until 2050

Figure 2.9 shows the functional diagram of the project at the level of the companies involved in the project. Suppliers (conversion, enrichment, FA fabrication, container flushing) were selected through announced tenders in 2017. The corresponding contracts were signed in 2018. In particular, on May 25, 2018, a contract was signed between Electricite de France SA (EDF) and TENEX. The contract price is about 1 billion and covers the period from 2022 to 2032.

Table 3.8 Number of ERU fuel assemblies, amount of fuel pellets and ERU produced by JSC MSZ for the customers of Siemens AG / Framatome ANP GmbH / Areva NP GmbH /AREVA GmbH / New NP GmbH in 1996-2021

Year	Number of FAs	Amount of fuel pellets produced, tU	Total amount of ERU produced, including fuel assemblies, fuel pellets and fuel powder (tU)
1996	4	0	2
1997	16	0	6
1998	16	0	6
1999	12	0	5
2000	102	0	35
2001	146	0	58
2002	192	0	45
2003	286	15	100
2004	196	29	97
2005	250	9	90
2006	170	9	69
2007	230	30	94
2008	216	56	132
2009	306	40	114
2010	370	40	140
2011	116	0	64
2012	200	40	94
2013	337	~ 40	~ 115
2014	352	~ 30	~ 120
2015	104	~ 9	~ 40
2016	32	~ 9	~ 20
2017	-	-	-
2018	112	-	36.071
2019	-	-	-
2020	40	-	12.902
Total	3,805	356	1,495