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NPP Krško Low and Intermediate Level Waste: Is More Rational Economical and Financial Management Plan Still Possible?

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ABSTRACT

According to the recently prepared 3rd Revision of the Krško NPP Radioactive Waste and Spent Fuel Disposal Program, low and intermediate level waste (LILW) will be divided in equal parts to be separately managed by Slovenia and Croatia.

After several years of negotiation, disposal at the Slovenian LILW repository in Vrbina was not agreed upon as a joint solution. The Intergovernmental Agreement requires that each country removes its share of waste from the NPP premises by 2025 – unless the joint solution is found by 2023, which now appears most unlikely.

However, full implementation of separate LILW management by 2025 does not appear much more likely either. To say nothing about rational aspects of the national LILW management plans.

Construction of the Slovenian repository (not yet really started) will be rather demanding and expensive (and certainly cannot be quite completed before 2025). And even more expensive are the compensations to the local community, already being paid for about a decade.

Development of the Croatian radioactive waste management center is at the stage of initial natural background radiation measurements, on the prospective site in a hostile community. Establishment of a simple surface storage facility, in the first phase, might be completed within several years (though not as early as planned, in 2023), at worst by circumventing the local community consent by the State issued administrative provisions.

And yet, it would not be entirely impossible to remove the LILW from the NPP "somewhere around 2025".

Slovenia perhaps can move its share to the nearby Vrbina disposal site even before serious repository construction works begin, and carry out any remaining treatment activities on that site.

Croatia plans to send its share to a third country, for conditioning and packaging. The shipments can begin and proceed even before the Croatian storage facility is completed.

However, given the fact that many details of the waste division and take-over (legal, technical and practical) have not yet been fully clarified, it is highly unlikely that the LILW removal will be fully completed in 2025. Therefore, both countries will probably tacitly tolerate

minor departures from the Intergovernmental Agreement, rather than attempt any small modifications.

The authors, on the contrary, propose that Slovenia and Croatia undertake an explicit modification of the Intergovernmental Agreement before 2023, in order to postpone the 2025 waste removal deadline for at least a decade or more. Such modification

- would eliminate the need for hasty implementation of the present management plans, in which optimal solutions might be overlooked,
- may facilitate financing of these plans, through postponement of major expenses, and
- could even open possibilities for serious revisions of present plans, so that at least some elements of joint management might be included.

The authors are convinced that present plans are not very rational solution for management of small LILW quantities from a single medium NPP.

The paper discusses the outlined potential advantages of the proposed Agreement modification, arguing that more rational LILW management options may still be possible.

Keywords*: radioactive waste, NPP Krško*

1 INTRODUCTION

Exploitation and decommissioning of the jointly owned Krško nuclear power plant (Krško NPP) are specified in the Intergovernmental Agreement (IA) between the Government of the Republic of Croatia and the Government of the Republic of Slovenia [1]. The Intergovernmental Committee (IC), in which both countries have symmetrical delegations, is in charge of monitoring the implementation of the Agreement.

The IA implementation instrument in the area of the NPP decommissioning and waste management are jointly prepared and periodically revised programs. The most recent variants are the Third Revision of the Krško NPP Decommissioning Program (**DEP Rev. 3**) and the Third Revision of the Krško NPP Radioactive Waste (RW) and Spent Nuclear Fuel (SNF) Disposal Program (**DIP Rev. 3**), adopted by the IC in 2020 [2].

These Programs firmly established two major milestones for RW&SNF management planning, which had been only speculated about in previous Programs revisions:

1. NPP Krško lifetime extension for additional period of 20 years, till January 14, 2043. First formal decisions were made in 2012, and subsequently supported by the IC in 2015. No doubts are harboured about successful conclusion of periodic safety reviews in 2023 and 2033, and no alternative scenarios are included in the third revision Programs. A hypothetical option of even further NPP life extension is informally mentioned.

2. Spent fuel dry storage facility (SFDS) at the Krško NPP site. It is the joint Slovenian-Croatian temporary solution for all SNF from the NPP and for high level RW (HLW) from the NPP decommissioning. Its establishment was agreed upon at the IC session in 2015, and DIP Rev. 3 planned its construction for 2020. The baseline scenario is the storage period of 60 years after the NPP shut down, until 2103.

However, regarding management of low and intermediate level waste (LILW) from the NPP Krško, DIP Rev. 3 did not manage to outline well defined and rational scenarios/solutions as for the two items above.

There were several years of negotiation between Slovenia and Croatia during DIP Rev. 3 preparation, unsuccessful in the sense that LILW disposal at the planned Slovenian repository in Vrbina was not agreed upon as a joint solution. Such outcome produced two consequences:

1. The LILW from the NPP Krško will be divided in equal parts, and each country will manage its share separately. The general plan is that this LILW will be managed according to the most recent national programs ([3], [4]) provisions for separate management. Though, by now it is clear that planned time schedules cannot be fully met.

2. The Intergovernmental Agreement requires that each country removes its share of waste from the NPP premises by 2025 (unless the joint solution is found by 2023, which now appears quite impossible). Also, by now it is clear that 2025 deadline cannot be fully met.

And yet, it may not be entirely impossible to remove "almost all present LILW" from the NPP "somewhere around 2025". Both countries will probably tacitly tolerate such "minor departures" from the Intergovernmental Agreement, rather than attempt its modifications.

The authors, on the contrary, propose that Slovenia and Croatia undertake an explicit modification of the Intergovernmental Agreement before 2023, in order to postpone the 2025 waste removal deadline for at least a decade or more.

The arguments for this proposal and the details of possible modification are described below.

2 HISTORY OF THE NPP KRŠKO LILW MANAGEMENT PLANS

2.1 Provisions of Disposal Program Revision 1

The first variant of jointly prepared and periodically revised Slovenian-Croatian programs was named Revision 1 of the Krško NPP Decommissioning and LILW and SNF Disposal Program. It was prepared during 2003 by the joint Project Team nominated by the IC, and in 2004 it was approved by both countries and adopted by the IC.

In present terms, its part dealing with LILW&SNF would be called DIP Rev. 1.

NPP Krško LILW management was planned on the assumptions that

- the NPP will operate until 2023,
- one joint repository (a standard surface vault-type facility) will be established either in the territory of the Republic of Croatia or in the territory of the Republic of Slovenia.

Construction of the LILW repository will be finished by 2018, it will remain in operation until 2037, and be shut down by 2042.

2.2 Scenarios of Disposal Program Revision 2

Revision 2 of the Krško NPP Decommissioning and LILW and SNF Disposal Program was started in 2008. It was carried out by essentially the same Project Team who worked on the Revision 1. After additional requirements by the Slovenian and Croatian stakeholders (gathered in the so called Advisory Body), Text version 2 of the Revision was completed in 2011 [5], but it was never formally adopted. One possible reason was that the Project team analysed 5 alternative scenarios, and the choice among them was left to the stakeholders as a political decision. Another possible reason was that the Project team would not reduce the scenarios costs beyond its professional judgement (the term suggested was "to rationalize").

But the Project team did propose/introduce a standby or standstill period for LILW repository operation, a period in which no waste is being disposed, whereby the operating cost would be significantly reduced – which is now generally accepted for the Slovenian repository project Vrbina. Also, the Project team informally suggested lower compensation to local community during that period, but formally only proposed reduced compensation for LILW extended storage that would postpone the need for disposal.

In present terms, the part of the Revision 2 dealing with LILW&SNF would be called DIP Rev. 2.

In this revision, the NPP Krško LILW management was described in 5 different scenarios. However, 2 scenarios became irrelevant in the meantime, after the NPP life extension until 2043 eliminated them. In addition, the scenario of joint LILW disposal starting in 2018 became impossible after the unsuccessful negotiation preceding the adoption of DIP Rev. 3. This means

that only last two scenarios of the Revision 2, named **S4** and **S5**, remain for present consideration.

S4 scenario is LILW division scenario strictly observing all requirements of the IA. Slovenia and Croatia did not agree on joint management, so that friendly co-operation can hardly be expected in the future (an Advisory Body specification). Therefore, they are required:

a) to remove all LILW from the NPP interim store by 2025,

b) to continue removing new LILW from the store at least each 5 years.

This requires continuous Vrbina repository operation 2018-2062, with no standstill period to reduce expenses.

Croatian LILW will be removed to a newly built storage in Croatia during 2023-2025. New LILW (operational and later decommissioning) will also be moved to this storage each 5 years. A surface vault-type repository will be built on the same macrolocation, but it will operate for only five years, 2057-2062.

This is clearly not a very rational scenario: the interim NPP store must not be used after 2025 for more than 5 years in a sequence, which increases costs for both sides, particularly for Slovenia.

S5 scenario is joint LILW management scenario, all expenses shared and calculated as if Vrbina repository will be used, but its construction and start of operation are postponed for 20 years.

The repository will be in operation 2038-2062, no standstill period is needed because all the NPP Krško LILW is disposed of in that period (after filling the first silo, the second silo is built by 2054).

However, additional space for prolonged storage in the NPP will be necessary (estimated 1200 cubic meters). Its licensing, construction (if needed), as well as its operating costs, are the responsibility of the NPP (an Advisory Body specification).

In S5 scenario, significant savings are achieved by paying only one half of the new LILW repository compensations during the prolonged interim storage of operational LILW in the NPP (actually, the amount of the previous compensations for LILW storage). Full repository compensations are resumed with the repository trial operations in 2037.

Also, postponement of the major investments (silo 1 and 2 construction) facilitates costs financing (discounted costs).

But the greatest advantage of this scenario is that many specifics of LILW disposal, and of LILW preparation for disposal, could be dealt with and resolved 20 years later than in other scenarios.

From the present viewpoint, this means that even the issue of negotiating joint management solution could be postponed for a decade or more, merely by a simple modification of the Intergovernmental Agreement, rather than giving up that option just because of the 2023 deadline.

2.3 Development of Slovenian LILW Management Plans Before DIP Rev. 3

By the time Revision 1 was completed, Slovenia had already decided to build its national LILW repository and put it in operation by the year 2013 (Slovenian law on radiation protection and nuclear safety from 2004 [6]). This was understood as a strategic decision that would facilitate future expansion of the Slovenian nuclear program (it caused no interference with the joint Slovenian-Croatian program).

Soon vigorous activities on the repository establishment followed. Site selection process soon focused on the Vrbina site in Krško municipality, and an original underground silo repository concept was found to be most suited to that location. First the “Conceptual Design for LILR Repository in Vrbina, Municipality Krško” was prepared in 2007, and then

"Preliminary Design for LILW Repository in Vrbina, Municipality of Krško" was completed in 2009 (by IBE/ARAO).

Repository siting was successfully completed, aided by the increased compensations to local communities. In Revision 1 the annual amount of 2,33 M€ 2002 was calculated as compensations for LILW repository operation, and in Revision 2 the annual amount of 5,075 M€ 2008 for LILW repository acceptance; the amounts were increasing for inflation until several years ago.

Decree on National Spatial Plan for LILW Repository on Vrbina Site in Municipality of Krško was adopted in December 2009, and new compensations have been paid since 2010.

2.4 Development of Croatian LILW Management Plans Before DIP Rev. 3

A site selection process for the location of national LILW repository was undertaken in Croatia from 1991 to 1995. Several regions including more than 30 suitable locations were identified in Croatia satisfying relevant safety criteria.

In 1999 macrolocation Trgovska gora was selected (the least opposition in the Parliament) and included in the Republic of Croatia Spatial Planning Program as location reserved for LILW repository. The Program specifies that Trgovska gora is the location on which further investigations will be conducted, and that partnership with local community will be developed ensuring, among other things, "possible forms of compensations to the local community".

For nearly 15 years after that, Croatian authorities showed little interest in LILW management plans in Croatia. Eventually, Croatian national RW and SNF management strategy was prepared, and approved in the Croatian Parliament in 2014, followed by National program for implementation of the Strategy adopted by the Croatian Government in 2018 [4]. Although "partnership with local community" has not been developed to date (they are still opposing acceptance of any RW), Trgovska gora remains the only Croatian region for future RW management, and former military complex Čerkezovac in this region is selected for the initial phase of RW storage.

The National Programme specifies that two facilities will be established within next several years: Central National Storage Facility (CNSF) for institutional waste (IRW) and disused sources (DS); and Long Term Storage facility (LTS) for LILW from Krško NPP.

3 NATIONAL LILW MANAGEMENT PLANS PRESENTED IN DIP REV. 3

DIP Rev. 3 describes the NPP Krško LILW management generally in accordance with the most recent provisions of national programs [3], [4] (for separate management), although already at the time of DIP Rev. 3 adoption it was clear that planned time schedules cannot be fully met. Here we mention only few aspects relevant for further discussion.

3.1 Slovenian NPP Krško LILW Management in DIP Rev. 3

Revision 2 of Disposal Program had demonstrated that one silo would be sufficient for all Slovenian LILW and 2 silos would suffice for joint Slovenian-Croatian LILW disposal.

After that, the activities focused on safety assessments, project refinements and site characterization.

In the time schedule of DIP Rev. 3, a three-year construction period of the repository is envisaged after obtaining a building permit. Although the building permit is not yet issued in August 2021, it is predicted in DIP Rev. 3 that the repository will be built by the end of 2022. And the repository is expected to begin trial operation in 2023, with regular operation starting before 2025.

To anybody mildly familiar with the complexities of the Vrbina silo repository, it should have been clear several years ago that such time schedule was entirely unrealistic.

Assuming regular operation start before 2025, DIP Rev. 3 plans that the repository "will continue to operate until the year 2027, when all Slovenian operating waste will have been disposed of; in 2028 the repository will enter the standby phase until re-entering the operation in 2050". All other remaining Slovenian NPP Krško LILW will be disposed of until the year 2058.

Duration of the repository standby phase is financially important because of high compensations to the local communities specified by the Slovenian Government Decree. DIP Rev. 3 foresees that "if compensation costs are based on draft novelation of the Decree, 6 M€ compensation costs should be paid during full operational phase and 0,6 M€ for standby phase". And this "full operational phase" includes the present period of the repository establishment. "Therefore, total costs for compensation during operating period are 97,2 M€, assuming first phase disposal ends 2027."

3.2 Croatian NPP Krško LILW Management in DIP Rev. 3

Planned operation of the Croatian so called Long Term Storage (LTS) for LILW from the Krško NPP is about 40 years. Since it is foreseen to be established in 2023, the establishment of repository for LILW is not required before 2051.

The Croatian share of NPP Krško LILW will be treated and conditioned into a form suitable for subsequent operations "in a dedicated waste management facility". It will be conditioned by packaging into Reinforced Concrete Containers (RCC).

One year is planned for the construction of LTS, followed by test period ending in 2022. Operation of the LTS will be divided into three periods: from 2023 to 2028 LTS receives RCCs from treatment and conditioning facility in a third country; from 2029 to 2049 LTS is in idle phase; from 2050 to 2059 the LTS is emptied by transferring stored RCCs to the Croatian repository.

Croatian half of operational LILW generated after 2024, as well as of decommissioning LILW, will be taken over from the Krško NPP site after 2050. Operational LILW (conditioned in the third country) and decommissioning LILW (conditioned on the Krško NPP site) will be transported directly to the Croatian repository.

It is now clear (and could have been anticipated in DIP Rev. 3) that LTS will not be licensed to start operation by the beginning of 2023. Čerkezovac complex has recently been transferred from the military to the jurisdiction of the Croatian RW management organization (the Fund for financing NPP Krško decommissioning and its RW and SNF management), but the site characterization (and other preparatory activities) are still in a relatively early phase.

Although various activities have been undertaken to establish "partnership with the local community", supported by the proposal of direct financial compensations of more than 1 M€ annually (8 million kuna) for the acceptance of RW management facilities, the local community is still opposed to the idea.

However, if needed, it may be possible to circumvent the local community opposition by the State issued administrative provisions.

4 DIP REV. 3 ISSUES

4.1 LILW Storage Space in the NPP

Limited capacity of the NPP present LILW store (so called SRSF, Solid Radwaste Storage Facility) has for a number of years been used as argument for early establishment and operation of the Slovenian repository (such as in 2013, in 2018, "as soon as possible").

This argument may have served (and perhaps still may serve) the purpose to support other legitimate Slovenian policy interests, but is entirely worthless otherwise. It is beyond any doubt possible to ensure additional LILW storage space in the NPP, and to postpone disposal (or takeover) of the NPP operational LILW for a decade or two, or even more.

The option was formally introduced in the S5 scenario of Disposal Program Revision 2, where additional space for prolonged LILW storage in the NPP (estimated at 1200 cubic meters) was needed to postpone the repository start of operation until 2038.

A novel variant of proposal to increase LILW storage space in the NPP appears in DIP Rev. 3. Describing the expected technical and practical difficulties of LILW removal from SRSF, Rev. 3 Executive Summary states that "any planned division and takeover may be quite difficult, if no manipulation and buffer storage is planned and built for all needed operations".

4.2 LILW Treatment, Conditioning and Packaging

Treatment, conditioning and packaging of the NPP Krško LILW is in DIP Rev. 3 described as follows (Executive Summary):

Before 2043

- "Croatian half: Transport and treatment with conditioning in RCC in the third country." The "third country" is not specified.
- "Slovenian half: Transport and treatment with conditioning in N2d containers in Slovenia." Whereto in Slovenia is not specified.

According to the IA, these activities should begin early in 2023. Is that really possible?

After 2043

- "Treatment and conditioning in N2d containers and RCC as planned in the Third revision of the Krško NPP Decommissioning program. Transport in corresponding LILW repositories in Croatia and Slovenia after 2050."

By 2043, a waste management facility (WMF) is assumed to be established on the NPP premises, and it will carry out all subsequent treatment and packaging.

But, can the above outlined plan be a rational solution? Certainly not, if the beginning of described treatment, conditioning and packaging of the NPP Krško LILW can be postponed.

4.3 DIP Rev. 3 Overall Concept Is Irrational and Poorly Specified

The issues mentioned above are two specific illustrations of the conceptual failure of DIP Rev. 3 regarding NPP Krško LILW management planning. Why these issues have not been seriously analysed in the Program, why more rational alternatives are not even noted?

Why are the time schedules unrealistic, what is to be gained by such a hurry?

Who really needs early LILW removal from the NPP and its hasty disposal/storage elsewhere?

Lot of ink has been spent on elaboration of Waste Acceptance Criteria (WAC). But these WAC are poorly correlated with the IA requirement that all LILW be immediately removed from the NPP: what if some waste streams cannot be made WAC-compatible?

Apparently, one of the obstacles to joint disposal was Croatian requirement that its institutional RW be placed in the Vrbina repository. But according to the Croatian National Program, the amount of this waste in the Croatian new dedicated storage facility (CNSF) is expected to increase at least till 2060. Without publicly available details of negotiation, it is hard to understand why Croatia would want to move part of CNSF content to Vrbina, or why Vrbina would not accept such small RW quantities if they can be made WAC-compatible.

The obvious rational alternative to DIP Rev. 3 is proposed in the next chapter. It could open possibility for additional negotiation of joint LILW disposal, but even if it doesn't, it would be by far more rational economical and financial management plan.

5 CONCLUSION: PROPOSAL OF MORE RATIONAL SOLUTION

The authors propose that the IA be seriously modified before 2023 and that the IC initiates next revision of DIP at the same time, specifying terms of reference or boundary conditions that would make the following options possible:

1. Temporary storage space at the NPP site should be increased so that all NPP operational LILW to be generated until 2043 can be accommodated;

2. The deadline for negotiating joint LILW disposal should be postponed to 2043, and the deadline for division and removal of all operational LILW from the NPP site should be postponed to 2045 for the case that negotiations on joint disposal fail;

3. A RW management facility for treatment, conditioning and packaging should be established at the NPP site in time to process operational LILW for disposal or further storage; it would be entirely irrational to build such facility for decommissioning LILW only;

4. Construction of the Vrbina repository should be postponed until 2038, regardless of whether it would be used only for the Slovenian share or for all LILW from the NPP; the time period after the building permit is obtained until the construction start should be declared the repository standby period for purposes of compensations to local community.

Also, the next DIP revision might address the following issues:

a. For small amounts of operational LILW containing long lived nuclides it may be difficult to meet WAC for planned facilities of further management. The stringent IA request to remove all operational RW from the NPP site might be modified to allow storage of these very small quantities together with the decommissioning HLW.

b. Croatia presently needs a new storage facility for its institutional RW, which will be used for at least several decades. Only when and if Croatian policy makers decide that no such facility will be needed for future acceptance of institutional waste, it would become sensible to consider disposal of that waste, possibly in arrangements involving disposal of the NPP Krško RW in Croatia or in Slovenia.

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