APPLICATION OF A SPECIFIC INDICATOR FOR THE ESTIMATION OF RADIOACTIVE WASTES GENERATION VOLUMES DURING NORMAL OPERATION OF NUCLEAR POWER PLANTS IN RUSSIA

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Generation of radioactive waste (RW) is viewed a most urgent problem of radiation safety under normal operation of nuclear power plants (NPP). The paper demonstrates the application of a specific indicator (rate) of RW generation per unit of generated power (m^3/GW·h) for a retrospective assessment and forecasting RW generation volumes at Russian NPPs. Mean and median values of annual specific RW generation rates were calculated for each NPP based on published environmental reports of JSC Rosenergoatom Concern for the period of 2008—2018. Advantage of applying median values in retrospective and forecast assessments was shown. Medians for solid very low-level, low-level, intermediate-level and high-level radioactive waste amounted to $1.5 \cdot 10^{-2}$ m^3/GW·h, $3.3 \cdot 10^{-2}$ m^3/GW·h, $3.3 \cdot 10^{-3}$ m^3/GW·h and $2.8 \cdot 10^{-4}$ m^3/GW·h, respectively; for liquid low-level and intermediate-level waste these values accounted for $1.4 \cdot 10^{-3}$ m^3/GW·h, $2.5 \cdot 10^{-3}$ m^3/GW·h, respectively. NPPs with RBMK reactor units are characterized by the highest mean and median values of specific RW generation rates for all RW categories. Given various types of reactor facilities and their characteristic specific rates, retrospective estimates for the total volume of liquid RW was increased by 8% and for solid RW — by 12%. The forecast estimates based on specific rate medians, as well as on increased power generation planned for Russian NPPs indicates probable increase in RW generation volumes by 0.8—7.1% (depending on waste category) in 2020—2027.

Keywords: *radioactive waste, specific indicator, reactor facility, nuclear power plant.*

Introduction

Radioactive waste (RW) is considered a most significant environmental factor associated with the operation of any nuclear power plant (NPP). Optimization principle being implemented in the context of RW management provides for various options [1], including by means of reducing the amount and activity of newly generated RW; compulsory conditioning of all retrievable RW accumulated earlier during NPP operation to bring them to a form suitable for disposal; as well as mandatory pre-disposal conditioning of newly generated RW. Such activities should be planned based on annual generation inventory accounting for each RW category. Identification of RW radionuclide composition is seen as a most difficult task in this area [2—4]. Nevertheless, not less important is the task of estimating and forecasting the amounts of RW generated during normal operation of NPPs, which is required for adequate planning of long-term RW management [5], since the infrastructure of disposal facilities depends to a large extent on the amount of waste transferred for disposal.

Over the entire period of Russian NPP operation, significant amount of RW has been accumulated in purpose-designed at-reactor storage facilities. NPP personnel in keeping a register of accumulated and newly generated RW inventory [6—8]. Part of the information on RW inventory (m3/year) generated annually during normal operation of NPPs has been published in annual reports on environmental safety for 2008—2018 that can be accessed via Rosenergoatom's website [9]. The structure and content of NPP environmental reports provides quantitative and qualitative characteristics associated with all factors affecting the population and the environment under normal NPP operation, including data on RW management.

Over the considered 11-year period, reports of 10 Russian NPPs should have presented data on annual RW generation as a set of 11 × 10 matrices for each waste category. However, this population is characterized by a large number of gaps: 33% of environmental reports provides no data on annually generated RW inventory. A number of reports cannot be accessed via the indicated Internet website: Leningrad NPP — the 2008 report: Kola, Novovoronezh, Smolensk NPPs — reports for 2009. Some reports provide information on annual RW generation in the form of diagrams containing no exact data on the volumes corresponding to each RW category. Thus, the published information can be considered as a limited sampling population: its representativeness basically relates to a random nature of the missing data. It seems unlikely that during the development of these environmental reports, purposeful (systematic) selection of the required values was performed. Assuming the representativeness, retrospective reproduction of the missing data can be done to estimate the total amount of waste generation corresponding to each RW category for the considered time period which can be done based on annual electricity production during normal operation of NPPs [10]. Under such estimates, specific generation of each RW category per each GWh of generated electricity is considered as a key element. Numerical values of specific indicator allow to compare the volumes of RW generation at various NPPs over time, regardless of the type and capacity of reactor units, as well as to predict future amounts of waste generation for each RW category based on planed electricity production. Specific indicator measured in m^3/GW·h for liquid (LRW) and solid (SRW) radioactive waste clearly demonstrates the scale of RW annual generation against the background of annual electricity production and allows to draw conclusions about the environmental efficiency of RW management at Russian NPPs.

Based on the published environmental reports of Rosenergoatom Concern for 2008—2018, this study demonstrates that retrospective recovery of missing information on the amounts of RW generation is possible for a selected time period both considering all NPPs in general and NPPs with a given type of reactor unit. Based on specific indicators, it also presents the forecasted amounts of RW generation given specific plans regarding energy production at NPPs in Russia. These estimates can be considered as targets presenting the generation of each RW category.

Characterization of source data

In 2008—2018, electricity production at Russian NPPs increased by 25.8%. In 2018, a total of 191,340 GW·h was produced compared to 152,058 GW·h generated in 2008 evidencing a total increment of 39,282 GW·h (Figure 1). NPPs with WWER reactor units have mainly contributed to such an increased electricity production — 34,331 GW·h (87.4%). Relevant contribution of NPPs with BN and RBMK reactor units has accounted for 4,437 GW·h (11.3%) and 513 GW·h (1.3%), respectively. On the whole, power generation during the considered period totaled 1,871,524 GW·h [10]

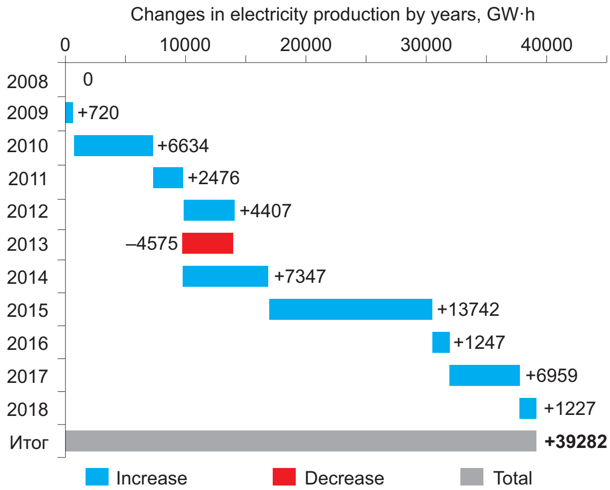

Figure 1. Dynamics of electricity production at Russian NPPs in 2008–2018 [10]

Continuously growing electricity production, with the exception of 2013, is likely to be accompanied by increasing annual waste generation. Assumed comparable increase in RW generation volumes for all RW categories cannot be refuted or confirmed based on fragmented annual data from NPP environmental reports [9]. Thus, considering all RW categories, the total number of values presented in all NPP reports for 2008—2018 ranges

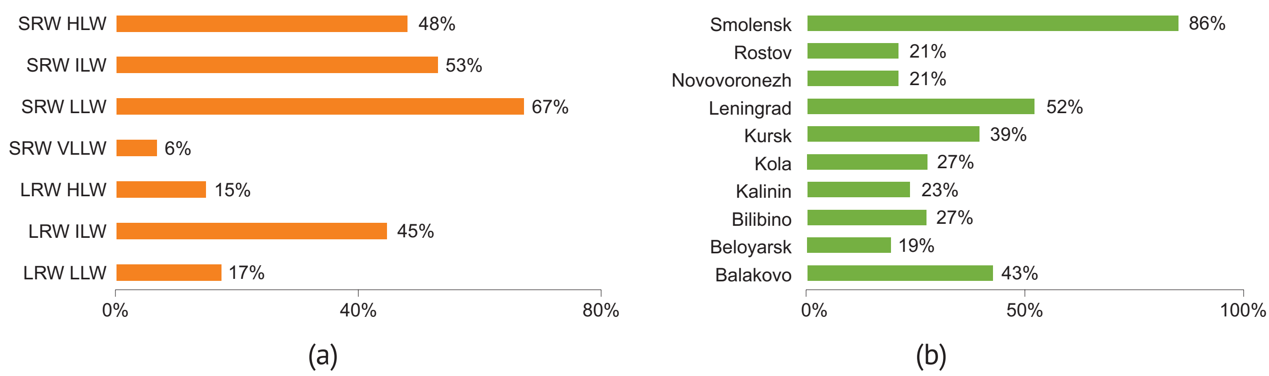

Figure 2. Completeness (in %) of environmental reports on Russian NPPs with data on annual RW generation in 2008–2018 considering different RW categories (a) and totally for each NPP given the specified RW categories (b) [9]. Abbreviations: HLW - high-level waste, ILW - intermediate-level waste, LLW - low-level waste, VLLW - very low-level waste

from 6 % for solid VLLW to 67 % for solid LLW from the corresponding populations presenting 110 values for each RW category (Figure 2a). In the considered time period for a single NPP, full total data on all seven RW categories should contain 77 values. However, in reality this value ranges from 19 % for Beloyarsk NPP to 86 % for Smolensk NPP (Figure 2b).

Figure 3 shows the breakdown of solid RW categories by the total amount of waste generated at Russian NPPs according to the environmental reports covering the entire study period. For solid radioactive waste, the contribution of each RW category is ranked as follows: LLW> ILW> VLLW> HLW with a multiple prevalence of low-level waste category.

Figure 3. Breakdown of solid RW categories by the volume of waste generated at all NPPs in Russia in 2008–2018 according to the environmental reports [9]

In terms of total LRW amounts, a slight overweight of intermediate-level waste inventory (53%) over the low-level one (47 %) is observed. The environmental reports reviewed do not provide information on VLLW LRW generation; data on liquid HLW category is either absent or indicates zero annual generation.

Considering significant fragmentation of the initial information, the given ratios of LRW and SRW amounts can be considered true only for sample data and may significantly differ from the true ratios between SRW and LRW categories. Gaps in the reported data also cause strong imbalances in the estimated RW generation at NPPs with different types of reactor units, which are comparable with the amounts of produced energy. Thus, most part of produced electricity accounts for NPPs with WWER (56 %) and RBMK (including EGP) (41 %) reactor units. Electricity production from NPPs with BN reactor units account only for 3 % of the total generation [10], therefore, comparable contribution to annual RW generation can be expected from WWER and RBMK reactors given no fundamental differences in technologies applied to ensure radiation and environmental safety. However, in contrary, the environmental reports indicate that considering all RW categories, RBMK contribution is many times greater than the one of WWER reactor units (Figure 4).

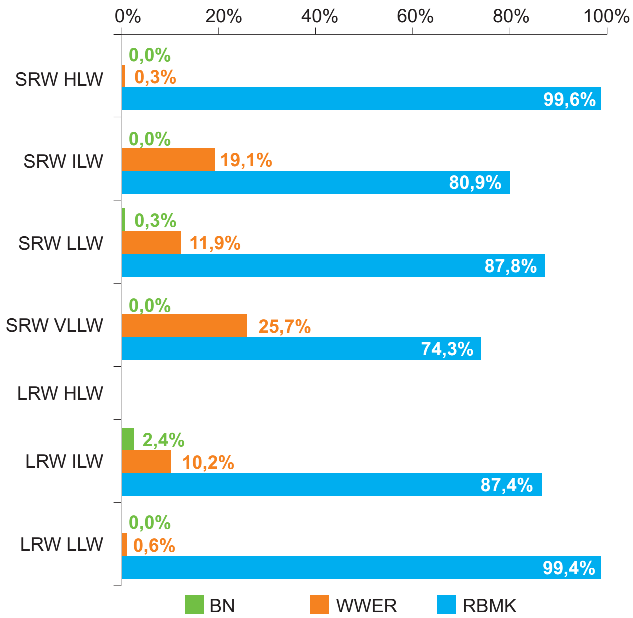

Figure 4. Contribution of NPP with various types of reactor units to RW generation based on environmental reports [9]

Petrospective recovery (interpolation) of values missing from the environmental reports can provide more precise estimates on annual LRW and

SRW generation and their ratios considering different RW categories. To this end, specific RW generation amount typical for NPPs with similar-type reactor units was calculated under this study.

Calculation of specific indicators and retrospective assessment of RW generation at Russian NPPs

Annual RW generation can be retrospectively evaluated based on statistically processed data on annual RW generation corresponding to each RW category (m^3/year) not adjusted to electricity production rates. However, this approach does not allow to consider some important characteristics of reactor units, such as power and capacity factor which is seen as a main disadvantage of this approach. Nevertheless, this drawback can be eliminated through the use of specific indicators. Normalization of the annual waste generation for each RW category per unit of produced electricity allows to combine or compare subsamples of data on NPPs with reactor units of various capacities in a correct way. To calculate the specific indicators for RW generation at Russian NPPs, the following steps were implemented:

- a sample of electricity production data (GW·h) was generated for each NPP accounting for each year within the 2008—2018 timeframe as the total amount of electricity produced by each NPP unit according to the PRIS database (IAEA) [10];
- subsamples of available data on annual LRW and SRW generation (m^3) were completed for each RW category based on environmental reports published by NPPs [9];
- for each NPP, sub-samples of ratios between annual volumes of waste generation accounting for each RW category and annual electricity production (m^3/GW·h) for each year within the considered timeframe were generated;
- considered were the patterns describing how the estimated specific RW generation indicators change with time for subsamples generated based on the available data on NPPs with RBMK, WWER and BN reactor units.

To formalize the calculations and evaluate the data obtained, the following conventions were introduced: W — annual RW generation volume, m^3; E — annual electricity production, GW·h; S — specific generation indicator accounting for each RW category, m^3/GW·h. The unknown value S_{ijk} for the i-th NPP was calculated based on all data available for the j-th RW category and the k-th year of observation (1):

$$S_{ijk} = W_{ijk} / E_{ik}. \qquad (1)$$

Each individual S_{ijk} value is specific and defines the generation volume for a specific RW category in a given year at a particular NPP for each GW·h of produced electricity. The set of values $\{S_{ijk}\}$ describes all possible values of specific indicators on the whole without taking into account the type and power capacity of the reactor units. Table 1 presents the main statistical characteristics of specific RW generation indicators for Russian NPPs, calculated for the entire available data set within the considered time frame (2008—2018). Average values $\bar{S}_j$ of specific indicators exceed the corresponding median values $\langle S_j \rangle$ for all RW categories, which indicates the asymmetry of frequency distributions within the studied quantities; therefore, it seems more appropriate to use medians as indicators for retrospective and predictive assessments of RW generation since they are more resistant to statistical outliers in the analyzed sample data.

Based on the obtained medians of specific indicators (Table 1), RW generation volumes accounting

Table 1. Descriptive statistics on annual specific RW generation indicators by RW categories generated at Russian NPPs in 2008—2018

RW category	Number of values	$\bar{S}_j$, m^3/GW·h	Standard deviation	$\langle S_j \rangle$, m^3/GW·h	Min, m^3/GW·h	Max, m^3/GW·h	$\bar{S}_j / \langle S_j \rangle$
				LRW			
LLW	19	$7.4 \cdot 10^{-2}$	$1.3 \cdot 10^{-1}$	$1.4 \cdot 10^{-3}$	0	1.23	52.2
ILW	49	$5.2 \cdot 10^{-2}$	$4.6 \cdot 10^{-2}$	$2.5 \cdot 10^{-2}$	$1.1 \cdot 10^{-2}$	$6.5 \cdot 10^{-1}$	2.1
HLW	16	0	0	0	0	0	–
				SRW			
VLLW	7	$2.8 \cdot 10^{-2}$	$1.7 \cdot 10^{-2}$	$1.5 \cdot 10^{-2}$	$8.1 \cdot 10^{-3}$	$5.6 \cdot 10^{-2}$	1.9
LLW	74	$8.4 \cdot 10^{-2}$	$9.3 \cdot 10^{-2}$	$3.3 \cdot 10^{-2}$	0	1.05	2.5
ILW	58	$7.9 \cdot 10^{-3}$	$7.5 \cdot 10^{-3}$	$3.3 \cdot 10^{-3}$	0	$5.5 \cdot 10^{-2}$	2.4
HLW	53	$3.3 \cdot 10^{-3}$	$5.2 \cdot 10^{-3}$	$2.8 \cdot 10^{-4}$	$1.6 \cdot 10^{-6}$	$1.1 \cdot 10^{-1}$	11.9

for four categories of SRW and two categories of LRW for each NPP for any year in the studied interval of 2008—2018 can be retrospectively estimated (2):

$$<W_{JIK}> = E_{ik} \cdot <S_j> . \quad (2)$$

In reality, such an assessment is not applicable to a specific NPP, but applies equally to all NPPs operating in Russia. This means that the calculated values $<W_{ijk}>$ do not adequately reproduce the amount of RW at a particular NPP, but are used only to estimate the total volume for each RW category and all NPPs both given a certain year $<W_{jk}>$ (3) and for the entire timeframe considered $<W_j>$ (4):

$$<W_{jk}> = \Sigma_i <W_{jik}> , \quad (3)$$

$$<W_j> = \Sigma_k <W_{jk}> . \quad (4)$$

As expected, the retrospective estimates covering both missing values on annual RW generation accounting for each RW category under a considered time period and those available in the environmental reports showed an increase of 25.8 % being proportional to the increase in electricity production. Moreover, LRW and SRW breakdowns differ from those derived based on the available public reporting data (see Figure 3). The share of ILW amounted to 95 % from the total LRW volume which is 42 % more than the estimates based on published data. Contribution of each RW category to the total SRW volume has been evolving as follows: it increased by 23 % for VLLW, decreased by 19 % for LLW, practically did not change for ILW and decreased by almost 4 % for HLW (Figure 5).

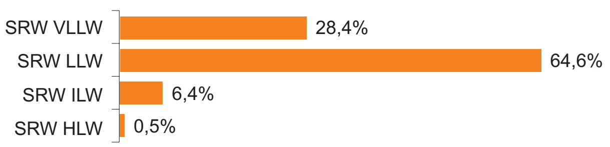

Figure 5. Retrospective assessment of SRW categories breakdown by the volume of waste generated at all NPPs in Russia in 2008–2018 not accounting for the type of reactor units

Medians $<S_j>$ from Table 1 were derived based on all available data, but not accounting for possible specific aspects of RW generation at NPPs with various types of reactor units. These specific aspects can only be ignored if the share of each NPP in the total volume of nuclear power generation remains stable. However, in 2008—2018, electricity production increased by less than 1 % at RBMK reactor units, by 42 % at WWER reactor units and by 117 % at BN reactor units. Therefore, retrospective assessment should take into account reactor-specific values of specific RW generation indicators at NPPs with reactor units of similar type. Despite limited initial data (Figure 2a, b), subgroups of specific indicators by types of reactor units were compiled and their median values $<S_j>$ type were calculated (Table 2).

Table 2. Medians of specific RW generation indicators for NPPs with different types of reactor units $<S_j>_{type}$, m³/GW·h

Reactor type	LRW		SRW			
	LLW	ILW	VLLW	LLW	ILW	HLW
RBMK	$1.5 \cdot 10^{-3}$	$4.1 \cdot 10^{-2}$	$4.4 \cdot 10^{-2}$	$5.7 \cdot 10^{-2}$	$5.0 \cdot 10^{-3}$	$8.3 \cdot 10^{-4}$
WWER	$5.0 \cdot 10^{-4}$	$1.8 \cdot 10^{-2}$	$1.4 \cdot 10^{-2}$	$9.0 \cdot 10^{-3}$	$1.3 \cdot 10^{-3}$	$2.3 \cdot 10^{-5}$
BN	–	$2.7 \cdot 10^{-2}$	–	$7.7 \cdot 10^{-3}$	–	$7.2 \cdot 10^{-5}$

Table 2 clearly shows a manifold exceedance in RW amounts generated due to power production at NPPs with RBMK reactor units compared to those generated at NPPs with WWER and BN reactor units, which is true for all RW categories. Generated RW amounts can be retrospectively estimated taking into account the type of reactor unit $<W_{ijk}>_{type}$ based on expression (2) by applying $<S_j>_{type}$ instead of $<S_j>$. Total waste volume for each RW category and all NPPs with same reactor type accounting for a particular year $<W_{ijk}>_{type}$ or the entire timeframe $<W_j>_{type}$ (2008—2018) is calculated using expressions (3) and (4), respectively.

Accounted specifics of median values $<S_j>_{type}$ manifest themselves by oppositely trending changes both in the total amount of RW and the share of each category in LRW and SRW volume. Thus, the total volume of LRW $<W_j>_{type}$ is higher by 8 %, but the volume of LLW LRW is by 38 % less than in the retrospective assessment not accounting for the specifics in specific RW generation indicators (Table 3). For SRW, the total volume $<W_j>_{type}$ is higher by 12 % compared to retrospective estimate $<W_j>$, even despite a 15 % decrease in the volumes of LLW and ILW (Table 4). A 29 % increase in the estimated volume of solid HRW is observed along with a 78 % increase in case of VLLW.

Table 3. Retrospectively estimated LRW volumes generated at all NPPs in Russia in 2008–2018 accounting for each LRW category

Assessment method	LRW amounts, m³		
	LLW	ILW	HLW
Not accounting for the type of reactor unit $<W_j>$	$2.67 \cdot 10^3$	$4.73 \cdot 10^4$	$5.00 \cdot 10^4$
Accounting for the type of reactor unit $<W_j>_{type}$	$1.65 \cdot 10^3$	$5.22 \cdot 10^4$	$5.38 \cdot 10^4$
Ratio	0.62	1.10	1.08

Table 4. Retrospectively estimated SRW volumes generated at all NPPs in Russia in 2008–2018 accounting for each SRW category

Assessment method	SRW amounts, m^3				
	VLLW	LLW	ILW	HLW	SRW total
Not accounting for the type of reactor unit $<W_j>$	$2.76 \cdot 10^4$	$6.27 \cdot 10^4$	$6.18 \cdot 10^3$	$5.15 \cdot 10^2$	$9.69 \cdot 10^4$
Accounting for the type of reactor unit $<W_j>_{type}$	$4.91 \cdot 10^4$	$5.34 \cdot 10^4$	$5.26 \cdot 10^3$	$6.65 \cdot 10^2$	$1.08 \cdot 10^5$
Ratio	1.78	0.85	0.85	1.29	1.12

Despite a significant increase in electricity production at WWER (42 %) and BN (117 %) reactor units, in 2008—2018 most part of generated waste inventory (in terms of its volume) was generated by NPPs with RBMK reactor units, which is true for all RW categories (Table 5). Since power generation growth at RBMK units during this time period accounted for less than 1 %, it can be expected that an increase in total RW generation volumes at all NPPs calculated retrospectively taking into account the specifics of specific indicators for different types of reactor units, will not be proportional to the growth in the electricity production (25.8 %). In particular, our calculations showed that in 2008—2018 RW generation volumes increased as follows: LRW LLW — by 13.0 %; LRW ILW — by 17.6 %; SRW VLLW — by 12.5 %; SRW LLW — by 8.2 %; SRW ILW — by 10.9 %; SRW HLW — by 2.7 %. In the future, expected replacement of RBMK reactor units by WWER reactors will be accompanied by a decrease in the amounts of RW generation with a stable level of electricity production achieved to date.

Table 5. Share of RW generated at NPPs with a given type of reactor unit accounting for each RW category, %

Reactor type	LRW		SRW			
	LLW	ILW	VLLW	LLW	ILW	HLW
RBMK	68.0	60.8	69.4	81.5	73.3	95.7
WWER	32.0	36.3	30.6	17.7	26.7	3.6
BN	-	3.0	–	0.8	–	0.6

Forecasted volumes of RW generation in 2020—2027

Plans of the Russian Federation on nuclear power development suggest that nuclear power plants located in Russia will generate at least 207.2 billion kWh of electricity per year in 2020 and at least 228.5 billion kWh·year in 2027 [11]. Thus, electricity production will increase by 10.3 %.

If median values of specific RW generation indicators $<S_j>$ are applied not accounting for the type of a reactor unit (Table 1), then the forecasted amount of waste to be generated in 2020 will amount to $5.5 \cdot 10^3$ and $1.1 \cdot 10^4$ m^3 for LRW and SRW, respectively. By 2027, the volume of each RW category will grow proportionally to the increase in electricity production, namely, by 10.3 % (Table 6).

Table 6. Forecasted generation volumes for each RW category $<W_j>$ at all Russian NPPs in 2020 and 2027

Year	LRW		SRW			
	LLW	ILW	VLLW	LLW	ILW	HLW
2020	$2.95 \cdot 10^2$	$5.24 \cdot 10^3$	$3.05 \cdot 10^3$	$6.94 \cdot 10^3$	$6.85 \cdot 10^2$	$5.70 \cdot 10^1$
2027	$3.25 \cdot 10^2$	$5.77 \cdot 10^3$	$3.37 \cdot 10^3$	$7.65 \cdot 10^3$	$7.55 \cdot 10^2$	$6.29 \cdot 10^1$

To predict the volumes of RW generation taking into account specific median values depending on the type of reactor unit $<S_j>$ type (Table 2), it is assumed that the entire increase in electricity production occurs at NPPs with WWER reactor units, whereas electricity generation at RBMK and BN reactors remains unchanged —70 billion kW·h and 8.5 billion kW·h per year, respectively [11]. Then the forecasted waste volumes in 2020 will amount to $5.61 \cdot 10^3$ and $1.07 \cdot 10^4$ m^3 for LRW and SRW, respectively. By 2027, an increase of 0.8—7.1 % will be observed depending on RW category (Table 7).

Table 7. Forecasted waste volumes for each RW category $<W_j>_{type}$ at all Russian NPPs in 2020 and 2027

Year	LRW		SRW			
	LLW	ILW	VLLW	LLW	ILW	HLW
2020	$1.67 \cdot 10^2$	$5.45 \cdot 10^3$	$4.95 \cdot 10^3$	$5.20 \cdot 10^3$	$5.25 \cdot 10^2$	$6.17 \cdot 10^1$
2027	$1.78 \cdot 10^2$	$5.83 \cdot 10^3$	$5.26 \cdot 10^3$	$5.39 \cdot 10^3$	$5.53 \cdot 10^2$	$6.22 \cdot 10^1$
Volume increase	6.4 %	7.1 %	6.2 %	3.7 %	5.4 %	0.8 %

In general, both approaches result in approximately same forecasted total amount of RW generation in 2027:

- LRW with no account taken of rector type — $6.10 \cdot 10^3$ m^3, accounting for the reactor type — $6.01 \cdot 10^3$ m^3;
- SRW with no account taken of rector type — $1.18 \cdot 10^4$ m^3, accounting for the reactor type — $1.13 \cdot 10^4$ m^3.

Despite the expected significant increase in electricity production at WWER NPPs, until 2027 most part of waste in the total waste volume regardless of its category will be generated at RBMK plants (Tables 8 and 9).

Table 8. Forecasted contribution (%) to the total volume for each RW category at NPPs with a given type of reactor unit in 2020

Reactor type	LRW		SRW			
	LLW	ILW	VLLW	LLW	ILW	HLW
RBMK	61.3	53.1	62.7	76.4	67.1	94.2
WWER	38.7	42.7	37.3	22.4	32.9	4.8
BN	-	4.2	-	1.3	-	1.0

Table 9. Forecasted contribution (%) to the total volume for each RW category at NPPs with a given type of reactor unit in 2027

Reactor type	LRW		SRW			
	LLW	ILW	VLLW	LLW	ILW	HLW
RBMK	57.6	49.6	59.1	73.7	63.7	93.4
WWER	42.4	46.4	40.9	25.1	36.3	5.6
BN	-	3.9	-	1.2	-	1.0

In 2027, ILW category will constitute to a 97 % of LRW volume. Figure 6 presents the forecasted breakdown on SRW volumes by RW categories in 2027.

Considering the total of waste generated by all NPP, almost 95 % of the forecasted SRW volume will account for VLLW and LLW.

Figure 6. Forecasted structure of SRW categories by the volume of waste generated at all NPPs in Russia in 2027

Conclusion

Information on annual RW generation volumes at Russian NPPs presented in the public environmental reports of Rosenergoatom Concern for 2008—2018 was found to be fragmentary. Thus, no adequate estimates on RW breakdown by categories could be made based on it, neither any unambiguous statement on an increase or decrease in the waste generation volumes given a significant increase (by 25.8 %) in electricity production. At the same time, available data could be used to derive average and median values of specific waste generation indicators for each nuclear power plant given two LRW categories and four SRW categories.

Considering constant contribution of each NPP to the total amount of electricity generated, retrospective and predictive estimates of RW generation amounts can be performed with no account taken of the type of reactor unit using the median values derived for the entire sample population. In this case, estimated changes in the volume of any RW category will correspond exactly to the changes in the electricity production. However, taking into account the trend towards a significant increase in electricity production at WWER reactor units and practically stable annual electricity production at RBMK and BN reactor units, it seems advisable to use medians of specific RW generation indicators tailored depending on the type of reactor installation, especially since the analysis showed a multiple excess of the specific generation rates for any RW category at NPPs with RBMK reactors compared to WWER and BN reactors. The use of such reactor-type specific RW generation indicator resulted in increased retrospectively evaluated volumes of LRW and SRW generated in 2008—2018 and a comparable forecast for 2027 as compared with the use of a specific indicators not accounting for the type of reactor installation. Both over the past period and in the future until 2027, the biggest amount of all LRW and SRW categories is estimated to be generated at NPPs with RBMK reactor units. In the future, replacement of RBMK units by WWER reactors will be accompanied by a decrease in the amount of RW generation while maintaining the achieved level of electricity production.

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