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IAEA-TECDOC-1815

Use of the Benchmarking System for Operational Waste from WWER Reactors

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USE OF THE BENCHMARKING SYSTEM FOR OPERATIONAL WASTE FROM WWER REACTORS

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FOREWORD

In 1991, the IAEA initiated a regional project on radioactive waste management at water cooled, water moderated power reactors (WWERs), with the objective to improve the safety, reliability and performance of the waste management systems. The design concept involved the storage of untreated waste at WWER sites, followed by the treatment, conditioning and disposal of accumulated waste during the decommissioning stage. This resulted in the accumulation of large amounts of radioactive waste stored at sites and increased risk of radiological incidents and contamination of the environment. There was therefore a need in countries operating WWERs for a new waste management strategy that covered all long term aspects of waste management.

One outcome of the project was a detailed questionnaire on the design requirements of WWERs, which included information on: waste management policies and technical requirements in participating countries; design data and operating parameters for waste collection, waste processing, and waste conditioning systems; characteristics of each waste stream at the plant (amount, volume, waste form, and chemical and radiochemical composition); and liquid discharge limits for each plant.

The IAEA continued this work with the development of the WWER Radioactive Waste Operations Benchmarking System (WWER BMS) in 2006 to collect, analyse and report waste management data from WWERs. With information provided directly by nuclear power plant operators, the data collected annually highlights the importance of establishing industry wide standards and guidelines for waste minimization, including source reduction, reuse and volume reduction.

The focus of this publication is on benchmarking low and intermediate level waste generated and managed during the normal operating life of a WWER, and it identifies and defines the benchmarking parameters selected for WWER type reactors. It includes a brief discussion on why those parameters were selected and their intended benchmarking benefits, and provides a description of the database and graphical user interface selected, designed and developed, including how to use it for data input and data analysis. The CD-ROM accompanying this publication provides an overview of practices at WWER sites, which were to a large extent prepared using the WWER BMS.

The IAEA is grateful to all the experts who contributed to the preparation of this publication. The IAEA officers responsible for this publication were M. Ojovan and Z. Drace of the Division of Nuclear Fuel Cycle and Waste Technology.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

The requirements of the IAEA Safety Standards on predisposal and disposal of radioactive waste are applicable throughout the entire lifetime of radioactive waste management facilities and activities and are used by Member States to ensure the assessment, reduction and, if necessary, control of radiation risks to workers, the public and to the environment [1, 2]. Radioactive waste management terms used within this report are in line with the IAEA Radioactive Waste Management Glossary [3]. The Institute for Nuclear Power Operations (INPO), which is comparable in its mission to the World Association of Nuclear Operators (WANO), developed simplistic performance indicators that established minimum levels of performance in key areas related to waste minimization [4]. These consisted primarily of a three-year rolling average waste generation volumes and minimization of routinely accessed contaminated areas. Both performance indicators included long term (20-year) industry-wide goals and all plants were ranked annually (and anonymously) according to industry-wide benchmark data. This benchmarking was accomplished for US pressurized power reactors (PWR) and boiling water reactors (BWR).

The IAEA-TECDOC titled Improvements of Radioactive Waste Management at WWER Nuclear Power Plants [4], highlighted the need to perform similar benchmarking of Russian water cooled water moderated energy reactors (WWER), which generically are PWR type reactors. The TECDOC discussed the importance of using industry-wide best practices for waste minimization, including source reduction, reuse and volume reduction. Such practices also promote waste safety and enhance the long term safety of stored and disposed wastes. The TECDOC suggested that these practices be:

- Incorporated into operating performance indicators and objectives;
- Tracked using common approaches;
- Benchmarked against the top WWER performers using an industry-wide database and software application.

It is a natural tendency of all plants to pursue being ranked among the top performers and, similarly, to avoid being a low performer, thereby driving down waste generation volumes and the size and number of contaminated areas industry-wide. In addition, benchmarking among plants promotes inter-plant communication and cooperation, thereby transferring good practices for waste minimization and enhanced waste safety measures related to waste generation, handling, storage, transport and disposal.

1.2. OBJECTIVES

The objectives of this TECDOC are to provide:

- An overview of the main features and components of the benchmarking database (data input, report template creation, reporting);
- A detailed description of the data fields, including qualifying information concerning the benchmarking parameters (highlighting differences between sites);
- An overview of the report template creation process, highlighting key reports;

- An overview of generating reports using previously defined templates;
- An overview of the use and benefits of the benchmarking reports, such as identifying the relative position of individual plants in terms of LILW management performance;
- Recommendations for future benchmarking activities, such as defining the deadline for annual updates to database submissions.

1.3. SCOPE

This TECDOC identifies and defines the benchmarking parameters selected for WWER reactors, including a discussion of the reasoning for their selection and their intended benchmarking benefits. It also discusses the IAEA's WWER benchmarking database and provides an overview of data input and reporting. It is designed to provide a basic user manual for the BMS. Benchmarking is performed against all operational waste. Used fuel and activated parts are excluded. Annex I on the CD ROM attached to this report contains the overviews of national practices at WWER sites which were to a large extent prepared using the BMS.

1.4. STRUCTURE

The structure of this report is as follows: section 1 gives an introduction to the and provides the explanation of the scope and objectives of the report. Section 2 provides a brief overview of status and trends of WWERs and the background of the development of the benchmarking approach and use of BMS. Section 3 gives a generic overview of the benchmarking database which is then described in details for data fields in the section 4. Sections 5 and 6 describe the creation of benchmarking report templates and BMS reports. An explanation of the benefits of the BMS and examples of its use are given in Section 7 with overall conclusions given in section 8. The Annexes to the report provide national reports from seven of the participating Member States, namely Armenia, Bulgaria, Czech Republic, Finland, Slovakia and Turkey (Annex I), and experts who participated in the development and practical use of BMS (Annex II).

2. RADIOACTIVE WASTE MANAGEMENT AT WWER NUCLEAR POWER PLANTS

2.1. OVERVIEW OF STATUS AND TRENDS OF WWER REACTORS

Currently there are 56 WWER-type nuclear power reactor units in operation with a further 15 new units under construction in 12 countries: Armenia, Bulgaria, Belarus, China, Czech Republic, Finland, Hungary, India, Islamic Republic of Iran, the Russian Federation, Slovakia and Ukraine.

The WWER is a series of pressurized water reactor designs developed originally in the former Soviet Union, and currently in the Russian Federation. The first WWER-type reactor unit, Model V-120 with gross electrical capacity 210 MW, was commissioned in 1964 at Novovoronezh NPP in the Russian Federation. The next WWER unit, having 365 MW electrical output, was commissioned at the same site in 1970. These early units were successfully commissioned and operated based on the Soviet standards and regulations valid at that time and subsequently provided the basis for development of more powerful reactors, such as the WWER-440, the first WWER to be constructed on a serial basis. The WWER-440 Model V-230 was the most common design, delivering 440 MW of electrical power, with six primary coolant loops each with a horizontal steam generator, and no containment structure similar comparable to that of western PWRs although provisions for confinement of accidental radioactivity were in place. An upgraded version of the V-230 model — Model V-270 — was specifically adapted for seismic areas. And Model V-213 includes added emergency core cooling and auxiliary feedwater systems as well as upgraded accident localization systems. In the design of this model, the General Design Criteria for Nuclear Power Plants, issued by the United States Atomic Energy Commission (US AEC) in 1971, were taken into consideration and became the standard for second generation PWRs.

The WWER Model V-187 was the prototype of the WWER-1000 Model V-320 and was commissioned at Novovoronezh NPP in 1981. The design of Model V-320 pertains to the third generation of WWER reactors and is a four-loop system housed in a containment-type structure with a spray steam suppression system. Based on the experience gained, Model V-428 (also known as NPP-91 or AES-91) and Models V-412 and V-466 (NPP-92 or AES-92) were developed. Along with the technology upgrade and economic improvements, the concept of beyond design basis accident (BDBA) management was utilized for these designs and was based on a balanced combination of passive and active safety systems.

Most of the WWER plants were provided with waste collection and storage systems to accommodate lifetime arisings of evaporator concentrates using stepwise expansions as needed. For low level dry solid wastes, on-site storage in concrete vaults in auxiliary buildings was included in the design concept. The evaporator concentrates and spent ion exchange resins from coolant treatment, were to be stored in stainless steel tanks in the auxiliary buildings. The high level dry solid wastes (e.g. in-core equipment) were to be stored within the main reactor building of WWER-440 s and within the auxiliary building of WWER-1000 units. The intermediate level dry solid wastes, mainly represented by spent aerosol filters and some wastes from maintenance were also to be stored in an auxiliary building [4].

Although the most recent WWER-1000 design incorporates some interim or final waste treatment and conditioning facilities, however, the design concept and waste management philosophy of WWER-type reactors has remained relatively unchanged over the past 40 years and includes the following [4]:

- Liquid radioactive releases into the environment were to be kept very low, generally significantly lower than the International Commission on Radiological Protection (ICRP) guidelines. Effluent release limits were typically one to three orders of magnitude lower than the same design limits for existing western PWRs in similar locations;
- The final conditioning of wet solid wastes (evaporator concentrates, spent ion exchange resins, filter cartridges) for most WWER-440 units and WWER-1000 units was not proposed during the operational lifetime of the plant; similarly, conditioning capabilities for dry solid waste were not provided, with the exception of the reactors in the Czech Republic;
- Raw liquid waste was treated by concentration, and concentrates were stored at the plant;
- Stored operating wastes were intended to be conditioned for final disposal during the first stage of NPP decommissioning together with the wastes arising from decommissioning.

The WWER-1200 (NPP-2006 or AES-2006) is the latest design evolution in a long line of WWER plants. It is a development of the WWER-1000 with increased power output to about 1200 MW(e) (gross) with additional passive safety features. This reactor meets all the international safety requirements for III+ generation of NPPs.

The Power Reactor Information System (PRIS) provides an overview of the status and trends of WWER-type nuclear power reactors around the world based on the IAEA`s PRIS Portal data [5]. Table1 gives a summary description of status and trends of WWER-type nuclear power reactors.

TABLE 1. WWER-TYPE NUCLEAR POWER REACTORS

Country	**NPP name**	**Status**	**Reactor type/ model**	**Electrical capacity per unit, MW(e)**			**Location**
Armenia	Armenian 2	Operational	WWER440 /V-270	375	375	408	Metsamor
Belarus	Belarusian 1	Under construction	WWER1200 /V-491	1109	1109	1194	Ostrovets
	Belarusian 2	Under construction	WWER1200 /V-491	1109	1109	1194	
Bulgaria	Kozloduy 5	Operational	WWER1000 /V-320	953	963	1000	Vratza

Country	NPP name	Status	Reactor type/ model	Electrical capacity per unit, MW(e)			Location
	Kozloduy 6	Operational	WWER1000 /V-320	953	963	1000	
China	Tianwan 1	Operational	WWER1000 /V-428	990	990	1060	Lianyungang
	Tianwan 2	Operational	WWER1000 /V-428	990	990	1060	
	Tianwan 3	Under construction	WWER1000 /V-428 M	990	990	1060	
	Tianwan 4	Under construction	WWER1000 /V-428 M	990	990	1060	
Czech Republic	Dukovany 1	Operational	WWER440 /V-213	420	468	500	Dukovany
	Dukovany 2	Operational	WWER440 /V-213	420	471	500	
	Dukovany 3	Operational	WWER440 /V-213	420	468	500	
	Dukovany 4	Operational	WWER440 /V-213	420	471	500	
	Temelin 1	Operational	WWER1000 /V-320	912	1023	1077	Temelin
	Temelin 2	Operational	WWER1000 /V-320	912	1003	1056	
Finland	Loviisa 1	Operational	WWER440 /V-213	420	496	520	Loviisa
	Loviisa 2	Operational	WWER440	420	496	520	

Country	NPP name	Status	Reactor type/ model	Electrical capacity per unit, MW(e)			Location
			/V-213				
Hungary	Paks 1	Operational	WWER440 /V-213	408	470	500	Paks
	Paks 2	Operational	WWER440 /V-213	410	473	500	
	Paks 3	Operational	WWER440 /V-213	410	473	500	
	Paks 4	Operational	WWER440 /V-213	410	473	500	
India	Kudankulam 1	Operational	WWER1000 /V-412	917	917	1000	Tirunellveli-Kattabomman
	Kudankulam 2	Under construction	WWER1000 /V-412	917	917	1000	
Iran, Islamic Republic of	Bushehr 1	Operational	WWER1000 /V-446	915	915	1000	Halileh
Russian Federation	Balakovo 1	Operational	WWER1000 /V-320	950	950	1000	Balakovo
	Balakovo 2	Operational	WWER1000 /V-320	950	950	1000	
	Balakovo 3	Operational	WWER1000 /V-320	950	950	1000	
	Balakovo 4	Operational	WWER1000 /V-320	950	950	1000	
	Baltic 1	Under	WWER1200	1109	1109	1194	Neman

Country	NPP name	Status	Reactor type/ model	Electrical capacity per unit, MW(e)			Location
		construction	/V-491				
	Kalinin 1	Operational	WWER1000 /V-338	950	950	1000	Udomlya
	Kalinin 2	Operational	WWER1000 /V-338	950	950	1000	
	Kalinin 3	Operational	WWER1000 /V-320	950	950	1000	
	Kalinin 4	Operational	WWER1000 /V-320	950	950	1000	
	Kola 1	Operational	WWER440 /V-230	411	411	440	Polyarnyye Zori
	Kola 2	Operational	WWER440 /V-230	411	411	440	
	Kola 3	Operational	WWER440 /V-213	411	411	440	
	Kola 4	Operational	WWER440 /V-213	411	411	440	
	Leningrad2-1	Under construction	WWER1200 /V-491	1085	1085	1170	Sosnovyy Bor
	Leningrad 2-2	Under construction	WWER1200 /V-491	1085	1085	1170	
	Novovoronezh 3	Operational	WWER440 /V-179	385	385	417	Novovoronezh
	Novovoronezh 4	Operational	WWER440 /V-179	385	385	417	
	Novovoronezh 5	Operational	WWER1000 /V-187	950	950	1000	
	Novovoronezh	Under	WWER1200	1114	1114	1199	

Country	NPP name	Status	Reactor type/ model	Electrical capacity per unit, MW(e)			Location
	2-1	construction	/V-392 M				
	Novovoronezh 2-2	Under construction	WWER1200 /V-392 M	1114	1114	1199	
	Rostov 1	Operational	WWER1000 /V-320	950	950	1000	Volgodonsk
	Rostov 2	Operational	WWER1000 /V-320	950	950	1000	
	Rostov 3	Operational	WWER1000 /V-320	1011	1011	1100	
	Rostov 4	Under construction	WWER1000 /V-320	1011	1011	1100	
Slovakia	Bohunice 3	Operational	WWER440 /V-213	408	471	505	Jaslovske Bohunice
	Bohunice 4	Operational	WWER440 /V-213	408	4741	505	
	Mohovce 1	Operational	WWER440 /V-213	408	436	470	Levice
	Mohovce 2	Operational	WWER440 /V-213	408	436	470	
	Mohovce 3	Under construction	WWER440 /V-213	440	440	471	
	Mohovce 4	Under construction	WWER440 /V-213	440	440	471	
Ukraine	Khmelnitski 1	Operational	WWER1000 /V-320	950	950	1000	Neteshin
	Khmelnitski 2	Operational	WWER1000 /V-320	950	950	1000	
	Khmelnitski 3	Under construction	WWER1000 /V-392B	950	950	1000	
	Khmelnitski 4	Under construction	WWER1000 /V-392B	950	950	1000	

Country	NPP name	Status	Reactor type/ model	Electrical capacity per unit, MW(e)			Location
	Rovno 1	Operational	WWER440 /V-213	361	381	420	Kuznetsovsk
	Rovno 2	Operational	WWER440 /V-213	384	376	415	
	Rovno 3	Operational	WWER1000 /V-320	950	950	1000	
	Rovno 4	Operational	WWER1000 /V-320	950	950	1000	
	South Ukraine 1	Operational	WWER1000 /V-302	950	950	1000	Nikolayev Oblast
	South Ukraine 2	Operational	WWER1000 /V-338	950	950	1000	
	South Ukraine 3	Operational	WWER1000 V-320	950	950	1000	
	Zaporozhye 1	Operational	WWER1000 /V-320	950	950	1000	Energodar
	Zaporozhye 2	Operational	WWER1000 /V-320	950	950	1000	
	Zaporozhye 3	Operational	WWER1000 /V-320	950	950	1000	
	Zaporozhye 4	Operational	WWER1000 /V-320	950	950	1000	
	Zaporozhye 5	Operational	WWER1000 /V-320	950	950	1000	
	Zaporozhye 6	Operational	WWER1000 /V-320	950	950	1000	

Furthermore, the recent developments in the selection of WWER technology for a country nuclear programme launch and/or expansion are:

- Four units of Akkuyu NPP (WWER-1200) in Turkey, according to the "Agreement between the Government of the Russian Federation and the Government of the Republic of Turkey on cooperation in relation to the construction and operation of a nuclear power plant at the Akkuyu site in the Republic of Turkey (Akkuyu Project Agreement)” signed in 2010 [6];

- In 2010, the Government of Finland made the Decision-in-Principle, which is the first step in the licensing process, for the new unit of Hanhikivi NPP (WWER-1200) for which Pyhäjoki was chosen as the site in 2011 [7];
- Two units of Rooppur NPP (WWER-1200) in Bangladesh, based on an agreement between the Government of the People’s Republic of Bangladash and Russian Federation on cooperation concerning the construction of Rooppur NPP’s signed in 2011 [8];
- In October 2010 an intergovernmental agreement was signed for building the Ninh Thuan 1 NPP’s at Phuoc Dinh site and in July 2015 Vietnam Electricity Holding Co. and NIAEP-Atomstroyexport, Russian Federation signed a general framework agreement for construction of the first unit with the actual WWER-1200 reactors [9].

2.1. BACKGROUND OF THE BENCHMARKING SYSTEM DEVELOPMENT

In 1991, the IAEA initiated a Technical Assistance Regional Project on Advice on Waste Management of WWER type reactors. The overall project objective was to improve the safety, reliability and performance of radioactive waste management systems at NPPs with WWERs. The design concept for waste management at WWERs involved the storage of untreated waste at NPP sites followed by the treatment, conditioning and disposal of accumulated waste during the decommissioning stage. This resulted in the accumulation of large amounts of radioactive waste stored at NPP sites and increased the risk of radiological incidents and contamination of the environment. There was, therefore, a need in countries operating WWER-type reactors to prepare and realize a new waste management strategy covering all long term aspects of waste management. The project was met with a great interest and all countries operating WWER NPPs at that time (Bulgaria, Czech Republic, Finland, Hungary, the Russian Federation, Slovakia and Ukraine) took part in the project from the very beginning.

The project mentioned above had two phases and lasted for four years. The first phase, that started in May 1991 and finished in December 1992, included identification of common problems and the provision of general recommendations and conclusions for the operators regarding radioactive waste management. At this stage the project also served to reestablish broken contacts between WWER operators after disintegration of the Council for Mutual Economic Assistance (CMEA) and to provide a unified force that would coordinate further activities in the NPP waste management area.

During the execution of the first phase of the project it was concluded that most countries operating WWER reactors had experienced serious problems with radioactive waste management. These problems were technical in nature and they manifested in:

- Concerns over differences in a waste management philosophy between WWER and other PWR design NPPs;
- Perceived higher waste generation rates at WWER plants than at their Western counterparts;
- Lack of public confidence that waste management at WWER plants could meet safety and reliability standards that were imposed and followed by the power plants operated in Western countries.

Most of these claims were based on qualitative statements which did not take into consideration differences in plant operating practices. Furthermore, these claims were not supported by any quantitative analysis that objectively compared waste generation rates at Western NPPs with the quantities of waste that were generated at plants using WWER-type reactors.

The results and the recommendations of the first phase of the project were published in 1993 as IAEA-TECDOC-705 Radioactive Waste Management of WWER-type Reactors [10], in which the following were pointed out:

(1) The introduction of an effective waste management system at NPPs and the further improvement of both operational and long term safety requires the application of a system engineering approach to all elements of the national waste management systems;
(2) Waste management practices currently applied at WWER NPPs could be substantially improved through administrative measures.

Consequently, based on the issues raised and recommendations made during the first stage, the next phase of the project was initiated and ran from February 1993 to mid-1995, this phase consisted of two tasks:

Task A — Evaluation of the existing NPP radioactive waste management infrastructure in participating countries and comparison with those prevailing in the selected industrialized European countries (France, Spain and the United Kingdom);

Task B — Comparative evaluation of the radioactive waste management systems of NPPs with WWER-type reactors.

The route selected to achieve the objective of Task A involved the preparation of a questionnaire which was completed by representatives of each of the participating countries. In 1994, the results of the Task A study were published in the form of working material entitled Legal Frameworks and Regulatory Structures for Radioactive Waste Management in Selected Countries of Eastern and Central Europe.

The objective of Task B was to develop an analytical, computerized tool that would allow objective comparison of waste management systems and provide insight to design and operational strengths and weaknesses pertinent to WWER NPPs.

From the beginning it was decided to use to the possible extent the experience and results achieved at the Electric Power Research Institute (ERPI) within the US project entitled Identification of Radioactive Waste Sources and Reduction Techniques and initiated in 1982. The ERPI project was aimed at establishing a reliable database on radioactive waste management systems at NPPs which could be used for comparative purposes with other NPPs. A standardized assessment methodology to enable a utility to evaluate effectiveness of the radioactive waste system in comparison with other NPPs was developed and utilized. A systematic evaluation methodology developed was used for periods: 1978–1981, 1982–1986 and 1986–1992. The ERPI project helped US NPP operators drastically reduce the quantity of generated waste. Over time that project evolved into a programme that became a part of the ‘waste minimization policy’ for utilities in the USA.

Task B activities were performed during the series of Expert Group meetings and workshops. A comprehensive and structured project questionnaire, that fully followed the design requirements of WWER reactors, was developed. In addition, instruction that led potential users, step by step, through required data collection and preparation was presented. And consequently, a comprehensive and detailed WWER Waste Management Database was compiled, containing:

- Waste management policies and technical requirements in participating countries;
- Design data and operating parameters for waste collection, waste processing, and waste conditioning systems;
- Characteristics of each waste stream at the plant (amount, volume, waste form, and chemical and radiochemical composition);
- Liquid discharge limits for each plant.

As a conclusion of Task B, the Expert Group recommended that the IAEA continue activities directed to improve radioactive waste management at WWER NPPs. These activities aimed at implementation of the waste minimization approach in waste management at NPPs by transferring the principles, tools, and organizational requirements of the waste minimization programmes to the WWER operators and aligning their practices to western standards.

3. OVERVIEW OF THE BENCHMARKING DATABASE

The radioactive waste benchmarking initiative for WWER reactors was discussed during work on IAEA-TECDOC-1492 (1997–2005), which recommended to “establish peer communication to promote waste minimization practices, especially to use benchmarking to track key waste related performance data”.

Development of the WWER Radioactive Waste Benchmarking System (BMS) was initiated in 2006, when the basic parameters to be included in the benchmarking initiative, the basic features of the database and the principal expectations for the output format and content were defined and the importance was highlighted of establishing industry-wide standards and guidelines for waste minimization, including source reduction, reuse and volume reduction

The BMS is used to collect, analyse, and report on waste management information from WWER-type NPP sites and enables participants to share their data and to determine how they rank among all participants in terms of commonly agreed and accepted waste management parameters. Data collection takes place annually, but benchmarking reports and analyses can be accessed throughout the year.

The BMS is part of the IAEA’s Nuclear Knowledge and Information Portal (NUCLEUS) [11, 12]. To access any database or information system within NUCLEUS, one first has to make a request to the IAEA for a NUCLEUS user account (see Fig. 1). Registration, management of the content of the BMS lookup lists, such as the WWER reactor site names, addresses, etc., access rights for the Systems Administrator and all administration of NUCLEUS is managed centrally within IAEA. All requests to change any lookup list are made through the BMS Systems Administrator. Within the NUCLEUS hierarchy, the BMS is referred to as the ‘NPP Benchmarking Database’. The NPP Benchmarking Database Administrator (System Admin) is a specific role within NUCLEUS, designated by the Waste Technology Section at the IAEA.

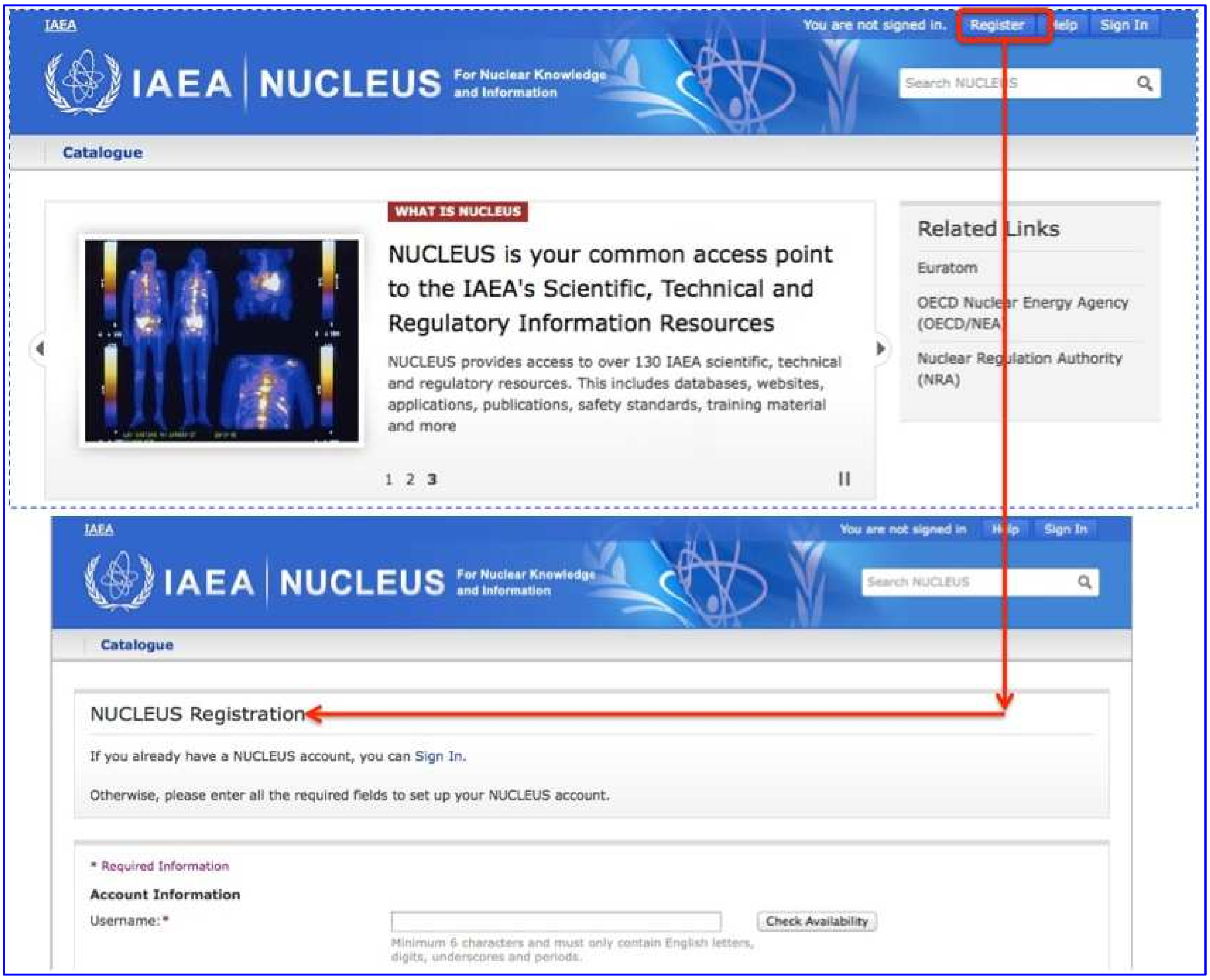


FIG. 1. Requesting a NUCLEUS account.

Access to the BMS is restricted to designated IAEA staff members and to nationally nominated participant(s) in countries with WWER reactors. Requests to participate in the BMS are made through official channels. The NPP Benchmarking Administrator grants access to the BMS for nominated participants.

There are three NPP benchmarking database roles:

1. The WWER reports administrator (reports admin) can:

   i. View all data for all WWER sites;

   ii. Create report templates and generate reports;

   iii. Publish or unpublish submissions from nominated participants;

   iv. Delete submissions.

2. WWER plant administrators (plant admin) can:

   i. Create, update, save, submit and delete WWER site submissions;

   ii. Create custom report templates, which are saved in ‘My Reports’.

Plant Administrators can only edit their own site submissions and can view and use only their own custom report templates.

3. WWER users can:

   i. View the information for each published WWER site submission;

   ii. Generate reports from templates except those in the 'My Reports' area.

A plant administrator may be responsible for one or more WWER sites.

The benchmarking database has three main modules presented in Fig. 2 the scope of which is provided in Table 2:

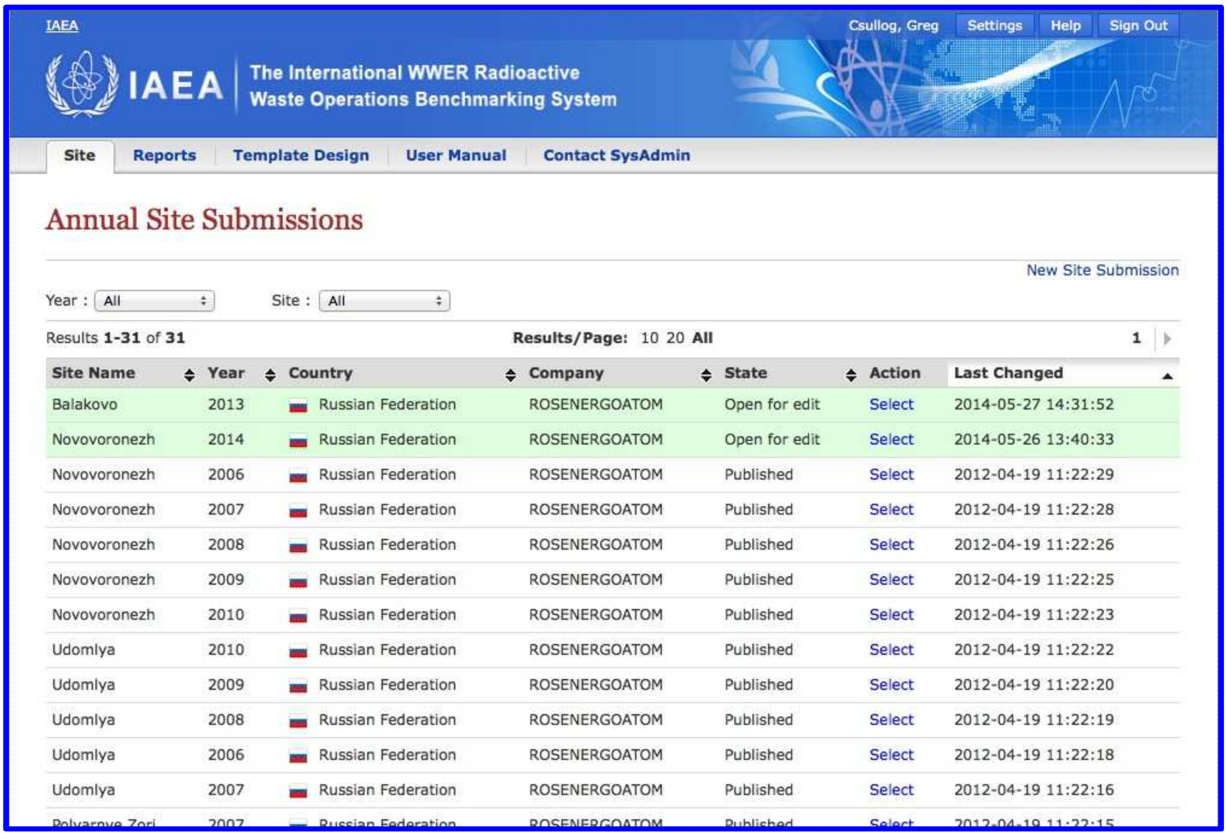


FIG. 2. Benchmarking database home screen.

TABLE 2. THE SCOPE OF MODULES OF BENCHMARKING DATABASE

Module	Description
Site (Annual site submission)	Plant admins create site submissions for their NPP sites for specified calendar years then submit them to the system admin to be review and published. An annual site submission can either be started from a blank data input screen or it can be pre-populated with data from a previous submission. For blank submissions, plant admins have to enter all data for the calendar year. For pre-populated submissions, plant admins only have to update the data that has changed from the previous submission. The ‘Annual Site Submission Module’ is described in Section 4.
Reports	Plant admins can generate standard or custom reports using the ‘Reports Module’. The ‘Reports Module’ is described in Section 6.
Template design	The database includes some standard reports that Plant Admins can use to review data submitted for their NPP site or other NPP sites. However, plant admins and reports admin can use the ‘Template Design Module’ to create and save report templates that can be used to generate customized reports. The ‘Template Design Module’ is described in Section 5.

4. DESCRIPTION OF THE SITE DETAILS DATA FIELDS

4.1. DATA GROUP 1 — SITE INFORMATION, GENERAL DATA AND EVENTS

The scope of data on-site information, general data and events is provided in Table 3 and illustrated in Figs 3 and 4.

TABLE 3. SCOPE OF DATA ON-SITE INFORMATION, GENERAL DATA AND EVENTS

Data field	Scope of field
Site name	Official name of the power plant site.
Country name	Selectable from a lookup list.
Company name	Selectable from a lookup list.
Total installed capacity in reporting year	Total actual power at the site in MW(e). This parameter indirectly indicates technological modifications that increased reactor power.
Refueling period	Number of months between refueling operations
Number of reactor units with operating licenses	This parameter provides information on the number of reactor units in operational mode. Reactor units temporarily shut down due to extensive maintenance activities or modifications should also be included in the reporting year and the percentage contribution to the total site's generation should be adjusted accordingly.
Electricity generated at site in reporting year	Electricity generated should be reported in TW·h.
Reporting year	Selectable from a lookup list.
Reactor type	Selectable from a lookup list. Only necessary for reactors with operating licenses.
Reactor unit power in current reporting year	Reactor unit power should be reported in MW(e).
Reactor model	Selectable from a lookup list. This parameter identifies generation by a specific reactor model.
Year commissioned	Should be entered in the format YYYY.
Percentage contribution	Contribution of each reactor unit to total site power.

Set percentage contribution	If checked, sets the “per unit” contribution of electricity to 100% divided by the number of licensed units (overrides data entered manually in “Percentage Contribution”).
The following factors impact waste generation (they take a NPP out of its normal operating envelope).	
General data (per site)	
Number of major outages this year due to maintenance	Integer value (typically refers to refueling that occurs once a year).
Outage period(outages) (days)	integer value (the number of days in the reporting year the reactor was off-line for outage)
Total days of operation	Calculated value (days in year – outage days).
Unplanned and planned events (If ‘Yes’ is selected, a required comment field is displayed and must be completed)	
Fuel damage	Only includes cases that result in an outage of more than 24 hours or cause significant changes in waste volumes/characteristics.
Equipment failure	Only includes cases that result in an outage of more than 24 hours.
Significant ppills	Only includes cases that result in an outage of more than 24 hours or cause significant changes in waste volumes/characteristics
Refurbishment for lifetime extension, power uprate and/or safety reasons	Select ‘Yes’ for all applicable cases.

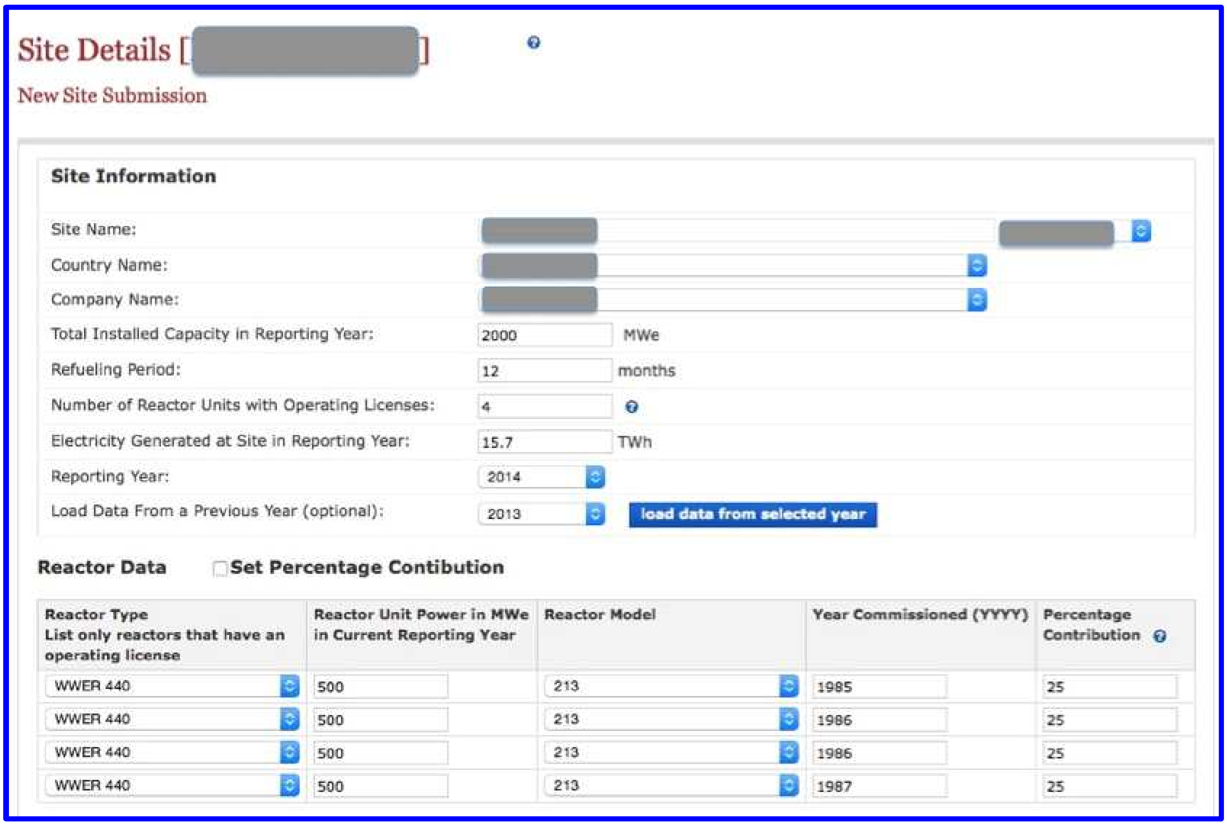


FIG. 3. Site information.

Note: 'Reactor Unit Power in MW(e)' and 'Total Electricity Generated in Reporting Year' are used to normalize data for inter-NPP comparisons.

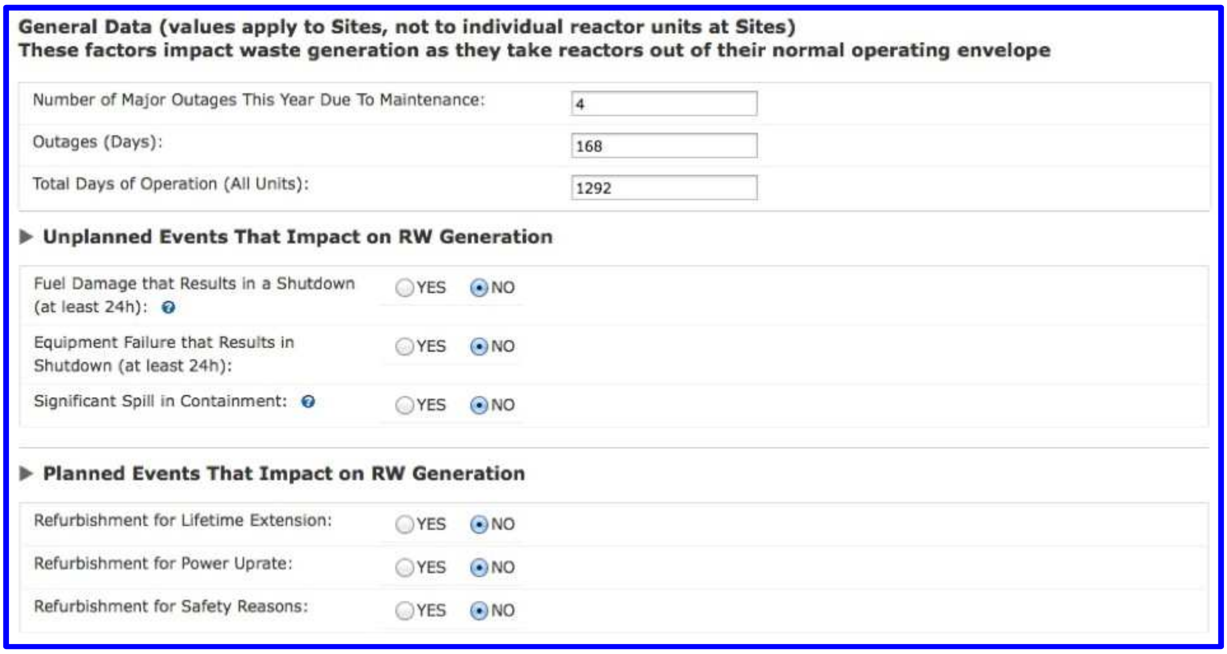


FIG. 4. General data, unplanned events, planned events.

Note: 'Total Days of Operation' is issued to normalize data for inter-NPP comparisons.

4.2. DATA GROUP 2 — BASIC STORAGE AND DISPOSAL DATA

The scope of data on basic storage and disposal is provided in Table 4 and illustrated in Fig. 5.

TABLE 4. THE SCOPE OF BASIC STORAGE AND DISPOSAL DATA

Are disposal waste acceptance criteria (WAC) approved by regulator?	‘Yes’ is selected where there are disposal WAC for any WWER operations waste. As an example, WAC may be approved for LLW, but not for ILW or HLW. This parameter indicates that the legal framework for the physical, chemical and radiological characterization of radioactive waste packages to support disposal has been established and approved by the regulator. It further implies that: a) A minimum set of analyses, data collection, parameters and procedures that demonstrate compliance with the WAC are in place; b) Waste forms for storage and disposal have been defined. WAC generally increase requirements for waste management activities such as greater sorting/segregation, defining the chemical and radiochemical analyses to determine the quantities of limiting radionuclides and the quality assurance system for the transfer of packages to and their acceptance by the repository etc.
Dry Solid Waste (DSW) + Solidified Wet Solid Waste (WSW) storage capacity	Volume in m^3 This parameter indicates the existing geometrical volume of the space designed for the safe storage of all categories of solid and solidified waste. Geometric capacity indicates the maximum space available for waste (100% packing efficiency). Depending on package design waste packages, like 200 L drums, can be placed in facilities with as low as 70% efficiency, greatly reducing the amount of waste that can be stored. Actions like changing stacking procedures can improve packing efficiency and increase the effective (usable) storage capacity. This parameter was chosen for benchmarking since a comparison of the capacity with waste generation rates can indicate a need to: • Segregate specific waste streams for clearance, reuse and recycling and/or to keep them for decay storage in separate storage facilities; • Modify storage procedures to minimize void volumes (maximize effective capacity);

	• Implement, apply or improve methods for DSW treatment and conditioning. The comparison can also be used to assess the consequences of delaying decisions to prevent premature exhaustion of storage capacity. This parameter helps explain why NPPs have implemented specific methods to maximize the use of existing storage facilities. A sufficient storage capacity can be used to justify a strategy of waiting for more effective technologies for DSW processing and conditioning (e.g. use of plasma torch), thus avoiding the premature and sometimes irreversible, implementation of technologies. It allows comparison of storage capacity for different models of WWER units. It is worth noting that a considerable part of storage capacity may have been used by historical wastes that were often stored inefficiently and without sorting or characterization. Available capacity can indirectly indicate the attitude of some national regulators towards the minimization of risks associated with the storage of DSW. If the regulator discourages additional storage capacity there is a driving force to minimize the amount of waste to be stored. The total storage capacity is one of the inputs for radiation protection and fire risk safety assessments.
Concentrate storage capacity (liquid)	Volume in m^3 This parameter indicates the existing capacity for the safe storage of treated liquid waste at a site. Storage capacity for concentrate has a major influence on a site's WSW management strategy. The design storage capacities are unable to accommodate the volume of all the concentrate generated during the initial design operational lifetime and there is only a limited possibility to extend existing storage capacity. The parameter was chosen as a benchmarking parameter because: • A sufficient storage capacity minimizes the risk of premature implementation of waste processing technologies that can lead to irreversible steps and provides time for optimization of waste processing technologies;

	• An insufficient storage capacity could indicate the need for expanding capacity if delays are expected in the implementation of effective processing technologies; • It can indicate the need or urgency to implement WSW treatment technologies; • It allows comparison of the design storage capacities of different models of WWER reactors. *Note: Storage capacities designed at some of the latest types/models of WWER reactors are noticeably lower and could differ from existing capacities at older types by more than a factor of 10.* Available capacity can indirectly indicate the attitude of some national regulators towards the minimization of risks connected to storage of WSW. If the regulator discourages additional storage capacity there is a driving force to minimize the amount of WSW to be stored. The total storage capacity is one of the inputs for radiation protection and environmental safety assessments. It is worth noting that a considerable part of original storage capacity may have been used by historical waste (in some cases by deposits of solid crystallized borates).
Emergency storage capacity for WSW (liquid)	Volume in m^3 This parameter provides complementary information. It indicates a legal safety requirement to keep adequate, spare storage capacity available for an emergency situation. The parameter was chosen as a benchmarking parameter because: • It provides data on the extent of the reserve storage capacity for WSW, which effectively reduces the amount of design storage capacity available for non-emergency use; • It reflects variability in legal requirements defining minimal storage capacities (e.g. total volume used for all types of waste or minimal storage capacity determined for each particular category of WSW).
Ion exchange resin storage capacity	Volume in m^3 This parameter applies only to tanks for storing slurries — it

	does not apply to the storage of dewatered resins. It indicates the existing capacity for the safe storage of spent ion exchange resins. The parameter was chosen as a benchmarking parameter because: It provides information on existing storage capacities at different types of WWER reactors. It indicates the necessity or urgency to implement/apply different treatment technologies. It indicates variability in ion exchange resin storage. Slurries are stored in the tanks included within the IX resin storage capacity. Dewatered resins are kept in alternative storage facilities, which are not included in the IX resin storage capacity. If a site has used little or none of its IX resin storage tank capacity that indicates dewatering was performed and resins were put into alternative storage. Therefore, it indirectly provides information on the consumption of alternative facility storage capacity by containers with IX resin (such as drums). It can indicate the use of an effective activity-based segregation process for discharged ion exchange resins where all resins are not slurried together in tanks regardless of their activity but, instead, are dewatered and stored according to activity. It indirectly indicates the availability of storage capacity for dewatered resins. It can further indicate opportunities for alternative processing options for IX resins, for reduced processing costs and for clearance/release of some resins. It provides an input for radiation protection and environmental protection safety assessments.
For the following parameters, ‘Yes’ is selected whether the disposal option is available on or off-site	
VLLW disposal site available	This is complementary information to provide data on the availability of a disposal option for VLLW. VLLW, according to GSG-1 definition, does not need high levels of containment and so is suitable for near surface disposal. In some countries VLLW can be disposed of in conventional landfill sites, this is subject to national policy and strategy.. Where there is a VLLW disposal site available, a considerable part of the radioactive waste generated during normal NPP operation can be rerouted and effectively disposed at these facilities. This may save capacity at licensed disposal sites designed for

	higher activity radioactive waste. A decrease in costs associated with characterization, treatment, conditioning and waste disposal of this waste compared to higher activity wastes can be expected. Generally solidification prior to disposal is not carried out and simpler transport and storage containers can also be used for these wastes.
LLW site available ILW site available	These parameters provide important data on the existence of a licensed and operating disposal sites for radioactive waste. They enable monitoring of the procedure of disposal site commissioning and subsequent changes in processing resulting from the start of waste disposal. The option to dispose waste significantly helps optimization of technological processes for waste management, decreasing operational costs and related radiation risks. Operational LLW and ILW disposal sites are not available in all participating countries. This is a crucial factor that has a substantial impact on an overall radioactive waste management strategy. The absence of a disposal site and related shortage of storage capacity often result in a pragmatic solution. Waste is removed, processed and converted to an "intermediate form" that is further stored before a final decision on conditioning and disposal. This approach helps to release a part of existing storage capacities for newly generated waste but leads to an increase in operational and capital costs and requirements for ~~a~~ construction of additional storage capacities often connected in a non-optimal way to waste processing. 'Yes' is selected for both 'LLW Disposal Site Available' and 'ILW Disposal Site Available' if a LILW Site is available.

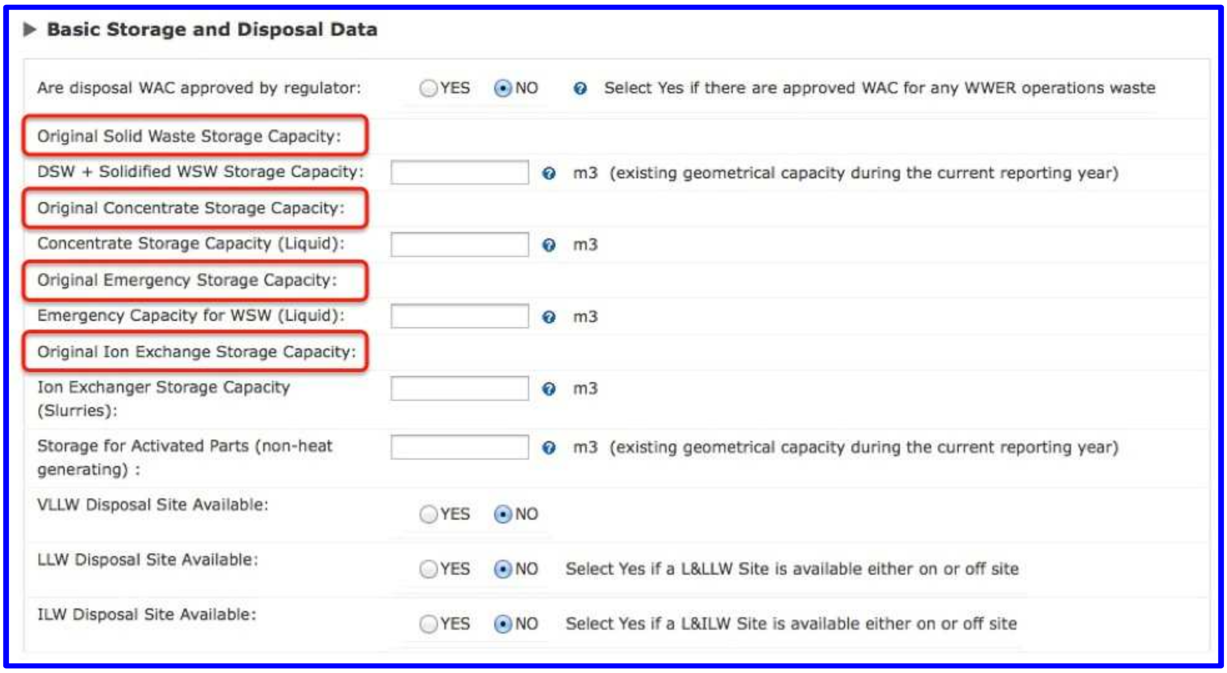


FIG. 5. Basic storage and disposal data.

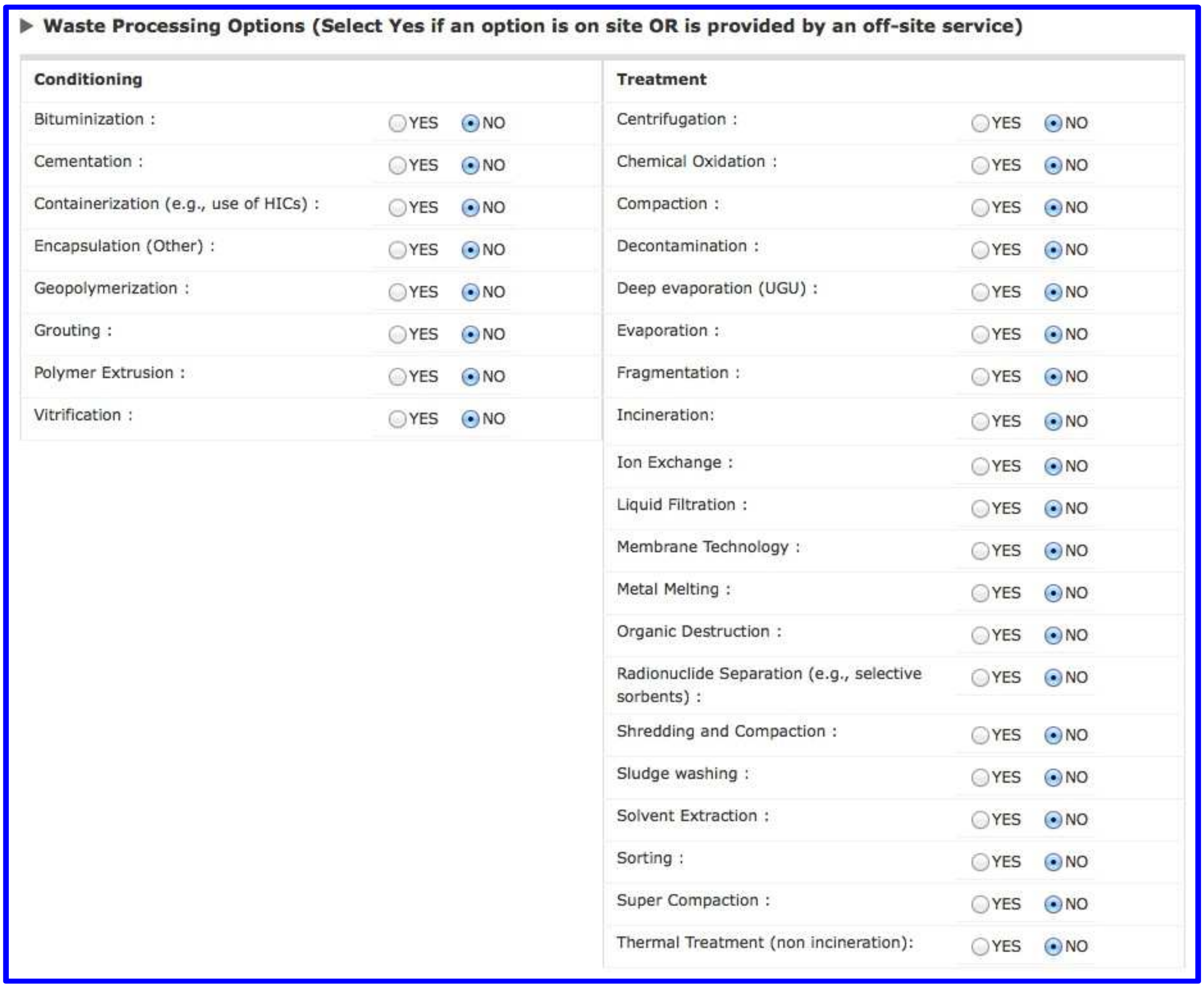
Note: The original storage capacity values are part of the default data set for the database. Once a Site Admin selects the site for a new submission, the default values are pulled from the database and populate the original capacity fields for 'Basic Storage' and 'Disposal Data'.

4.3. DATA GROUP 3 — WASTE PROCESSING OPTIONS

The parameters shown in Fig. 6 were selected for benchmarking since they can:

- Track the adoption or abandonment of the various processing options listed;
- Provide an overview of a site's current infrastructure;
- Be used to compare storage usage versus technology adoption (for example, the introduction of super compaction can reduce storage);
- List sites using specific technologies;
- Show where technologies are accessible/available.

Yes is selected if the identified option is on-site or provided by an off-site service.



▶ **Waste Processing Options (Select Yes if an option is on site OR is provided by an off-site service)**

Conditioning		
Bituminization :	◯YES	⦿NO
Cementation :	◯YES	⦿NO
Containerization (e.g., use of HICs) :	◯YES	⦿NO
Encapsulation (Other) :	◯YES	⦿NO
Geopolymerization :	◯YES	⦿NO
Grouting :	◯YES	⦿NO
Polymer Extrusion :	◯YES	⦿NO
Vitrification :	◯YES	⦿NO

Treatment		
Centrifugation :	◯YES	⦿NO
Chemical Oxidation :	◯YES	⦿NO
Compaction :	◯YES	⦿NO
Decontamination :	◯YES	⦿NO
Deep evaporation (UGU) :	◯YES	⦿NO
Evaporation :	◯YES	⦿NO
Fragmentation :	◯YES	⦿NO
Incineration:	◯YES	⦿NO
Ion Exchange :	◯YES	⦿NO
Liquid Filtration :	◯YES	⦿NO
Membrane Technology :	◯YES	⦿NO
Metal Melting :	◯YES	⦿NO
Organic Destruction :	◯YES	⦿NO
Radionuclide Separation (e.g., selective sorbents) :	◯YES	⦿NO
Shredding and Compaction :	◯YES	⦿NO
Sludge washing :	◯YES	⦿NO
Solvent Extraction :	◯YES	⦿NO
Sorting :	◯YES	⦿NO
Super Compaction :	◯YES	⦿NO
Thermal Treatment (non incineration):	◯YES	⦿NO

FIG. 6. Waste processing options.

Note: The ‘Ion Exchange’ item should be selected if the treatment technology uses ion exchange resins. The ‘Radionuclide Separation’ item should be selected if the treatment technology uses specific radionuclide separation materials.

4.4. DATA GROUP 4 — LIQUID PROCESSING AND PARAMETERS

The scope of data on liquid processing and parameters is provided in Table 5 and illustrated in Fig. 7.

TABLE 5. SCOPE OF DATA ON LIQUID PROCESSING AND PARAMETERS

pH of concentrate — upper and lower values	This is complementary information to provide data on the chemical regime used in concentrate storage tanks. The parameter was chosen as a benchmarking parameter because it is easily measurable as the pH data (including historical data) are accessible at most WWERs. The complex nature of boron chemistry and the limited solubility of borates in specific pH ranges lead to the need for careful adjustment of pH value in concentrate storage tanks. The incorrect pH within a storage tank could result in massive

	crystallization and formation of solid deposit. The presence of solid deposit in storage tanks is unwanted and complicates further processing of the concentrate. It may require use of additional chemicals and/or mechanical processes that increase the eventual total volume of stored waste. Higher pH values (>11) generally indicate an intention to keep a higher concentration of borates in the concentrate and prevent their precipitation. Lower pH values (<7) indicate storage of an atypical type of concentrate generally with a lower content of boric acid (e.g. decontamination solutions, chemical cleaning agents). Higher pH value indicates higher consumption of NaOH used for the pH value adjustment. Some of WSW processing technologies (e.g. bituminization, selective sorbents, and separation of boric acid) can be effectively used only in precisely determined pH ranges. Additional chemicals (typically nitric acid) used for the pH adjustment may generate additional (secondary) waste.
Consumption of fresh boric acid per year	Mass in tonnes. Discharges of boric acid containing waste streams from the majority of WWER NPPs to the environment are strictly limited. Annual consumption of boric acid provides an effective indicator for benchmarking of WWER plants with other PWR plants, where the volume of generated concentrate is low, and/or there exists an option to discharge boric acid to the environment (e.g. NPPs situated on the coast, NPPs processing wastewater without the use of evaporators). This is a performance indicator that reflects losses of boric acid and helps to identify a potential impact to the consequent technological process (e.g. cementation). The parameter defines the amount of fresh boric acid that is added into the system each year. The parameter was chosen as a benchmarking parameter because: • The quantity of boric acid consumption (e.g. mass of boric acid put into technological systems in a given year) can be easily measured or estimated and the data on the boric acid consumption history are generally available; • It provides possibilities for optimization of consumption of boron in the operation of an NPP including the maintenance; • It reflects the design solution and technological features

	of an NPP related to the startup, shut down, leakage control, drainage, sampling system and generic operating procedures; • It has a direct impact on the volume of generated WSW, WSW management and operational costs. It can have negative impacts on the NPP staff as well as on the environment. *Note: In August 2008, in the 30th Adaptation to Technological Progress to EU directive 67/548/EEC, the European Commission decided to amend its boric acid classification to reprotoxic category 2 and to apply the risk phrases R60 (may impair fertility) and R61 (may cause harm to an unborn child).*
Boric acid (borates) generated	Mass in tonnes. This parameter defines the total mass of alkaline borates declared as boric acid in storage tanks at the end of a given year. It is a complementary parameter that helps understand the potential impact on subsequent technological processes and provides an input for planning of storage/disposal capacities. Estimation of the total mass of boric acid may need additional effort in chemical analyses. The parameter was chosen as a benchmarking parameter because: • It allows comparison of the annual consumption of boric acid and the content of boric acid in waste in on- and off-site storage; • It can be used to estimate the volume of any products from processing of boric acid containing waste. For example, high boric acid content could preclude cementation and require alternative processing resulting in either higher or lower product volumes depending on the process(es) implemented; • It can be used to estimate the quantity of chemical waste that can be removed from the concentrate and disposed in industrial repositories as chemical/toxic waste; • It provides information on the distribution of boric acid between the liquid and solid phases (in the case of the presence of a solid phase in storage tanks) in concentrate storage tanks; • It provides data for assessing the need for additional liquid waste processing systems.

Total mass of solids (salts)	Mass in tonnes This parameter defines the total mass of all solids (e.g. salts such as borates, nitrates, oxalates, carbonates, sludge and other impurities) in storage tanks at the end of a given year. Determination of the total solids content in concentrate may require additional chemical analyses. Generally it is estimated from representative samples of concentrate taken from storage tanks and dried to a constant weight. In the case of a significant amount of a solid deposit in a storage tank, the total mass of the solid can be assessed from the estimated volume and an average density of the solid deposit. The parameter was chosen as a benchmarking parameter because: • It is a supplementary parameter providing input data to design capacities necessary for the treatment and conditioning of the stored concentrate, as well as data to determine minimal capacities for storage and disposal of the final waste form; • It provides a uniform basis for an effective comparison of the total solids quantity contained in the concentrate accumulated at a NPP; • It provides feedback on the effectiveness of WSW minimization programmes; • It may also indicate compliance with the WSW processing technology, technical specification and /or with regulatory requirements.
Option to discharge boron	Discharges of boric acid containing waste streams from the majority of WWER NPPs to the environment are strictly limited. It provides an input for the comparison with other NPPs where an option to discharge boric acid to the environment exists.
Activity of ^{60}Co in storage	Input as GBq Close attention is paid to the minimization of the cobalt content in construction materials used for the production of the main WWER technological components. Radioactive ^{60}Co originating from activated construction materials considerably contributes to the worsening of the overall radiation situation at an NPP. ^{60}Co present in the concentrate is incorporated in complex chemical compounds. Due to this fact, processes designed for an effective removal of ^{60}Co from bulk volumes of bottom concentrates consist of several steps comprising the use of strong oxidation agents (e.g. ozone, hydrogen peroxide) and separation

	methods. The parameter asks for the total activity of ^{60}Co contained in the storage tanks at the end of a given year. The parameter was chosen as a benchmarking parameter because: • The activity of ^{60}Co can be easily measured and the data on the ^{60}Co activity (including historical) are available at all participating NPPs; • ^{60}Co represents activated corrosion products and can be used for a rough approximation of the total activity of corrosion products; • It can reflect different concentration of cobalt in construction materials used at an NPP; • It provides data for the determination of radiation protection measures and for dose calculations; • It may influence the selection of technologies for a separation of activity from the bulk waste if applicable; • It provides an input for scaling factors application for activity limits calculation for release, storage and disposal; • It can reflect the impact of large scale decontamination activities performed at an NPP, typically decontaminations of the main technological components such as the steam generator or full system decontamination
Activity of ^{137}Cs in storage	Input as GBq Nuclear fuel used in the nuclear reactor is exposed to many changes of physical, chemical and radiological parameters during the operational campaign. Together with minor deficiencies in construction of fuel elements it can result in a release of fission products into the reactor coolant. ^{137}Cs due to its relatively long halftime remains in the coolant. In the course of primary circuit coolant cleaning ^{137}Cs is removed and transferred into WSW streams. The parameter defines the total activity of ^{137}Cs in the concentrate stored in storage tanks at the end of a given year. The parameter was chosen as a benchmarking parameter because: • The activity of ^{137}Cs can be easily measured and data on ^{137}Cs activity is available at all participating NPPs;

	• It reflects the status of the fuel, increased activity of ^{137}Cs indicates fuel failures; • It provides data for the determination of radiation protection measures including long term storage and disposal; • Higher activities of ^{137}Cs can support the introduction of technologies for a selective separation of activity from the bulk waste if applicable; • It provides an input scaling factors application for activity limits calculation for release, storage and disposal. High activity of ^{137}Cs in the bottom concentrate indicates a possible presence of other contaminants (e.g. Sr, Am, Pu)

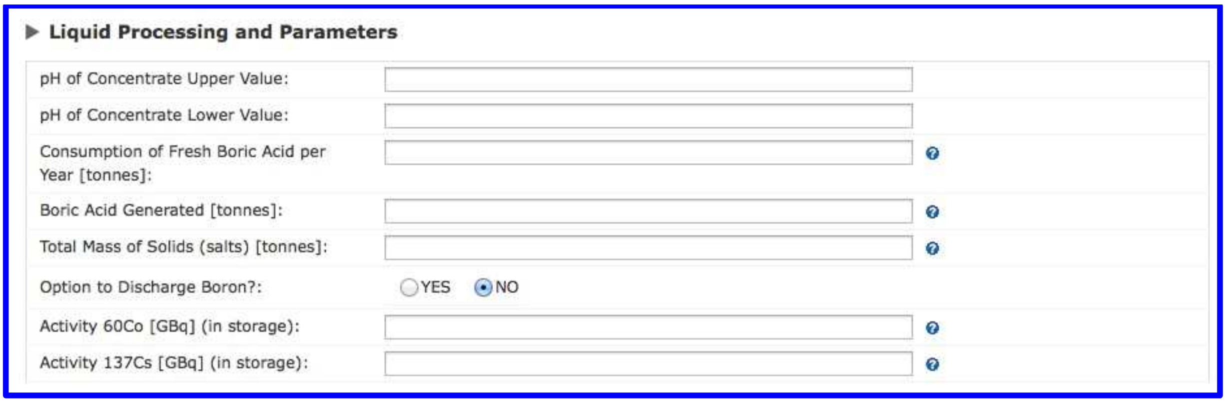
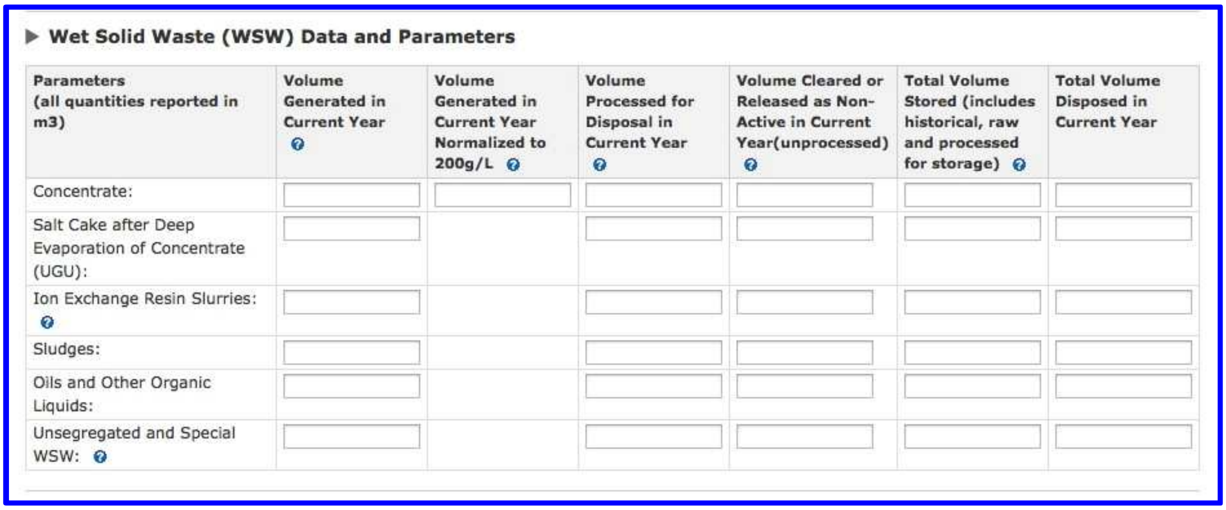


FIG. 7. Liquid processing and parameters.

4.5. DATA GROUP 5 — WET SOLID WASTE DATA AND PARAMETERS

The scope of data on WSW and parameters is provided in Table 6 and illustrated in Fig. 8 that is a matrix where the top row indicates the units for reporting parameters and the left hand column lists the various WSW parameters selected for benchmarking. In the table that follows, reporting units are discussed first, followed by a discussion of the parameters.



▶ **Wet Solid Waste (WSW) Data and Parameters**

Parameters (all quantities reported in m3)	Volume Generated in Current Year	Volume Generated in Current Year Normalized to 200g/L	Volume Processed for Disposal in Current Year	Volume Cleared or Released as Non-Active in Current Year(unprocessed)	Total Volume Stored (includes historical, raw and processed for storage)	Total Volume Disposed in Current Year
Concentrate:						
Salt Cake after Deep Evaporation of Concentrate (UGU):						
Ion Exchange Resin Slurries:						
Sludges:						
Oils and Other Organic Liquids:						
Unsegregated and Special WSW:						

FIG. 8. Wet solid waste processing data and parameters.

TABLE 6. SCOPE OF DATA ON WET SOLID WASTE AND PARAMETERS

Parameter	Reporting units and scope
Volume generated in current year	m^3 This unit provides information on the volume of WSW as-generated and transferred to storage at the end of a given year. Data on WSW annual generation is available at all participating NPPs and can be easily measured or estimated. The volumes of the various WSW categories are used to evaluate NPP operational efficiency and reflects the dynamics of its changes. Evaluating volumes over time is useful for trending, identification of deviation from expected values and ensuring a timely response to abnormal situations. It provides data for: • Deeper analysis of conditions in the area of WSW treatment, for the evaluation of efficiency of programmes for waste production minimization in relation to other NPP systems, for the optimization of operational costs, and for the evaluation of external influences and changes in legislation; • Planning of financial means and capacities; • Modifications of contractual relations with external suppliers

	providing the processing, transport and disposal of waste; • Planning of the scope of chemical, radiochemical and safety analyses.
Volume generated in current year – normalized to 200 g/L	m^3 This unit is a performance indicator used for benchmarking of concentrate generation only. It provides a uniform basis for a detailed comparison across all NPPs, taking into account differences in WSW processing strategies and eliminates the impact of varying dry solid content in the generated concentrates.
Volume processed for disposal in current year	m^3 This unit indicates that WSW processing for disposal has been implemented (on- or off-site) for a NPP. This parameter provides data on the quantity of waste taken from WSW storage for treatment/conditioning to a form that meets WAC for disposal at the end of a given year. It is a performance indicator used to evaluate NPP operational efficiency (this assumes treatment and/or conditioning result in a volume reduction, which may not always be the case, e.g. cementing increases volumes) of WSW (including historical waste) and reflects the dynamics of its changes. Treatment and conditioning of WSW can also be provided by specialized contracting organizations approved by the regulator. Includes solidified WSW.
Volume cleared or released as non-active in current year (unprocessed)	m^3 This unit provides information on the volume of WSW released or cleared at the end of a given year. This parameter indicates that effective procedures used for separation, processing, radiological characterization and clearance or release of WSW to the environment have been established and used.
Total volume stored (includes historical, raw and processed for storage)	m^3 This unit is used for, strategic, long term planning as it reflects the overall NPP (company's) liabilities for stored waste waiting for disposal. It provides input data for implementing WSW treatment and conditioning as well as the data to determine minimal capacities for storing and disposal of waste in its final form. The unit provides information on the total (actual) quantity of

	WSW in storage (including any historical accumulation) at the end of a reporting year. It reflects the extent of tasks (legislative, technical and financial) to be addressed in the future, including all associated aspects. Includes solidified WSW
Total volume disposed in current year	m^3 This unit provides: • Important information on the availability of an operational disposal site applicable to a particular category of WSW as well as on the use of the potential to dispose radioactive wastes in a disposal site; • It also provides information on the amount/volume of the final form of solidified WSW in a given year. It is a very important performance parameter used for the evaluation of the NPP operation effectiveness from the point of view of lowering the amount of stored wastes and it reflects the dynamics of its changes. Processing of annual data on the production of waste within a wider period of time enables determination of average disposal rates, identification of any deviations from expected volumes and timely reaction to anomalous disposal rates and their causes; • Data for the planning of financial means and capacities for the next period; • Indication of necessary modifications to contractual relations with external suppliers securing the transport and disposal of waste.
Parameters	
Concentrate	WWER reactors differ from PWR reactors with the use of boric acid in their primary coolant circuit and in related safety systems. A certain amount of boric acid can get into WSW and consequently into the concentrate during liquid waste treatment. Due to specific design features of WWER reactors, the generation of concentrate is relatively high and its value in most cases ranges between approximately 50–150 m^3/year for one reactor unit. Further treatment of concentrate is complicated by the limited solubility of borates (boric acid salts) contained in the waste together with the fact that discharges of WSW containing boric acid into the environment are strictly limited. Designed storage capacities at operational NPPs are not able to accommodate the total volume of concentrate generated during

	the operational period and there is only a limited possibility to extend the existing storage capacity at an operational NPP. Limited infrastructure and lack of processing and disposal facilities emphasizes the importance of this parameter. The parameter was chosen as a benchmarking parameter because: • Data on the amount and composition of generated concentrate (including historical) is available at all NPPs and is easily measurable. Great attention is paid to the evaluation of data on the amount and composition of concentrate as the quantity of generated concentrate has a direct impact on the financial state of the NPP (operational cost, material cost, waste management cost, storage and/or disposal fees). • Parameters on quantity of concentrate generation, processing and disposal are often used as a part of corporate key performance indicators. • Data on generation of concentrate reflects the overall performance of technological equipment and systems, the performance of the operational staff, the status of the chemical regime, the quality and adherence to procedures and manuals, the condition of technological equipment, the duration of outages, the scope of maintenance activities, and the impact of a fuel failure. • A higher volume of generated concentrate may reflect a preferred strategy in concentrate management where a higher volume of concentrate with a lower salt content better meets the technical specification of subsequent processes.
Salt cake after deep evaporation of concentrate (commonly known as UGU by WWER operators)	Monitoring the generation salt cake allows a detailed comparison of NPP operating technologies for deep evaporation (UGU). This parameter is not applicable to all WWERs. The parameter was chosen as a benchmarking parameter because: • It indicates the extent of activities focused on the minimization of concentrate storage capacities; • Data on the amount and composition of salt cake, including historical data, is easily measurable and available at all applicable NPPs; • It provides elements for further optimization and

	planning for processing, storage and disposal.
Ion exchange resin slurries	Ion exchange (IX) resins are considered to be liquid waste with a relatively high content of fine solid particles. This waste category includes a variety of resins, charcoal, sludge and, in some cases, also spent sources. Determination of the actual volume of stored IX resin can be difficult due to the absence of directly readable indicators. The total volume of stored waste is therefore expressed as a sum of volumes of fresh non-active sorbents that were loaded into the technological systems for the period of the NPP operation. Data obtained from exact measurements should be used where available. Spent IX resins consist of a mixture of sorbents originating from different technological systems collected in storage tanks. The activity of the various waste streams is very variable and can range up to several orders of magnitudes. Spent IX resins are stored and processed separately from other WSW streams due to their specific physical, chemical and radiological characteristics. The parameter was chosen as a benchmarking parameter because: • It defines potentially problematic waste that may require specific technologies for its retrieval, treatment and conditioning; • Due to a limited access to the stored waste and lack of handling areas, the removal of waste from the storage tanks may require an introduction of additional technological equipment, remote controlled devices and/or modification to the existing infrastructure; • Usually spent IX resins have a higher activity than many wastes, which can require precise estimates of activity limits to demonstrate compliance with WAC, and with additional radiation protection measures; • It provides elements for optimization and planning for the processing, storage and disposal of spent IX resins; • The waste requires more efforts for characterization especially in the case of larger volumes; • It may also indicate the compliance with technical specification or regulatory requirements; • Transportation of solidified ion exchange resin to storage

	or disposal facilities may require additional radiological protection measures (e.g. use of shielding containers); • The use of thermal processes (drying, thermal decomposition, incineration) may require additional environmental protection and industrial safety measures; • A part of IX resins originated from systems containing low active or non-active media (e.g. steam generator blown-down cleaning systems) have a high potential for clearance and discharge to the environment.
Sludges	This parameter refers to sludge removed from technological systems. Sludge is generated in the course of operations, decontamination, cleaning or maintenance activities. Generally, the majority of sludge is collected in wastewater treatment systems (sedimentation, overflow tanks, etc.) and in concentrate storage tanks. Considerable quantities of potentially non-active sludge are generated during the cleaning of heat exchanger tube sheets and bundles. The parameter was chosen as a benchmarking parameter because: • It provides valuable information on the status of separation technologies in operation at a particular NPP; • Sludge can lead to plugging and/or clogging of parts of the equipment and contributes to reduction in performance efficiency of heat exchangers; • When removed from technological the system or storage facilities (with the use of filtration or centrifugation) it represents waste with limited information and requires initial chemical and radiological characterization; • It provides information on potentially problematic waste that may require the introduction of specialized technological equipment and processes for removal, separation and further processing; • It defines the quantity of waste with generally higher activity which is very often mixed with ion exchange resins. The characterization may be more complicated than in the case of ion exchangers.
Oils and other organic liquids	Most of contaminated oils and organic liquids generated at NPPs are decontaminated (e.g. by centrifugation, extraction, distillation or use of sorbents) and consequently recycled or

	released as non-active waste. Accumulation of oils and organic liquids occurs where processing options do not exist. The parameter describes organic/petroleum-based oils and solvents, which are a potentially problematic waste that may require specific technology for further processing and for storage. It was chosen as a benchmarking parameter because: • It requires the creation of sufficient safe storage for flammable organic liquids, these facilities were often not built during the original installation of the NPP; • Stored waste increases fire and radiation risks and may require further safety measures (installation of fire detection and extinguishing systems).
Unsegregated and special WSW	This parameter covers waste that cannot be processed for financial, technical, safety or legislative reasons with the use of technologies applicable to other WSW categories. It is stored as-generated. It includes problematic waste streams that may require specific processing or segregated storage. It may include historical wastes without any characterization data or waste resulting from unplanned events such as a major fuel failure. Examples include: • Residues from concentrate processing; • Cleaning and/or decontamination solutions containing complexing substances like NTA, EDTA or mixtures of organic and inorganic acids the character of which fundamentally differs from the composition of concentrate, and for which accessible technologies for treatment and modification at NPPs cannot be used. Special batches of waste containing high alpha contamination that cannot be disposed in an existing disposal sites as they do not fulfil requirements set in WAC, or for which the final form for storage and disposal has not yet been determined. The parameter was chosen as a benchmarking parameter because this waste may require special handling and technology and presents a challenge to the waste manager. This waste uses existing storage capacities for a long period, and in some cases processing of this category of waste is postponed until the NPP

	decommissioning phase. If non-zero values are reported, the database displays a required comment field for users to provide a summary of the unsegregated or special WSW.

4.6. DATA GROUP 6 — DSW DATA AND PARAMETERS

The scope of data on DSW and parameters is provided in Table 7 and illustrated in Figure 9 that is a matrix where the top row indicates the units for reporting parameters and the left hand column lists the various DSW parameters selected for benchmarking. In the table that follows, reporting units are discussed first, followed by a discussion of the parameters.

▶ **Dry Solid Waste (DSW) Data and Parameters**

Parameters	Quantity Generated in Current Year		Quantity Processed for Disposal in Current Year		Quantity Cleared or Released as Non-Active in Current Year		Total Quantity Stored (includes historical, raw and processed for storage)		Volume Disposed in Current Year
	tonnes	m3	tonnes	m3	tonnes	m3	tonnes	m3	
Processible by Current Options:									
Not Processible by Current Options:									
Metals:									
Other DSW:									

FIG. 9. Dry solid waste processing and parameters.

TABLE 7. SCOPE OF DATA ON DRY SOLID WASTE AND PARAMETERS

Reporting Units: In some cases mass and/or volume can be entered. Users decide which unit to use. In addition, allowing either unit to be reported allows users to change reporting practices in the future (see “Quantity processed for disposal in current year”)	
Quantity generated in current year	Tonnes and/or m^3 This unit refers to the quantity of DSW as-generated and transferred to storage and is used to monitor the yearly arisings of various DSW streams. It can be used to rank NPPs according to quantities generated in a given year.
Quantity processed for disposal in current year	Tonnes and/or m^3 Typically this is the amount of waste expressed as a sum of the volumes of drums, bags, containers, bins or, in some cases, the change in storage capacity. The value is not very accurate and does not include differences due to pretreatment of waste. The quantity of processable DSW expressed in units of mass does not depend on material and/or shape and provides a standardized basis for comparison of annual DSW generation for the estimation of efficiency of consequent treatment processes

	(e.g. compaction, high pressure compaction). The introduction of weighing and reporting of processable DSW generation in units of mass could provide improved support for minimization activities. This change may make current methods more effective and/or may bring introduction of new progressive methods that are not based on a mere change of shape or volume. Reporting the quantity of DSW processed for disposal in the current year revealed significant differences in approaches for reporting the waste generated in the controlled area as radioactive waste. The differences can be described as follows: a) All the waste generated in the controlled area is from its origin considered radioactive and it is disposed as such without further sorting. b) A part of the waste generated in the controlled area is sorted according to the value of the dose rate measured at a defined distance. Wastes below a certain threshold are discharged into the environment. c) All the wastes generated in the controlled area are considered radioactive until they are proved by an approved procedure (dependent upon the waste specific activity) to fulfil clearance criteria for discharging of waste into the environment. Those differences have a fundamental influence on the value given in the benchmarking database for the volume of DSW processed for disposal in the current year.
Quantity cleared or released as non-active in current year	Tonnes and/or m^3 This unit applies to the waste generated in the controlled area with very low levels of radionuclides. Determination of levels using qualified measurement techniques allows for sorting of the waste eligible for clearance from active waste. Activity levels are routinely compared to values established by a regulatory body and expressed in terms of activity concentration and/or total activity (clearance levels). If the waste meets prescribed criteria, it can be released from regulatory control and discharged into the environment. The introduction and effective use of the clearance procedure can bring major savings in waste treatment costs as well as in the costs of storage and disposal. The unit was chosen as for benchmarking because it provides

	information that the NPP has established and uses procedures approved by the regulator for separation, processing, radiological characterization and clearance of particular WSW stream before discharging into the environment.
Total quantity stored	Tonnes and/or m^3 This unit is used for, strategic, long term planning as it reflects the overall NPP (company's) liabilities for stored waste waiting for disposal. It provides input data for implementing DSW treatment and conditioning as well as the data to determine minimum capacities for storing and disposal of waste in its final form. It provides information on total quantity of DSW in storage (including any historical accumulation) at the end of a reporting year. It reflects the extent of tasks (legislative, technical and financial) to be carried out in the future, including all associated aspects. DSW generally includes a significant quantity of combustible materials. Data on the quantity of combustible materials provides basic information for the estimation of related risks of fire and the necessity to install adequate fire detecting and extinguishing systems. Storage of a large amount of damp waste that was not properly sorted and processed (mainly historical waste such as wet cleaning rags and cloths used for cleaning up and decontamination) or waste stored in areas with higher humidity may accelerate decomposition accompanied by a generation of gases and an increase of costs connected with ensuring hygienic and industrial safety standards.
Total volume disposed in current year	m^3 This unit provides: • Important information on the availability of an operational disposal site applicable to a particular category of DSW as well as on the fact that the NPP uses the potential to dispose radioactive wastes in a disposal site. • It also provides information on the amount/volume of the final form of stored conditioned DSW in a given year. It is one of very important performance parameters used for the evaluation of the NPP operation effectiveness from the point of view of lowering the amount of stored wastes and it reflects the dynamics of its changes. Processing of annual data on the production of waste within a wider period of time enables determining the tendencies, identifying of deviation from

	expected facts and timely reacting to arisen situations. • Data for planning of financial means and capacities for the future period of time. • Indication of necessary modifications to contractual relations with external suppliers securing the transport and disposal of waste.
Parameters	
Processable by current options	Processable DSW. This waste includes compressible and combustible waste streams since clear criteria to determine and segregate these streams do not exist at most WWER NPP. In fact, most combustible waste can be compressed (taking into account the compress force of the compactor and adequate pretreatment) but a considerable part of compressible waste cannot be incinerated due to limitations stated in the technical specification (content of Cl, F, Br in plastics, sulphur in rubber..) of a particular incinerator. Division into two categories (compressible and combustible waste) provides no added value for benchmarking purposes, especially in the case of an NPP without access to the combustion technology. Processable waste indicates the quantity of waste with a limited potential for decontamination. When properly segregated, applicable treatment and conditioning processes (e.g. compaction, high force compaction, incineration) can provide effective volume reduction. The parameter was chosen as a benchmarking parameter because a significant part of the arising waste is typically treated to reduce the volume and to stabilize waste for storage or for further treatment/conditioning. Processable waste includes a considerable quantity of historical waste (often not properly sorted, characterized, packed or recorded). Removal of waste from storage wells, its characterization and treatment may require upgrading of current processing equipment and in some cases even a construction of specialized facilities for waste processing and storage. Much of the amount of processable waste (e.g. paper, plastic, rubber, textile, wood, thin cables) is generated during outages and maintenance activities, and reflects practices in the: • Use of disposable, individual protective clothing and equipment; • Use of plastic foils and wrapping materials; • Exclusion of consumable materials in radiation controlled

	areas; • Washing and cleaning of reusable protective clothing and equipment; • Use of cleaning rags and cloths for decontamination purposes; • Collection, sorting and characterization of DSW. Assessments of the above can provide inputs for the minimization of DSW generation.
Not processable by current options	Non-Processable DSW includes wastes that cannot be treated for any financial, technical, safety or legislative reasons with the use of technologies applicable to other DSW categories. It is stored as-generated. The parameter was chosen for benchmarking because: • It indicates segregated wastes that may require special considerations for storage. • It shows the portion of arising raw waste that is untreatable, and therefore can be expected to occupy the greatest storage volume on a per unit generation basis. Examples include bulk concrete pieces, uncompressible and non-combustible waste, unprocessed bulk filtration units (iodine and aerosol filters), waste contaminated with or containing fissile materials, etc.
Metals	This parameter refers to metals segregated from other DSW. Metal waste comprises a broad range of contaminated materials (iron, stainless steel, copper, lead, etc.). Aluminium, zinc coated metals, painted or encapsulated lead and cables represent streams with special handling considerations before processing, storage and/or disposal. This parameter was chosen as a benchmarking because: • The metal generated in controlled areas represents wastes with a high potential for decontamination, recycle or reuse but with only a limited potential for an effective volume reduction. • Activity, weight, shape and dimensions predetermine its further processing. • Technological processes applicable for a large quantity of metal DSW treatment and/or conditioning may require processing off-site in specialized workshops or facilities

	(decontamination, cutting, melting). • The profit from sale of decontaminated and cleared metal waste can offset other waste management cost. Reduced storage and disposal needs also represent a cost-benefit. Determination of further waste treatment and conditioning requires an exhaustive cost–benefit analysis. The use of cutting and/or decontamination prior to clearance is reasonable in cases where authorized procedures can determine radiological contamination, a procedure for waste clearance is approved by the regulator and there is access to the scrap metal market for its recycling or reuse. Large metallic components (e.g. replaced steam generators in storage) are not included in this parameter.
Other DSW	This parameter includes waste that cannot be treated for any financial, technical, safety or legislative reasons with the use of technologies applicable to other DSW categories. It indicates the quantity of DSW that is special in the sense that it may be toxic, hazardous or otherwise problematic to manage. It may be either processable or non-processable, but is included in this category for the purpose of tracking and comparing the generation of this special type of waste. Examples include asbestos, chemical wastes with high toxicity, flammability, or reactivity, and other “exotic” and/or uncommon waste types. The parameter was chosen as a benchmarking parameter because these wastes represent typically small volumes but large problems from a management standpoint. The generation of these wastes is interesting for comparison as it leads to a discussion of practices to either substitute or avoid their generation. Sometimes waste that cannot be effectively segregated is managed as other DSW (for example, see the submission for Khmelnitska — 2012). Volumes of dewatered IX resins should be reported under other DSW.

5. CREATION OF BENCHMARKING REPORT TEMPLATES

The “Report Templates” tool allows users to easily and quickly report on the data that has been entered into the benchmarking database. This is a very important aspect of the database as it facilitates the comparison of WWER site performance (benchmarking) and it gives site managers an overview of their own site’s performance.

There are two types of report templates: fixed format and variable format. The report templates groups, format and description are provided in Table 8.

The fixed format templates cannot be viewed or edited by users however, users select these fixed format templates in the “Reports” component of the database (see Section 6) to generate reports. Figure 16 in Section 6, indicates that users interactively define the site(s) and reporting year(s) for fixed for reports.

For variable format templates, users specify which parameters to report, such as the volume of concentrate generated, and save their templates. Users then generate reports based on these saved templates. Users can edit their saved templates to make changes. Users specify the default site(s) for reporting when they create and save templates. As with fixed format reports, users interactively define the site(s) and reporting year(s) for variable format reports.

Selecting templates, sites, reporting year and other parameters for reporting is discussed in Section 6.

TABLE 8. REPORT TEMPLATES GROUPS, FORMAT AND DESCRIPTION

Template Group	Format	Description
01 Basic site report .	Fixed	Figure 10 shows the “Basic Site Report”. The report’s template allows users to report on basic storage and disposal data, liquid processing and parameters and general data for any WWER site.
02 Waste processing options	Fixed	Figures 11 and 12 show the “Waste Processing Options Report”. If multiple sites are selected, reports will have the format shown in Figure 11. If a single site is selected, reports will have the format shown in Figure 12.
05 Overall report	Fixed	Figure 13 shows the “Overall Report”, which is used to report all data input for a site on a specified reporting year. This allows users to quickly view all data entered, which facilitates finding errors and correcting them.
03 Wet solid waste data and parameters 04 Dry solid waste data and	User defined	Figure 14 shows the home page of the template design component of the database. In Figure 14, the “00 Show All Template Groups” was selected from the

parameters 06 My report templates		template group selector (this is an optional action). To create a template, users click the “New Template” button, which opens up the new template creation screen that is shown in Figure 15. The user specifies the report’s title and the purpose of the report. The user then selects the parameters to be reported when reports are generated from the template. Typically, if only parameters for liquid waste processing data or WSW data are selected, users would choose template group 03 or 04 respectively. Users also have the option of choosing Template Group 06 for an existing saved template. Before templates can be used to generate a report they must be published. See Figure 14 and Figure 15.

Basic Site Report for Paks for 2009

data redacted for this TECDOC

Basic Storage and Disposal Data

Are disposal WAC approved by regulator:	[redacted]				
	Original				
DSW + Solidified WSW Storage Capacity:	8379	[redacted]	m3	[redacted]	% Used
Concentrate Storage Capacity (Liquid):	6895		m3		% Used
Emergency Capacity for WSW (Liquid):	1481		m3		
Ion Exchanger Storage Capacity (Slurries):	2123		m3		% Used
Storage for Activated Parts (non-heat generating):			m3		
VLLW Disposal Site Available:	No				
LLW Disposal Site Available:	**Yes**				
ILW Disposal Site Available:	**Yes**				

Liquid Processing and Parameters

			Ranges for All Sites (2009)	
			minimum	maximum
pH of Concentrate Upper Value:	[redacted]		[redacted]	
pH of Concentrate Lower Value:				
Consumption of Fresh Boric Acid per Year:		tonnes		
Boric Acid Generated:		tonnes		
Total Mass of Solids (salts):		tonnes		
Option to Discharge Boron?:				
Activity 60Co (in storage):		GBq	[redacted]	
Activity 137Cs (in storage):		GBq		

General Data

		minimum	maximum
Number of Outages	[redacted]	[redacted]	
Operational Days			
Outage Days			
Fuel Damage that Results in a Shutdown (at least 24h):			
Equipment Failure that Results in Shutdown (at least 24h):			
Significant Spill in Containment:			
Refurbishment for Lifetime Extension:			
Refurbishment for Power Uprate:			
Refurbishment for Safety Reasons:			

FIG. 10. Basic site report.

Waste Processing Options Report

Conditioning Facilities

Bituminization	2006	2007	2008	2009	2010	2011	2012	2013	2014
Kozloduy									
Paks									
Temelin	✓	✓	✓	✓	✓	✓	✓		

Cementation	2006	2007	2008	2009	2010	2011	2012	2013	2014
Kozloduy	✓	✓	✓	✓	✓	✓	✓		
Paks									
Temelin									

Containerization (e.g., use of HICs)	2006	2007	2008	2009	2010	2011	2012	2013	2014
Kozloduy	✓	✓	✓	✓	✓	✓	✓		
Paks									
Temelin									

Encapsulation (Other)	2006	2007	2008	2009	2010	2011	2012	2013	2014
Kozloduy									
Paks									
Temelin				✓		✓	✓		

Grouting	2006	2007	2008	2009	2010	2011	2012	2013	2014
Kozloduy	✓	✓	✓	✓	✓	✓	✓		
Paks									
Temelin									

Polymerization Extrusion	2006	2007	2008	2009	2010	2011	2012	2013	2014
Kozloduy									
Paks									
Temelin		✓	✓		✓				

Vitrification	2006	2007	2008	2009	2010	2011	2012	2013	2014
Kozloduy									
Paks									
Temelin									

Treatment Facilities

Centrifugation	2006	2007	2008	2009	2010	2011	2012	2013	2014
Kozloduy									
Paks									

⋮

etc.

FIG. 11. Waste processing options report — multiple sites.

Waste Processing Options Report

Temelin

Conditioning Facilities

Conditioning Facilities	2006	2007	2008	2009	2010	2011	2012	2013	2014
Bituminization	✓	✓	✓	✓	✓	✓	✓		
Cementation									
Containerization (e.g., use of HICs)									
Encapsulation (Other)				✓		✓	✓		
Grouting									
Polymerization Extrusion		✓	✓		✓				
Vitrification									

Treatment Facilities

Treatment Facilities	2006	2007	2008	2009	2010	2011	2012	2013	2014
Centrifugation	✓	✓	✓	✓	✓	✓	✓		
Chemical Oxidation									
Compaction	✓	✓	✓	✓	✓	✓	✓		
Decontamination		✓	✓		✓				
Deep evaporation (UGU)									
Incineration		✓	✓	✓	✓	✓	✓		
Liquid Filtration				✓					
MembraneTechnology									
Metal Melting					✓	✓	✓		
Organic Destruction									
Radionuclide Separation (e.g., Selective Sorbents)									
Shredding and Compaction	✓	✓	✓	✓	✓	✓	✓		
Sludge washing									
Solvent Extraction	✓	✓	✓		✓	✓	✓		
Super Compaction							✓		
Thermal Treatment (non incineration)									

FIG. 12. Waste processing options report — single site.

Overall Report for Paks for 2009
(data redacted for this TECDOC)

Site Name:	Paks	
Country Name:	Hungary	
Company Name:	Paks NPP Ltd.	
Total Installed Capacity in Reporting Year:	2000	MWe
Refuelling Period:	12	months
Number of Reactor Units with Operating Licenses:	4	
Electricity Generated at Site in Reporting Year:	15.4	TWh
Reporting Year:	2009	

Reactor Data

Reactor Type	Reactor Unit Power in MWe as-designed	Reactor Model	Date Commissioned (YYYY-MM-DD)	Percentage Contribution
WWER 440	440	213	1982-12-14	25
WWER 440	440	213	1984-08-26	25
WWER 440	440	213	1986-09-15	25
WWER 440	440	213	1987-08-09	25

General Data These Factors Impact Waste Generation (They Take NPP Out of Their Normal Operating Envelope)

Number of Major Outages This Year (Per Site) Due To Maintenance:	[redacted]
Outages (days):	
Total Days of Operation (all units):	

Basic Storage and Disposal Data

Are disposal WAC approved by regulator :	[redacted]	
DSW + Solidified WSM Storage Capacity :		m3
Concentrate Storage Capacity (Liquid) :		m3
Emergency Capacity for WSW (Liquid) :		m3
Ion Exchanger Storage Capacity (Slurries) :		m3
Storage for Activated Parts (non-heat generating) :		m3
VLLW Disposal Site Available :		
LLW Disposal Site Available :		
ILW Disposal Site Available :		

Waste Processing Options

Conditioning Methods Used		Treatment Methods Used	
Bituminization :	No	Centrifugation :	No
Cementation :	No	Chemical Oxidation :	**Yes**
Containerization (e.g., use of HICs) :	No	Compaction :	**Yes**
Encapsulation (Other) :	No	Decontamination :	**Yes**
Grouting :	No	Deep evaporation (UGU) :	No
Polymerization Extrusion :	No	Incineration :	No
Vitrification :	No	Liquid Filtration :	**Yes**
		MembraneTechnology :	**Yes**
		Metal Melting :	No

⋮

etc.

FIG. 13. Overall report.

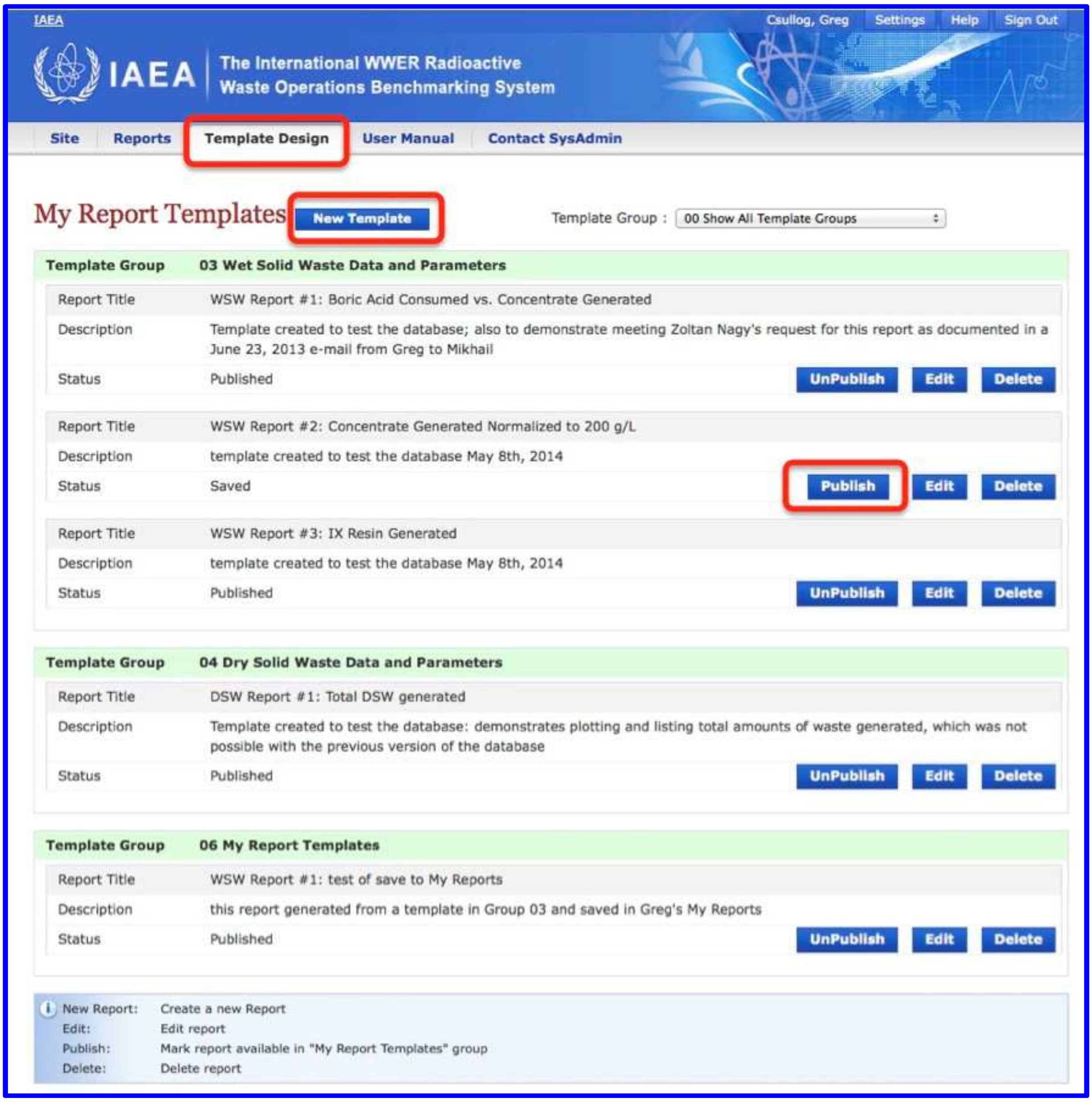
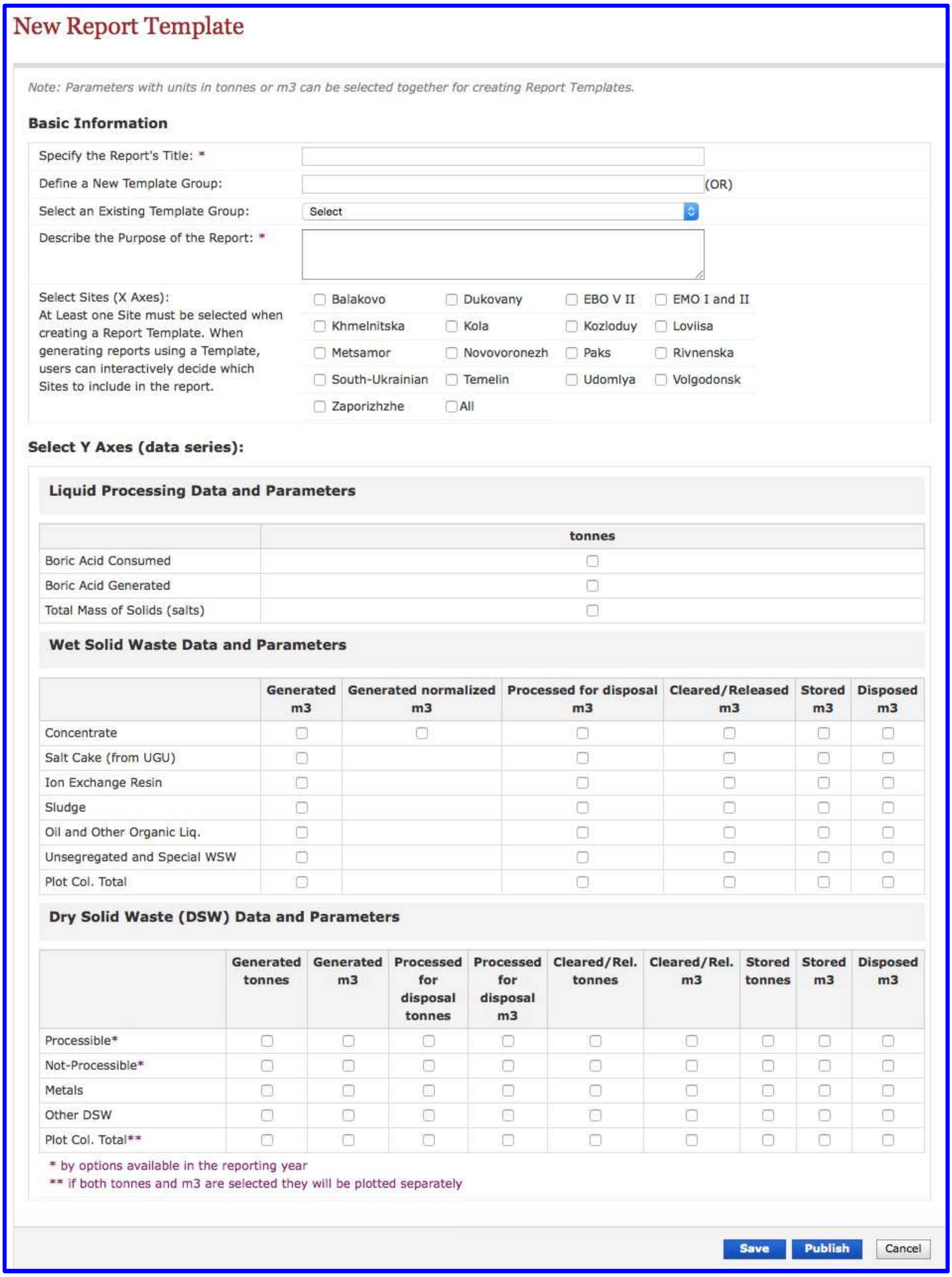


FIG. 14. Template design component of the database.



New Report Template

Note: Parameters with units in tonnes or m3 can be selected together for creating Report Templates.

Basic Information

Specify the Report's Title: *	
Define a New Template Group:	(OR)
Select an Existing Template Group:	Select
Describe the Purpose of the Report: *	
Select Sites (X Axes): At Least one Site must be selected when creating a Report Template. When generating reports using a Template, users can interactively decide which Sites to include in the report.	☐ Balakovo ☐ Dukovany ☐ EBO V II ☐ EMO I and II ☐ Khmelnitska ☐ Kola ☐ Kozloduy ☐ Loviisa ☐ Metsamor ☐ Novovoronezh ☐ Paks ☐ Rivnenska ☐ South-Ukrainian ☐ Temelin ☐ Udomlya ☐ Volgodonsk ☐ Zaporizhzhe ☐ All

Select Y Axes (data series):

Liquid Processing Data and Parameters

	tonnes
Boric Acid Consumed	☐
Boric Acid Generated	☐
Total Mass of Solids (salts)	☐

Wet Solid Waste Data and Parameters

	Generated m3	Generated normalized m3	Processed for disposal m3	Cleared/Released m3	Stored m3	Disposed m3
Concentrate	☐	☐	☐	☐	☐	☐
Salt Cake (from UGU)	☐		☐	☐	☐	☐
Ion Exchange Resin	☐		☐	☐	☐	☐
Sludge	☐		☐	☐	☐	☐
Oil and Other Organic Liq.	☐		☐	☐	☐	☐
Unsegregated and Special WSW	☐		☐	☐	☐	☐
Plot Col. Total	☐		☐	☐	☐	☐

Dry Solid Waste (DSW) Data and Parameters

	Generated tonnes	Generated m3	Processed for disposal tonnes	Processed for disposal m3	Cleared/Rel. tonnes	Cleared/Rel. m3	Stored tonnes	Stored m3	Disposed m3
Processible*	☐	☐	☐	☐	☐	☐	☐	☐	☐
Not-Processible*	☐	☐	☐	☐	☐	☐	☐	☐	☐
Metals	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other DSW	☐	☐	☐	☐	☐	☐	☐	☐	☐
Plot Col. Total**	☐	☐	☐	☐	☐	☐	☐	☐	☐

* by options available in the reporting year
** if both tonnes and m3 are selected they will be plotted separately

Save Publish Cancel

FIG. 15. New template creation screen.

6. REPORTING

Figure 16 shows home page of the reports component of the database. The user's first action is to select the template group (see Section 5 for the full list of template groups).

Once the template group is selected, the report title selection field dynamically updates to show the titles for all templates in the group. As noted in Section 5, template groups with fixed format templates only have a single template with a fixed title. If the template group has multiple report titles, the second action users take is to select the title of the report to be created.

Users then select other reporting options according to the guidance provided in their user manual (see Fig. 2).At least one reporting year must be selected, multiple years can also be selected. Check marks indicate the default site(s) to be reported on, which is/are defined in the report template. Users can interactively change which site(s) are reported on.

Once all option choices are made, users click the "Submit" button, example reports follow throughout this section.

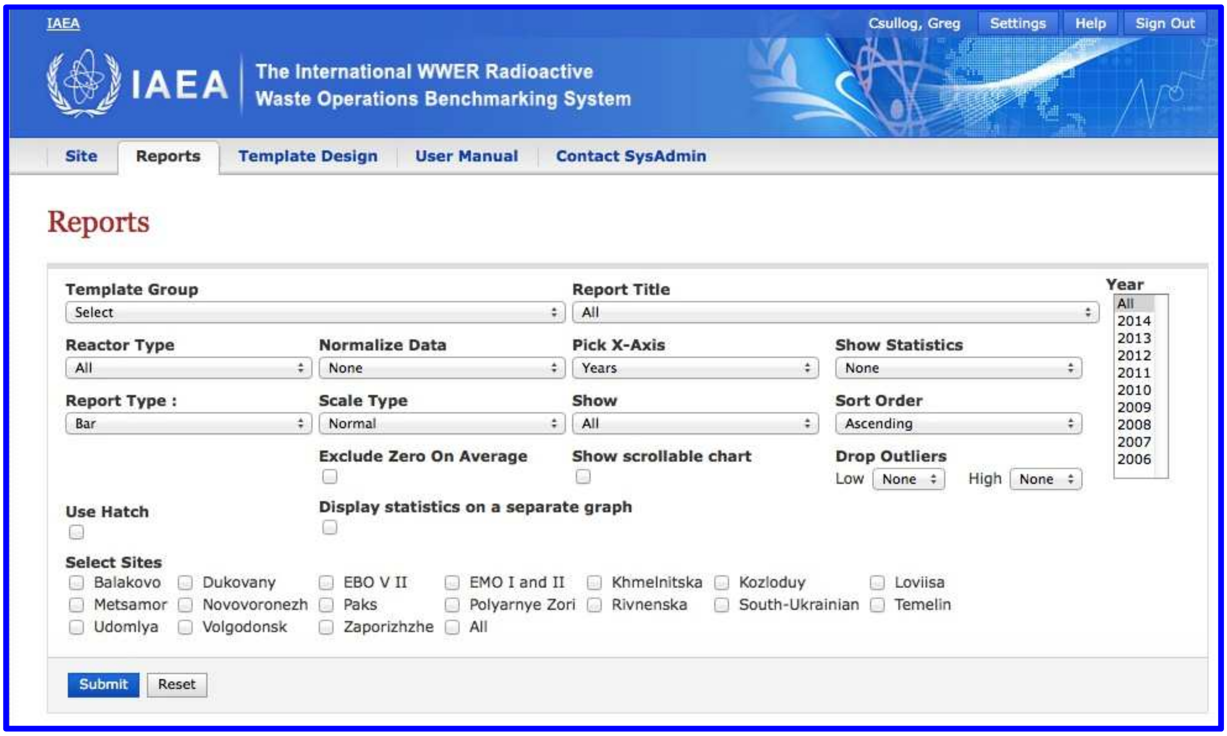


FIG. 16. Report selection page.

In July 2013, a benchmarking workshop was held in Paks, Hungary, the following statements appear in the workshop's report:

"Participants agreed on three parameters that are the most important to report and to compare from NPP to NPP…

… #1: Concentrate generated (normalized to 200 g/L) and normalized to TW·h, operating days or number of reactor units."

… #2: Ion exchange resin generated normalized to TW·h, operating days or number of reactor units

… #3: Total DSW generated normalized to TW·h, operating days or number of reactor units.”

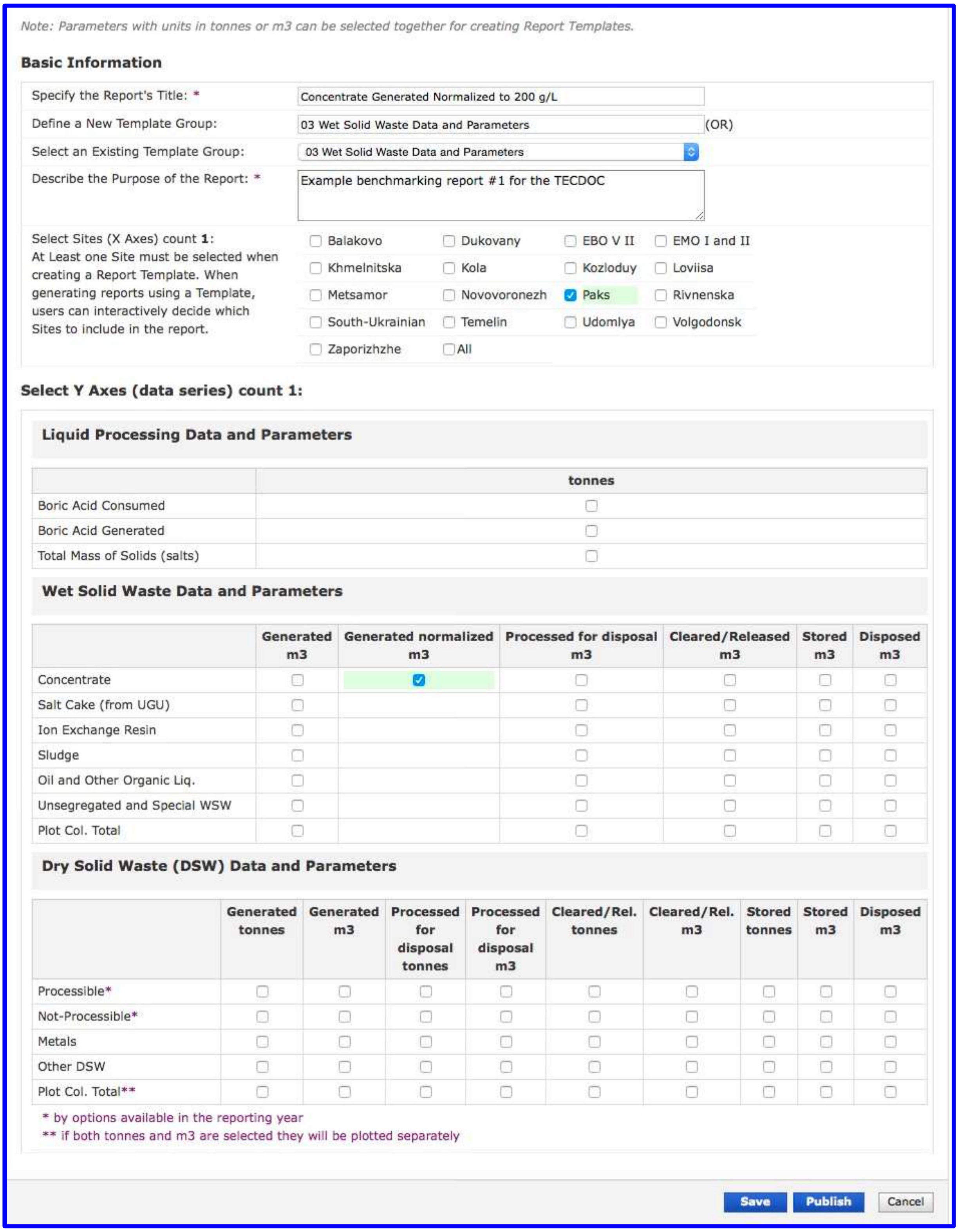
The three reports cited are known as the “Must Have Reports”. FIG. 17 shows a report for “Must Have Report #1” — Concentrate Generated, Normalized to 200 g/*L*” with the option to normalize data to the number of operating days selected.

The template for this report was created by selecting “Concentrate – Generated Normalized” on the “New Template Creation” screen, see Fig. 18, and saving the selection with the indicated report title.

The report was generated by selecting (see Fig. 16.):

- Template Group = “03 Wet Solid Waste Data and Parameters”;
- Report Title = “Concentrate Generated Normalized to 200g/L”;
- Normalize Data = Operating Days;
- Site = Paks;
- Years = 2006–2013.

FIG. 17. “Must Have Report #1” — Concentrate Generated, Normalized to 200 g/L.



Note: Parameters with units in tonnes or m3 can be selected together for creating Report Templates.

Basic Information

Specify the Report's Title: *	Concentrate Generated Normalized to 200 g/L
Define a New Template Group:	03 Wet Solid Waste Data and Parameters (OR)
Select an Existing Template Group:	03 Wet Solid Waste Data and Parameters
Describe the Purpose of the Report: *	Example benchmarking report #1 for the TECDOC

Select Sites (X Axes) count **1**: At Least one Site must be selected when creating a Report Template. When generating reports using a Template, users can interactively decide which Sites to include in the report.

☐ Balakovo	☐ Dukovany	☐ EBO V II	☐ EMO I and II
☐ Khmelnitska	☐ Kola	☐ Kozloduy	☐ Loviisa
☐ Metsamor	☐ Novovoronezh	☑ Paks	☐ Rivnenska
☐ South-Ukrainian	☐ Temelin	☐ Udomlya	☐ Volgodonsk
☐ Zaporizhzhe	☐ All		

Select Y Axes (data series) count 1:

Liquid Processing Data and Parameters

	tonnes
Boric Acid Consumed	☐
Boric Acid Generated	☐
Total Mass of Solids (salts)	☐

Wet Solid Waste Data and Parameters

	Generated m3	Generated normalized m3	Processed for disposal m3	Cleared/Released m3	Stored m3	Disposed m3
Concentrate	☐	☑	☐	☐	☐	☐
Salt Cake (from UGU)	☐		☐	☐	☐	☐
Ion Exchange Resin	☐		☐	☐	☐	☐
Sludge	☐		☐	☐	☐	☐
Oil and Other Organic Liq.	☐		☐	☐	☐	☐
Unsegregated and Special WSW	☐		☐	☐	☐	☐
Plot Col. Total	☐		☐	☐	☐	☐

Dry Solid Waste (DSW) Data and Parameters

	Generated tonnes	Generated m3	Processed for disposal tonnes	Processed for disposal m3	Cleared/Rel. tonnes	Cleared/Rel. m3	Stored tonnes	Stored m3	Disposed m3
Processible*	☐	☐	☐	☐	☐	☐	☐	☐	☐
Not-Processible*	☐	☐	☐	☐	☐	☐	☐	☐	☐
Metals	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other DSW	☐	☐	☐	☐	☐	☐	☐	☐	☐
Plot Col. Total**	☐	☐	☐	☐	☐	☐	☐	☐	☐

* by options available in the reporting year
** if both tonnes and m3 are selected they will be plotted separately

Save Publish Cancel

FIG. 18. Creation of the template for "Must Have Report #1".

Figure 19 shows “Must Have Report #2” and Fig. 20 shows the creation of its template. In this example, data has been normalized to the number of operating reactors.

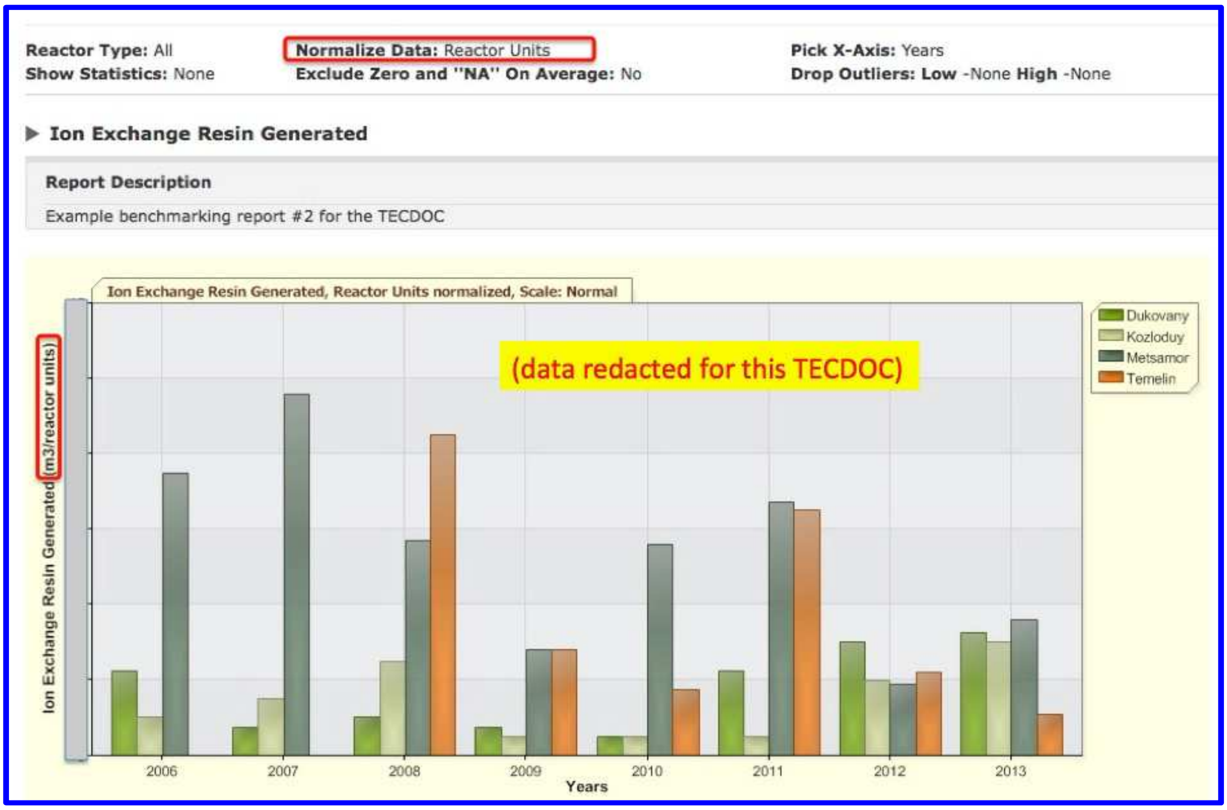
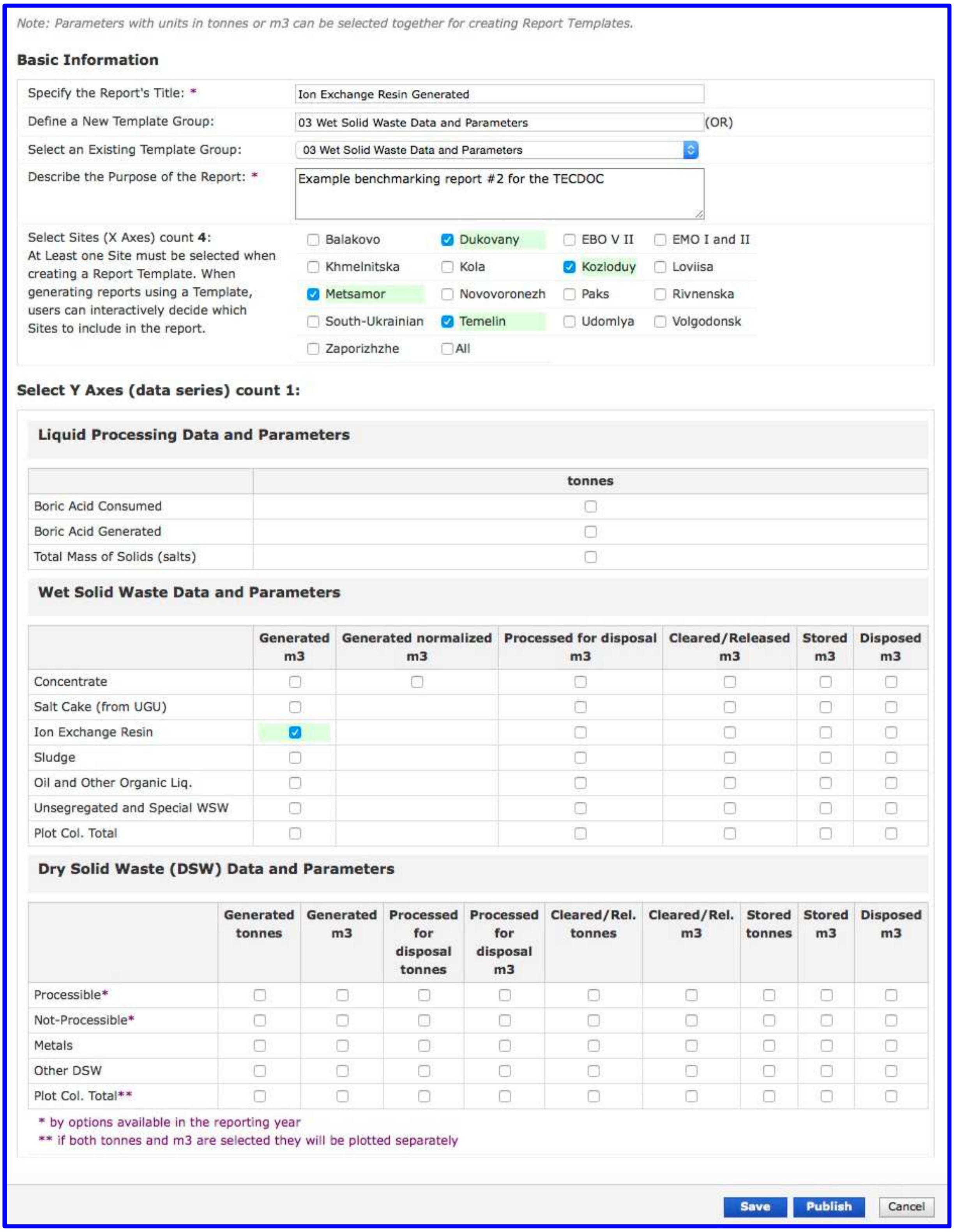


FIG. 19. “Must Have Report #2”: Ion Exchange Resin Generated.



Note: Parameters with units in tonnes or m3 can be selected together for creating Report Templates.

Basic Information

Specify the Report's Title: *	Ion Exchange Resin Generated
Define a New Template Group:	03 Wet Solid Waste Data and Parameters (OR)
Select an Existing Template Group:	03 Wet Solid Waste Data and Parameters
Describe the Purpose of the Report: *	Example benchmarking report #2 for the TECDOC
Select Sites (X Axes) count **4**: At Least one Site must be selected when creating a Report Template. When generating reports using a Template, users can interactively decide which Sites to include in the report.	☐ Balakovo ☑ Dukovany ☐ EBO V II ☐ EMO I and II ☐ Khmelnitska ☐ Kola ☑ Kozloduy ☐ Loviisa ☑ Metsamor ☐ Novovoronezh ☐ Paks ☐ Rivnenska ☐ South-Ukrainian ☑ Temelin ☐ Udomlya ☐ Volgodonsk ☐ Zaporizhzhe ☐ All

Select Y Axes (data series) count 1:

Liquid Processing Data and Parameters

	tonnes
Boric Acid Consumed	☐
Boric Acid Generated	☐
Total Mass of Solids (salts)	☐

Wet Solid Waste Data and Parameters

	Generated m3	Generated normalized m3	Processed for disposal m3	Cleared/Released m3	Stored m3	Disposed m3
Concentrate	☐	☐	☐	☐	☐	☐
Salt Cake (from UGU)	☐		☐	☐	☐	☐
Ion Exchange Resin	☑		☐	☐	☐	☐
Sludge	☐		☐	☐	☐	☐
Oil and Other Organic Liq.	☐		☐	☐	☐	☐
Unsegregated and Special WSW	☐		☐	☐	☐	☐
Plot Col. Total	☐		☐	☐	☐	☐

Dry Solid Waste (DSW) Data and Parameters

	Generated tonnes	Generated m3	Processed for disposal tonnes	Processed for disposal m3	Cleared/Rel. tonnes	Cleared/Rel. m3	Stored tonnes	Stored m3	Disposed m3
Processible*	☐	☐	☐	☐	☐	☐	☐	☐	☐
Not-Processible*	☐	☐	☐	☐	☐	☐	☐	☐	☐
Metals	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other DSW	☐	☐	☐	☐	☐	☐	☐	☐	☐
Plot Col. Total**	☐	☐	☐	☐	☐	☐	☐	☐	☐

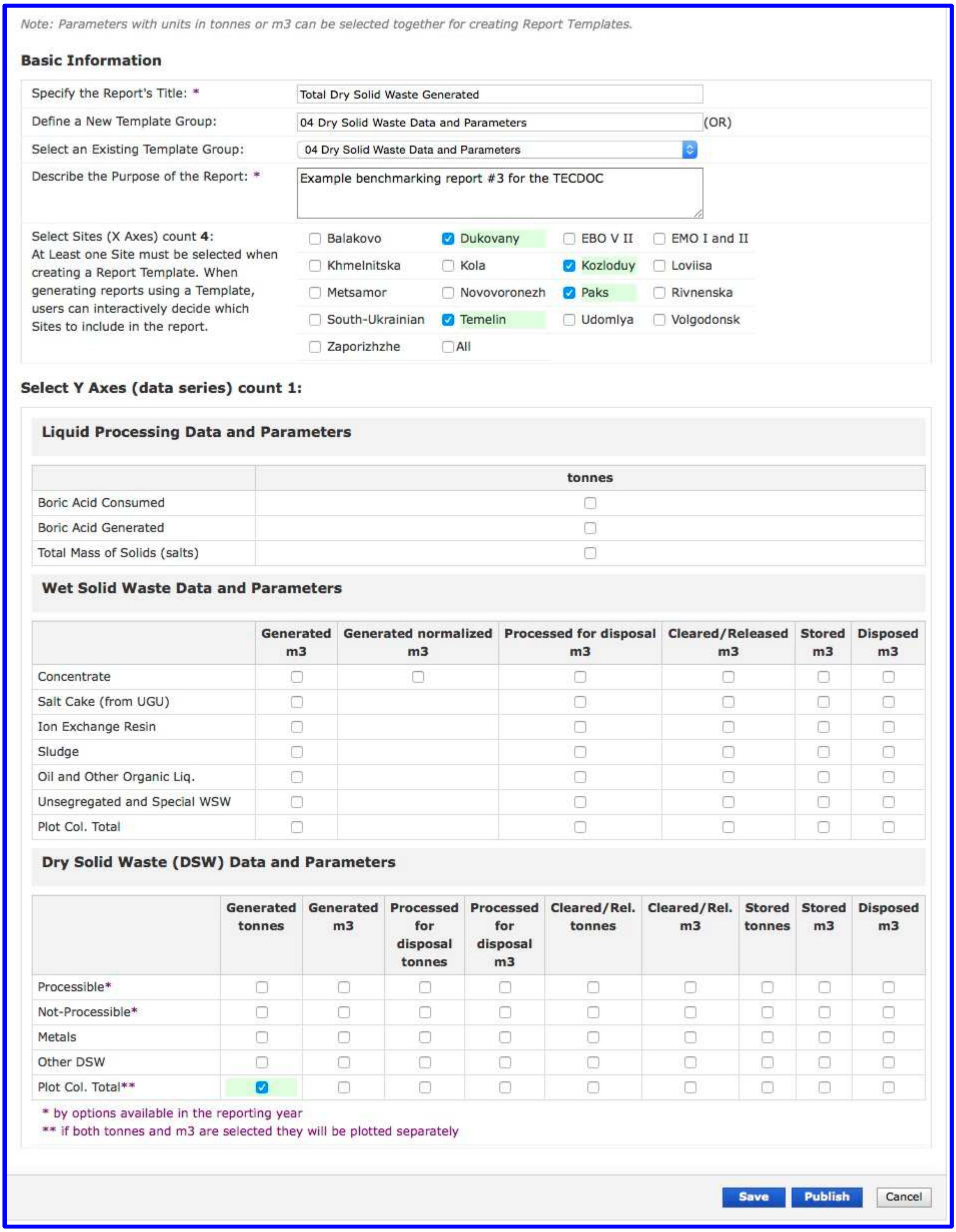
* by options available in the reporting year
** if both tonnes and m3 are selected they will be plotted separately

Save Publish Cancel

FIG. 20. Creation of the Template for Must Have Report #2.

Figure 21 shows "Must Have Report #3" and Fig. 22 shows the creation of its template. In this example, data has been normalized to the TW·h of electricity generated.

FIG. 21. "Must Have Report #3": Total Dry Solid Waste Generated.



Note: Parameters with units in tonnes or m3 can be selected together for creating Report Templates.

Basic Information

Specify the Report's Title: *	Total Dry Solid Waste Generated
Define a New Template Group:	04 Dry Solid Waste Data and Parameters (OR)
Select an Existing Template Group:	04 Dry Solid Waste Data and Parameters
Describe the Purpose of the Report: *	Example benchmarking report #3 for the TECDOC
Select Sites (X Axes) count **4**: At Least one Site must be selected when creating a Report Template. When generating reports using a Template, users can interactively decide which Sites to include in the report.	☐ Balakovo ☑ Dukovany ☐ EBO V II ☐ EMO I and II ☐ Khmelnitska ☐ Kola ☑ Kozloduy ☐ Loviisa ☐ Metsamor ☐ Novovoronezh ☑ Paks ☐ Rivnenska ☐ South-Ukrainian ☑ Temelin ☐ Udomlya ☐ Volgodonsk ☐ Zaporizhzhe ☐ All

Select Y Axes (data series) count 1:

Liquid Processing Data and Parameters

	tonnes
Boric Acid Consumed	☐
Boric Acid Generated	☐
Total Mass of Solids (salts)	☐

Wet Solid Waste Data and Parameters

	Generated m3	Generated normalized m3	Processed for disposal m3	Cleared/Released m3	Stored m3	Disposed m3
Concentrate	☐	☐	☐	☐	☐	☐
Salt Cake (from UGU)	☐		☐	☐	☐	☐
Ion Exchange Resin	☐		☐	☐	☐	☐
Sludge	☐		☐	☐	☐	☐
Oil and Other Organic Liq.	☐		☐	☐	☐	☐
Unsegregated and Special WSW	☐		☐	☐	☐	☐
Plot Col. Total	☐		☐	☐	☐	☐

Dry Solid Waste (DSW) Data and Parameters

	Generated tonnes	Generated m3	Processed for disposal tonnes	Processed for disposal m3	Cleared/Rel. tonnes	Cleared/Rel. m3	Stored tonnes	Stored m3	Disposed m3
Processible*	☐	☐	☐	☐	☐	☐	☐	☐	☐
Not-Processible*	☐	☐	☐	☐	☐	☐	☐	☐	☐
Metals	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other DSW	☐	☐	☐	☐	☐	☐	☐	☐	☐
Plot Col. Total**	☑	☐	☐	☐	☐	☐	☐	☐	☐

* by options available in the reporting year
** if both tonnes and m3 are selected they will be plotted separately

Save Publish Cancel

FIG. 22. Creation of the Template for Must Have Report #3.

The examples shown above and the user manual provide enough guidance for users to define and use pre-defined report templates to generate detailed reports that support assessing waste management practices at their sites and for comparing those practices at the various WWER NPP sites.

7. AN EXPLANATION OF THE BENEFITS OF BMS AND EXAMPLES OF ITS USE

The benefits of the WWER benchmarking programme can include:

- Enhancing interaction between WWER operators resulting in agreements on terminology and parameters to compare;
- Establishing a mechanism for information exchange, including consistent and agreed reporting formats;
- Rapidly identifying the relative position of individual plants in terms of their LILW management performance;
- Identifying the strengths and weaknesses for each WWER Site;
- Serving as a tool/model for additional reporting, such as monthly or quarterly reporting of specific parameters;
- Identifying top performers and the waste management practices (including parameters) they are applying to achieve top performance, which provides a driving force to improve performance and justifies what was carried out to achieve these results;
- Identifying alternative liquid processing practices similar plants are using to improve performance;
- Quantifying annual storage volumes (liabilities) and disposal volumes on an industry-wide and national basis;
- Capturing lessons learned and technology transfer;
- Generating periodic summary reports of benchmarked data and what that data means to the industry;
- Reducing routinely accessed contaminated areas on an industry-wide basis, which will translate to faster maintenance, improved operator access, shorter outages, reduced radiation exposures, fewer personnel contamination events and significant reductions in LILW generation, storage and disposal volumes.

All of the above can result in substantial, annually recurring cost savings, waste volume reduction and enhanced waste management safety. The work lays the foundation for the IAEA to:

- Provide continuing, long term support to WWER waste management organizations;
- Identify plant-specific improvement opportunities;
- Assist those plants to implement effective and innovative solutions.

Benchmarking programmes also establish a process of continuous improvement through an iterative cycle of benchmarking, identification of improvement opportunities, implementation of improvements and evaluation of improvement effectiveness.

The WWER Benchmarking System is a useful planning and control tool also for National Nuclear Regulatory Bodies, which enables the supervision and control of radioactive management at NPPs, including waste minimization programmes and for policy making activities that will support these programmes.

The following example charts (see Figures 23–38) illustrate the benchmarking results with the explanations/comments to them.

Table 9. GUIDANCE ON MINIMUM REPORTING FOR BENCHMARKING

Example #	Parameter(s)	Normalization
Generation		
1	Concentrate normalized to 200 g/L	# of reactor units
2	Ion exchange resin	
3	Total dry solid waste and metals	
4	Total dry solid waste and metals: stacked bars	
Processing for Disposal/Clearance		
5	Concentrate	none
6	Ion exchange resin	
7	Dry solid waste by type processed and cleared (stacked)	
8	Total dry solid waste reported by mass and volume	
Storage		
9	Concentrate	none
10	Ion exchange resin	
11	Total dry solid waste stored by volume	
12	Total dry solid waste stored by mass	
Disposal/Clearance		
13	Concentrate	none
14	Ion exchange resin	
15	Total dry solid waste	
16	Wet solid waste cleared (oils, other organic liquids, IX resins)	

Figure 23 illustrates the benchmarking results of concentrate generation that have a complex character reflecting the overall performance of technological equipment and systems, such as the condition of technological equipment or the scope of maintenance activities,) and the performance of the operational staff (e.g. the quality and observance of procedures and manuals). In addition, a continuous high volume of generated concentrate may reflect a preferred strategy in concentrate management, for instance a higher volume of concentrate with a lower salt content better meets the technical specification of subsequent processes.

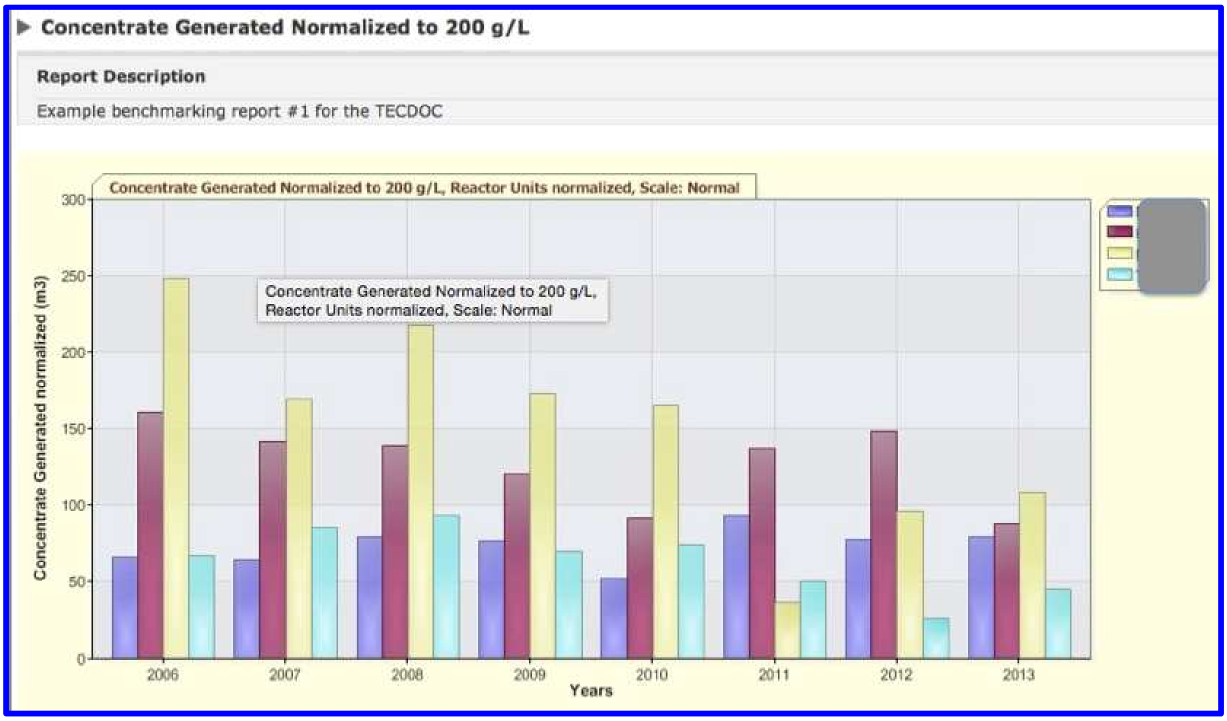


FIG. 23. Example Benchmarking Report #1 (see Table 1).

The comparison of ion exchange resin annual generation rates presented in Fig. 24 provides a conception of the status of chemical regime, of the quality and adherence to procedures, the impact of a fuel failure and etc. Moreover, a higher volume of generated ion exchange resin may indicate the compliance with technical specification or regulatory requirements.

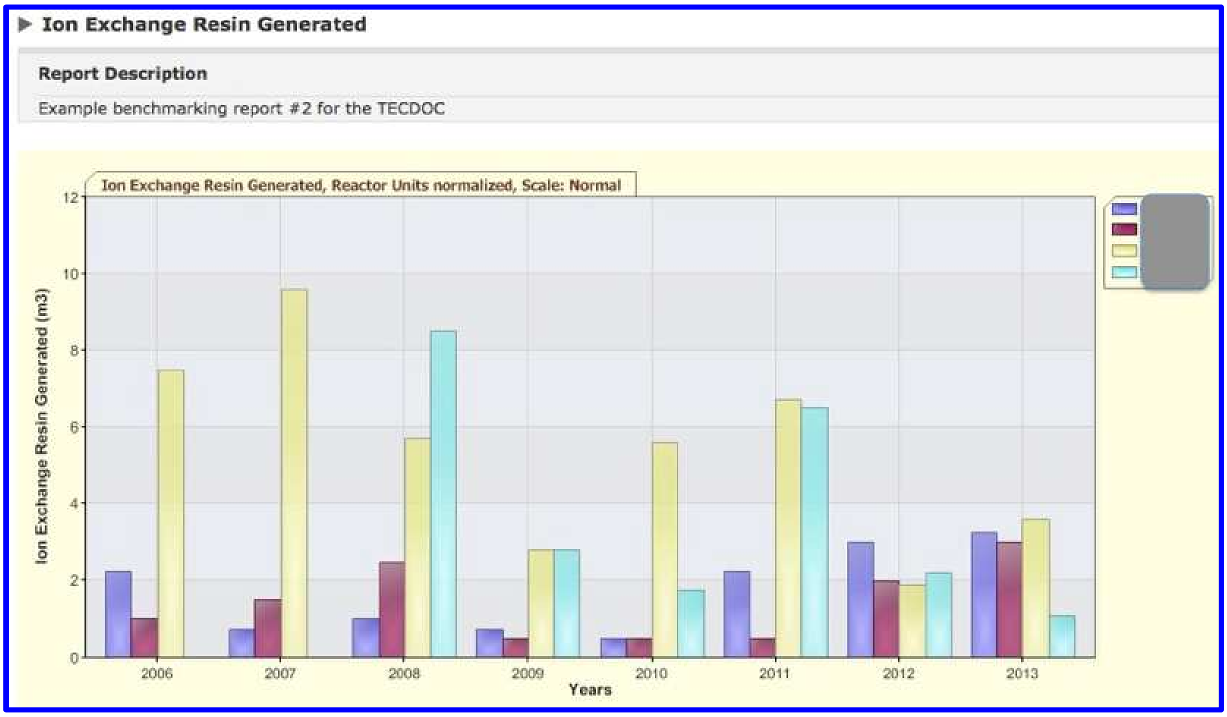


FIG. 24. Example Benchmarking Report #2 (see Table 1).

Figure 25 provides an opportunity to follow the trend of generation of a particular type of DSW, which in turn reflects the adherence to the waste generation minimization requirement (e.g. proper sorting and characterization of waste, exclusion of consumable materials in control zone, etc.), and operational practices such as the use of disposable individual protective clothing and cleaning rugs for decontamination purposes. However, a higher generation rate of processable waste may reflect activities on management of historical waste that was not originally properly sorted, characterized and processed. It is also possible to infer the duration of outages and scope of maintenance activities (e.g. refurbishment for design lifetime extension, for safety reason, etc.) from the volumes of generated DSW. The above mentioned activities also impact the volume of metal generation. Meanwhile, the lack of available technologies for treatment of arising DSW may be traced by the higher generation rate of non-processable waste (often expressed in volume), and therefore the greatest storage volume on a per unit generation basis can be expected to be occupied by such waste (e.g. bulk concrete pieces, bulk filtration units, etc.).

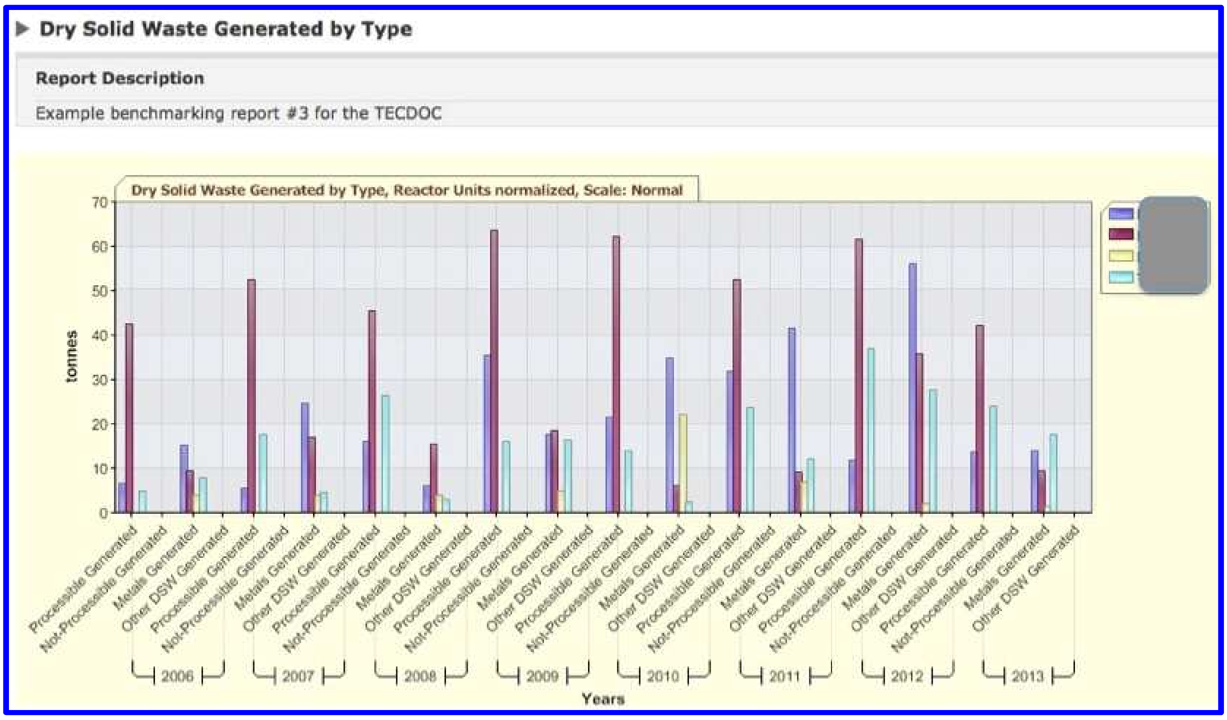


FIG. 25. Example Benchmarking Report #3 (see Table 1).

Figures 25 and 26 are illustrations of the results of benchmarking of DSW generation, but the use of 'stacked' scale for the creation of Report provides an opportunity for easier visual perception of the correlation of generation of particular types of DSW at the NPPs selected for benchmarking and for estimation of changes in the ratio. The benchmarking reveals significant differences in approaches for reporting the waste generated in the controlled area as radioactive waste (e.g. all the waste generated in the controlled area is from its origin considered radioactive or is considered radioactive until they are proved by an approved procedure to fulfil clearance criteria).

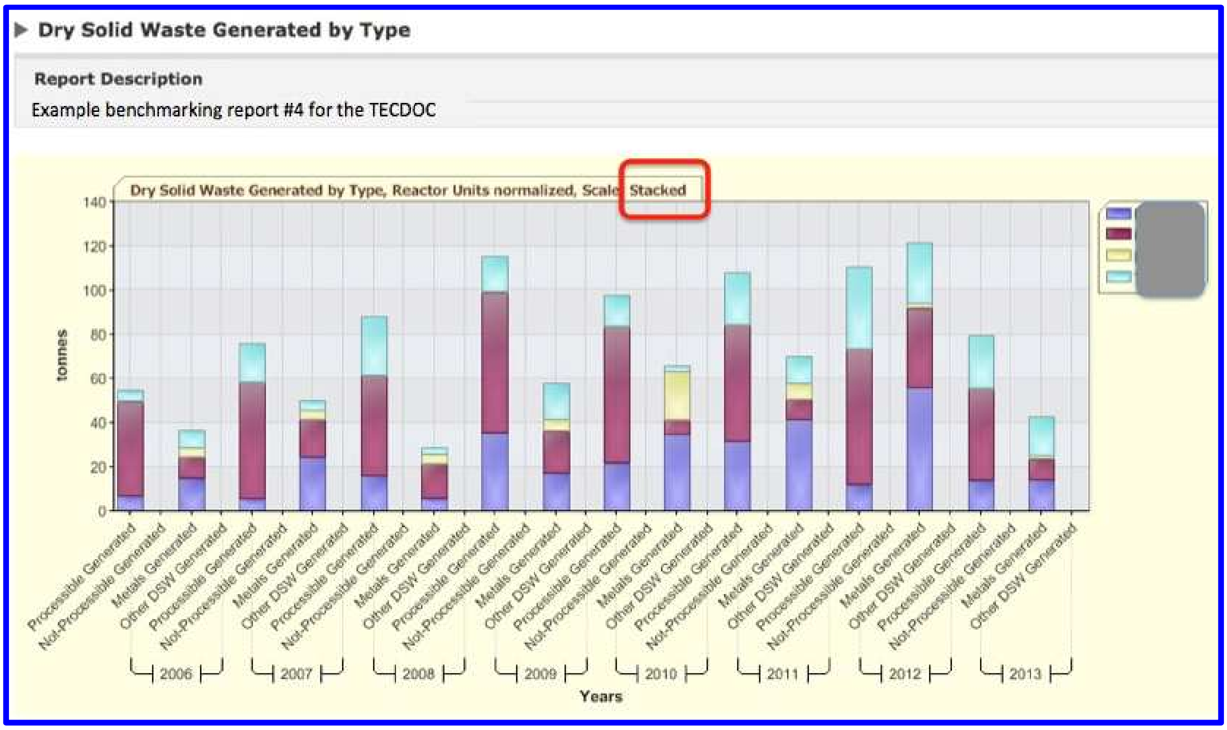


FIG. 26. Example Benchmarking Report #4 (see Table 1).

The benchmarking of concentrate processing data, illustrated in Fig. 27, enables the evaluation of the NPP operational efficiency from the waste volume minimization point of view and reflects the dynamics of its changes. In addition, a sharp increase of volume of processed concentrate may reveal an implementation of a targets or an improvement of the waste management system. While a lower processing rate may indicate the adherence to requirements/restrictions or reflect the performance of equipment and systems.

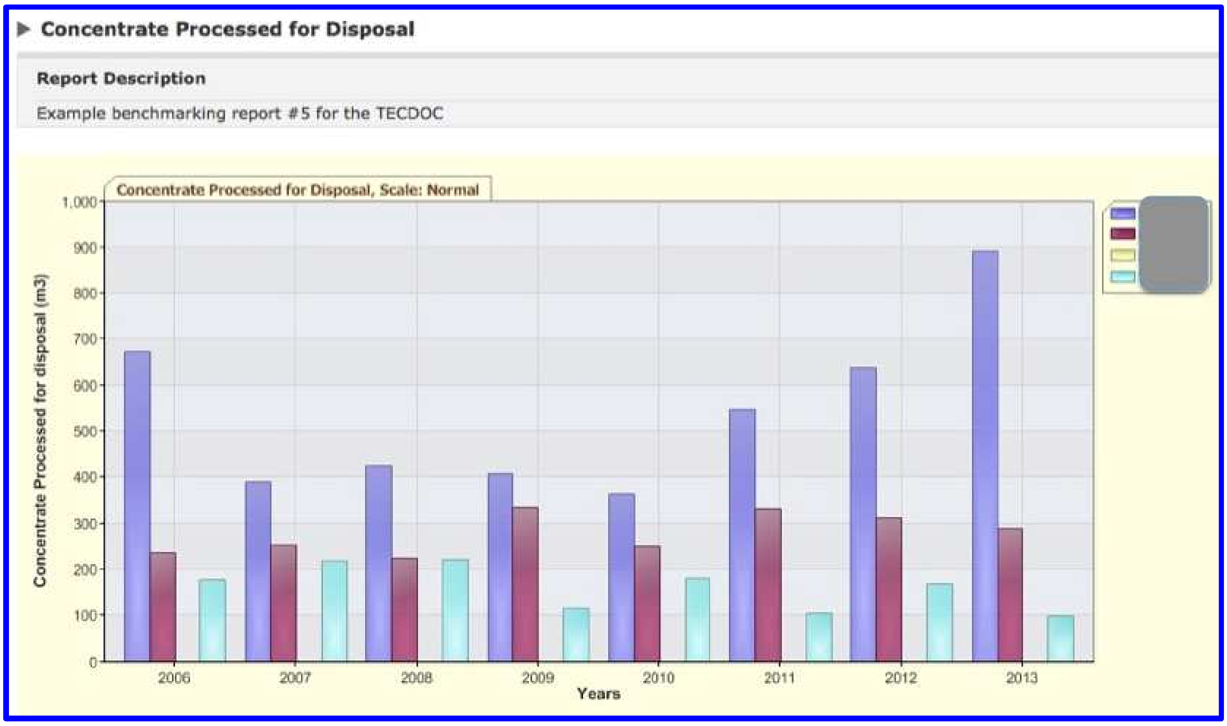


FIG. 27. Example Benchmarking Report #5 (see Table 1).

The ion exchange resin processing data in Fig. 28 may indicate the availability of specific technology at one of the sites (e.g. remote controlled devices) or modification of existing infrastructure to enable the removal of resin from storage tanks.

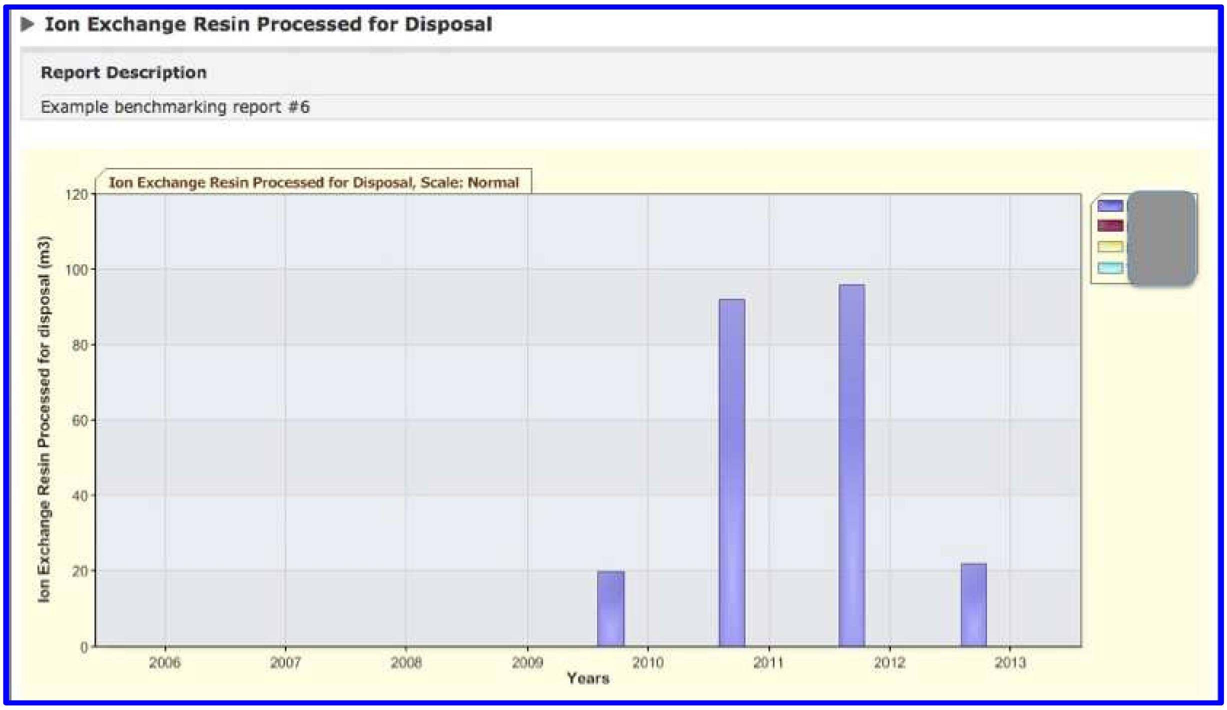


FIG. 28. Example Benchmarking Report #6 (see Table 1).

The benchmarking of data on DSW processed for disposal expressed in units of mass (see Figure 29) may provide a basis for the estimation of efficiency of treatment processes regardless of material or shape, especially taking into consideration that metal generated in the controlled area represents waste with limited potential for effective volume reduction. The benchmarking of data on cleared DSW may reflect the availability and effective use of procedures for segregation, processing, radiological characterization and clearance of particular DSW stream before discharging into the environment.

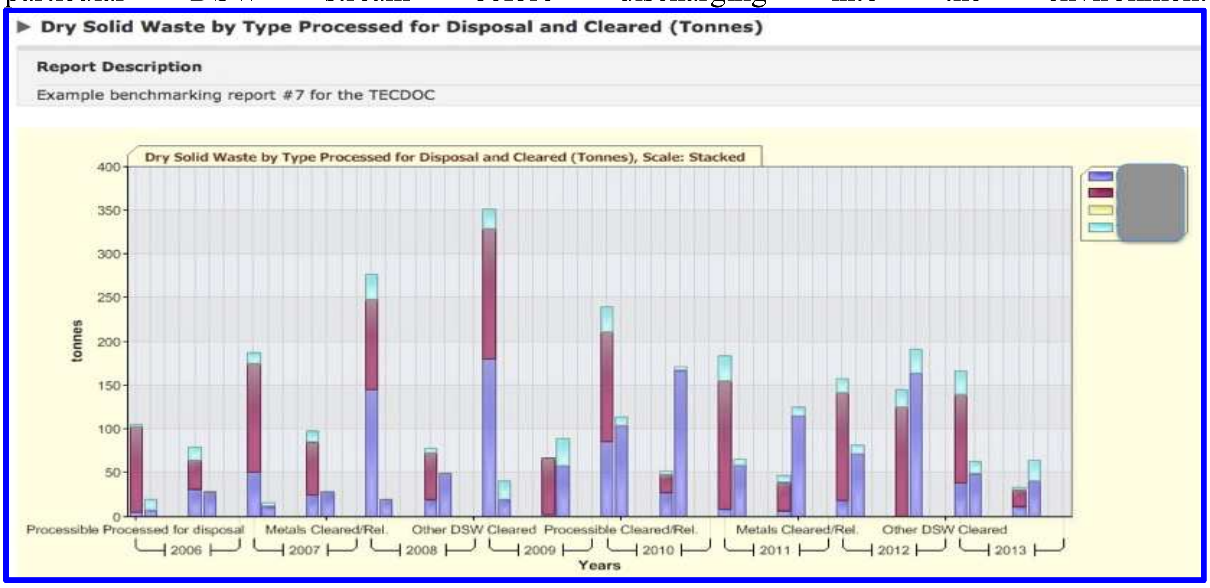


FIG. 29. Example Benchmarking Report #7 (see Table 1).

The results of benchmarking of DSW processed for disposal, illustrated in Figure 30, reveal significant differences in approaches for reporting the waste generated in the controlled area as radioactive waste and these differences have a fundamental influence on the predicative value of the volume processed for disposal. The benchmarking of data expressed in units of both mass and volume may reflect the efficiency of implemented treatment processes and therefore may induce an improvement in effectiveness of current methods or an introduction of new progressive methods. In addition, the introduction of weighing waste may reflect a preferred approach for tracking DSW for other purposes (e.g. basis for estimation of processing price).

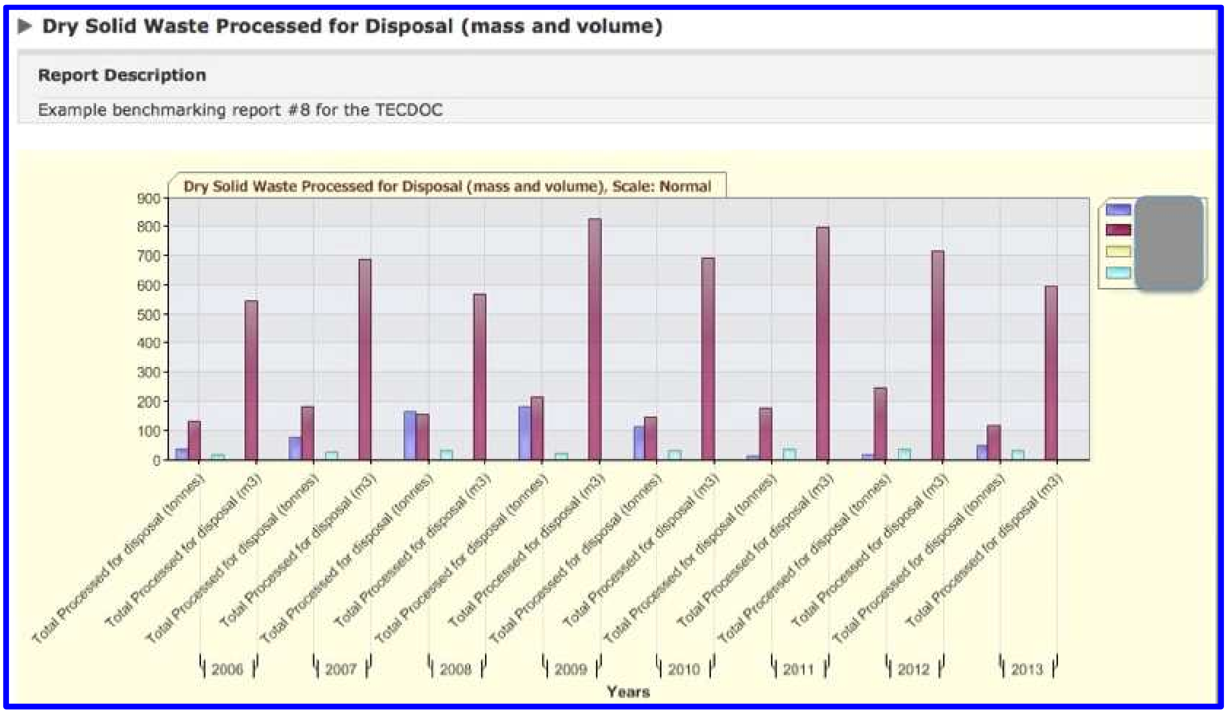


FIG. 30. Example Benchmarking Report #8 (see Table 1).

Figure 31 reflects the use of limited storage capacities, that is affected by circumstances like a lack of processing and disposal capacities and the operational efficiency of an NPP with respect to waste minimization. Furthermore, it may indirectly indicate the attitude of the regulatory body towards the minimization of risks connected to concentrate storage and this may serve as a driving force for the reduction of stored concentrate. A higher volume of stored capacity may highlight the need or urgency of processing technology implementation or of increasing storage capacity (for example in the case of delays in the implementation of processing technologies). Meanwhile, a lower volume of stored concentrate has a major influence on the management strategy as it may minimize the risk of premature implementation of waste processing technologies that can lead to irreversible steps and provides time for optimization of waste processing technologies.

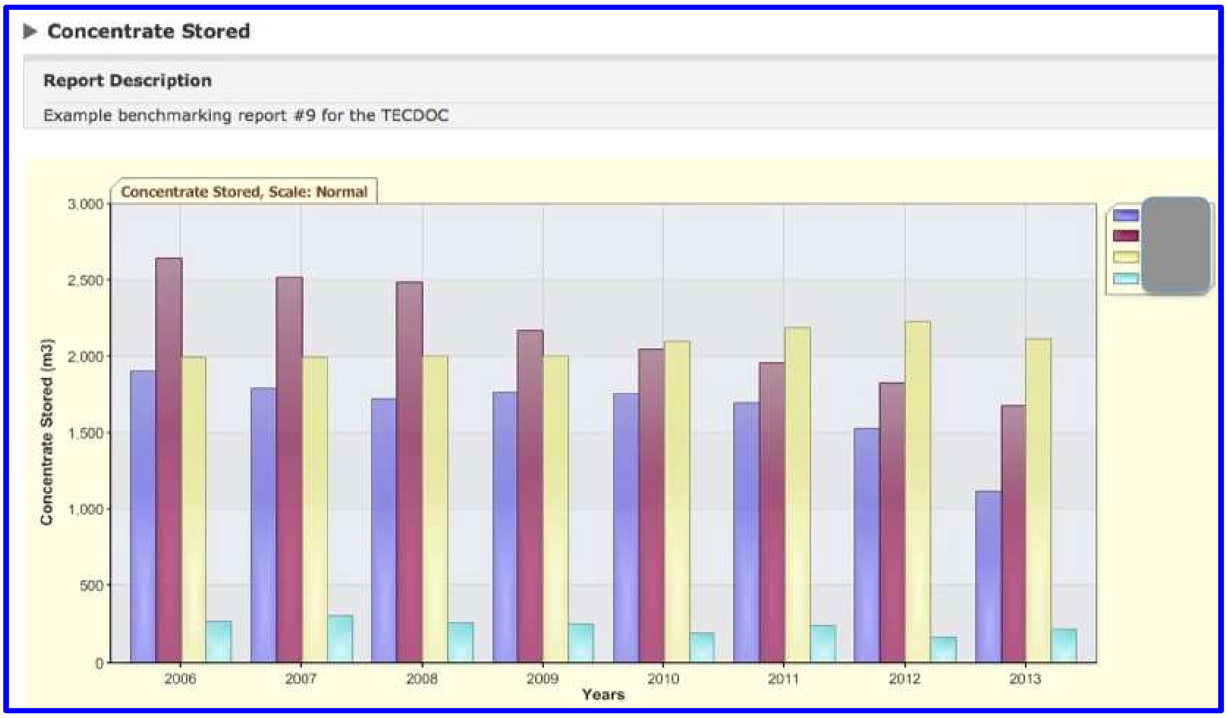


FIG. 31. Example Benchmarking Report #9 (see Table 1).

Figure 32 on stored volumes of ion exchange resin provides an opportunity to follow the developments in management of such potentially problematic waste (taking into consideration the previous discussion of Figure 28 on the processing of ion exchange resin). A higher volume of stored resin may reflect the compliance with technical specification or regulatory requirements and may also highlight the urgency in implementing different treatment technologies. However, a lower volume of stored resin may reflect an operational performance (e.g. the use of an effective activity-based segregation process) and may indirectly indicate the availability of storage capacity for dewatered resins.

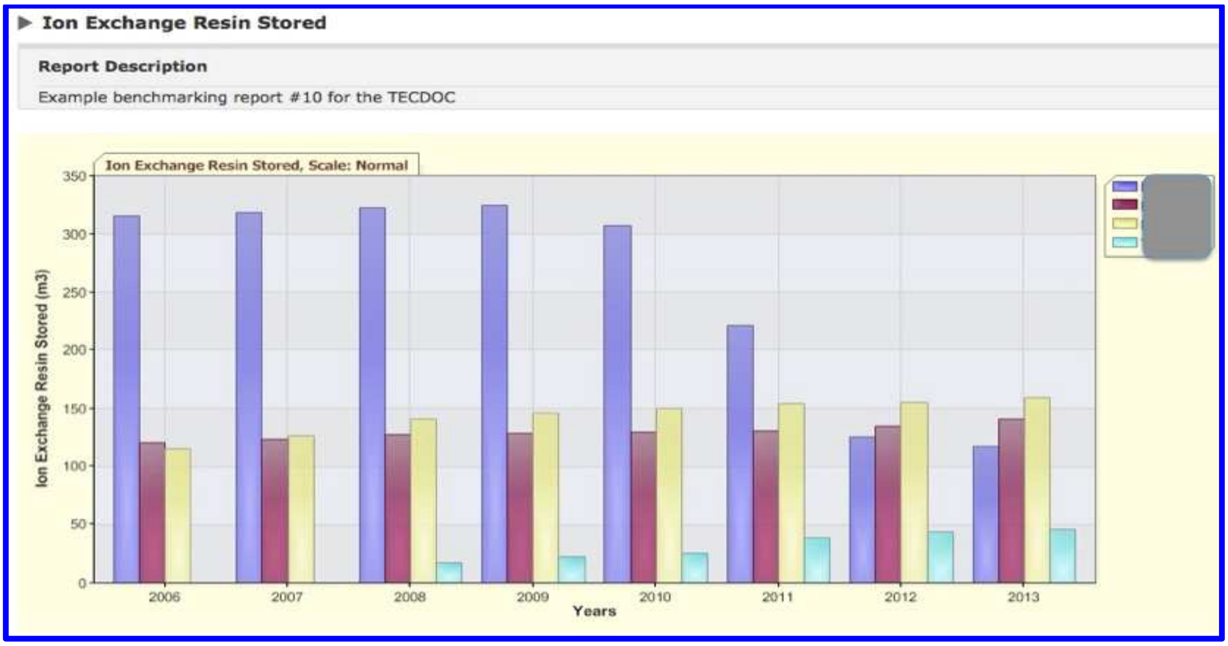


FIG. 32. Example Benchmarking Report #10 (see Table 1).

The benchmarking of data on stored volumes of DSW, as illustrated in Fig. 33, provides an overall view of the effective use of storage capacity (e.g. packing efficiency, storage procedures, etc.). It also indicates the presence of historical accumulations often stored without consideration of an increase of usable capacity. A lower level of storage capacity occupation may reflect the activity on segregation of specific waste streams (e.g. for clearance, reuse and recycling and/or availability of decay storage) and may indirectly indicate the attitude of the regulator towards the minimization of risks associated with the storage of DSW, which may be a driving force to minimize the amount of waste stored.

FIG. 33. Example Benchmarking Report #11 (see Table 1).

In addition to the explanations above, the benchmarking of stored quantities of DSW, as illustrated in Figure 34, may reveal the extent of future waste management(legislative, technical and financial). The benchmarking of data expressed in units of both mass and volume may reflect the efficiency of implemented processing technology and/or of stacking procedures and consequently may initiate enhancement activities.

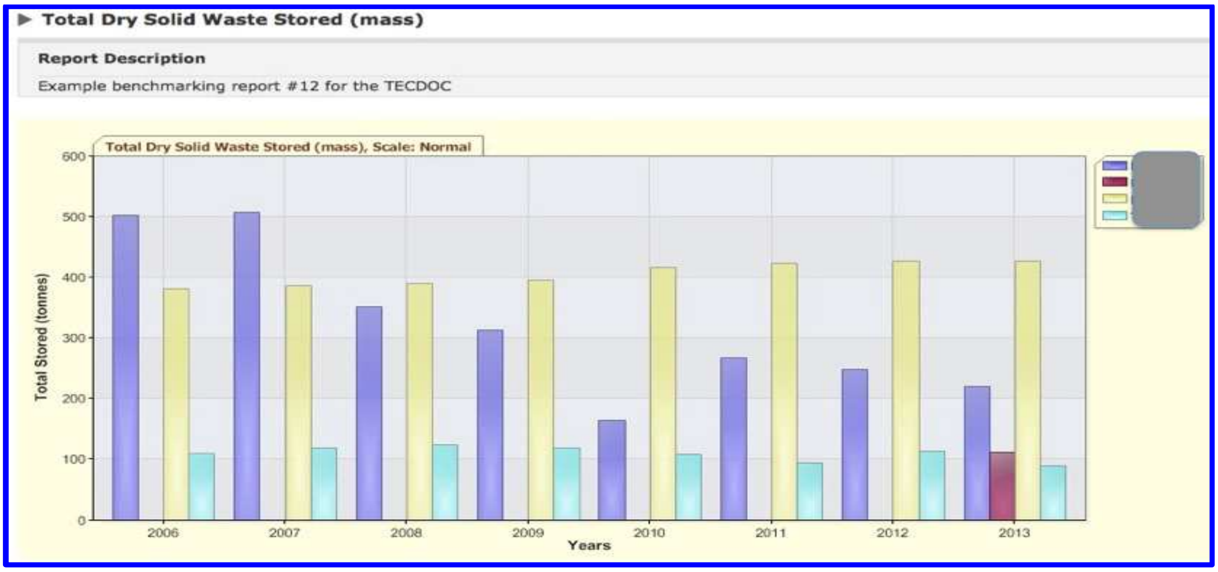


FIG. 34. Example Benchmarking Report #12 (see Table 1).

Figures 35 –37 provide important data on the existence of operational disposal facilities, which has a significant impact on an overall NPP operation and on the radioactive waste management strategy. In addition, Fig. 35 provides information on the volume of the final form of concentrate disposed of in a given year, which is an important performance parameter used for the evaluation of NPP operation effectiveness from the point of view of minimization of the amount of stored wastes.

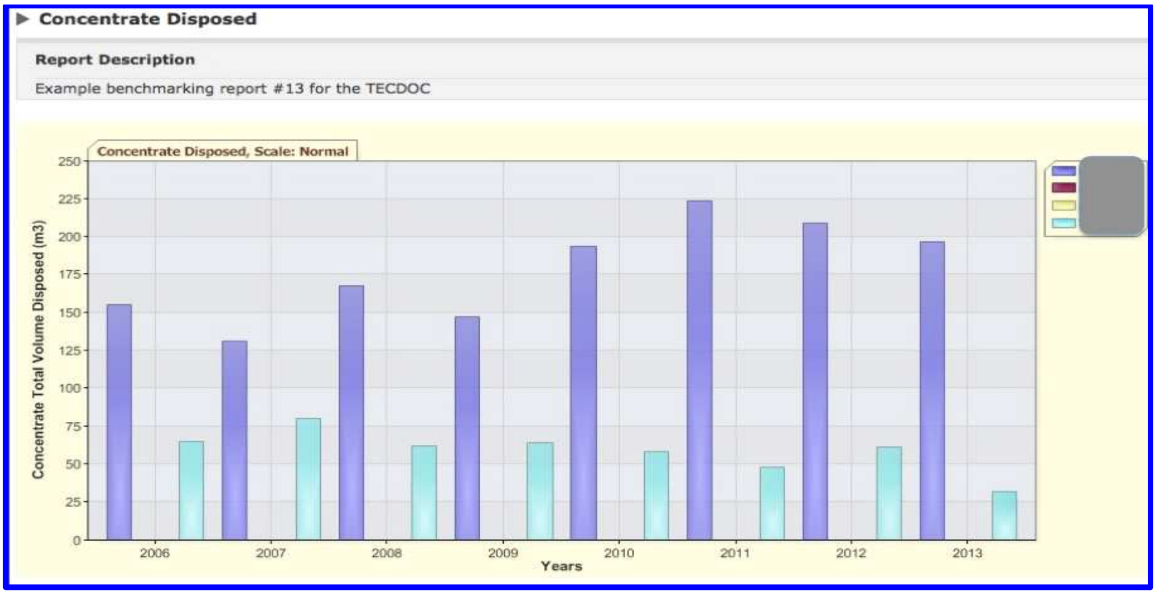


FIG. 35. Example Benchmarking Report #13 (see Table 1).

Figure 36 illustrates the availability and use of an operational disposal facility for ion exchange resin. The wide fluctuation shown in the Fig. 36 may indicate the adherence to a requirement and/or restriction on the volume disposed in a given year.

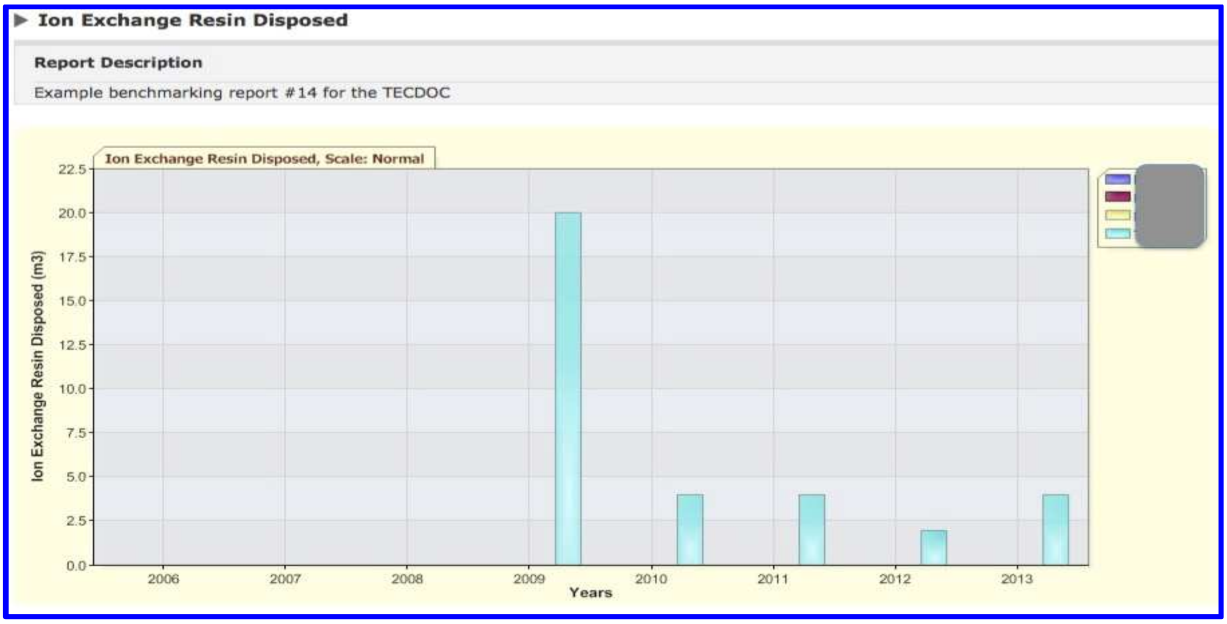


FIG. 36. Example Benchmarking Report #14 (see Table 1).

It should be noted that missing information in in the Figure 36 is due to the incompleteness of current BMS data.

Figure 37 indicates the availability of an operational disposal facility for DSW. The observed fluctuation in disposed volumes may indicate the adherence to a requirement and/or restriction. In addition, the comparison of data in Figures 30 and 37 and the revealed deviations between the volumes of DSW processed for disposal and the disposed volumes may indirectly reflect the performance of the radioactive waste management system. Processing of annual data on the production of final waste form to be disposed within a wider period of time enables the identification of patterns, highlighting any deviation from expected volumes.

FIG. 37. Example Benchmarking Report #15 (see Table 1).

Figure 38 on cleared waste is the indication of the establishment and effective use of procedures for segregation, radiological characterization, treatment (if needed) and clearance or release of WSW to the environment that is an additional evidence of implementation of waste minimization principle.

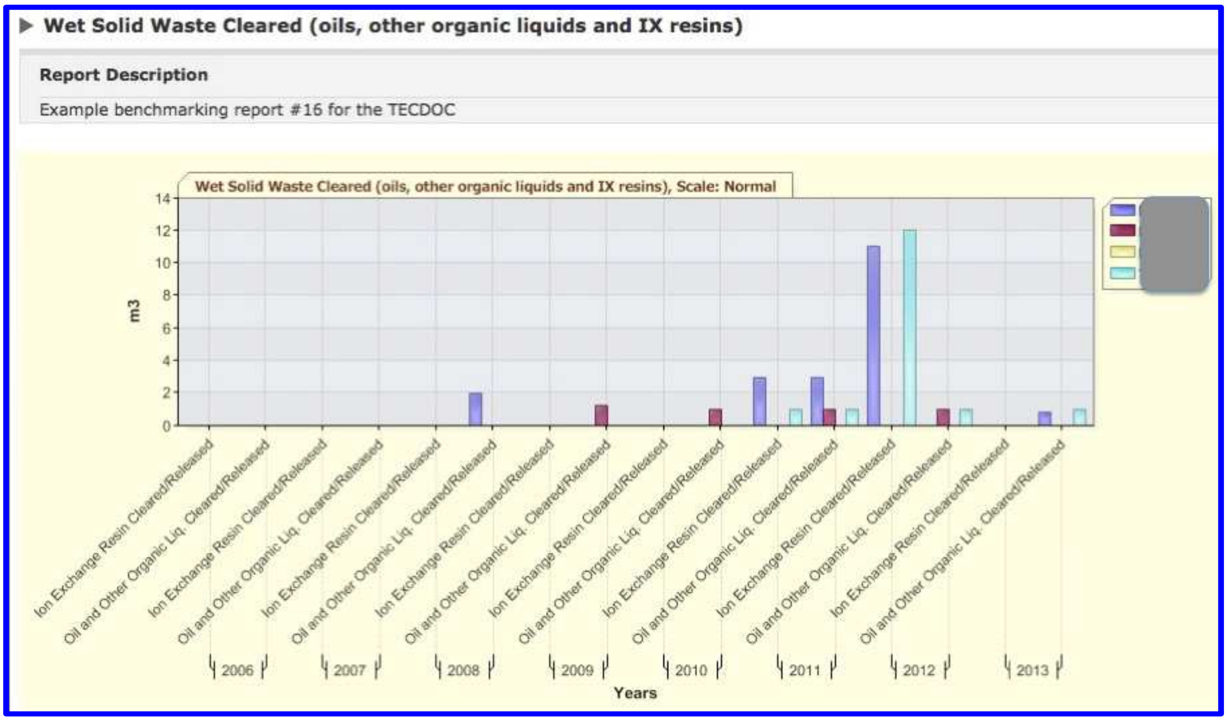


FIG. 38. Example Benchmarking Report #16 (see Table 1).

8. CONCLUSIONS

This TECDOC provides a comprehensive overview of the application and serves as an introductory user manual for the benchmarking database. It also includes overviews of national practices at WWER sites in the Annexes, which were partially prepared using the benchmarking database.

The International WWER Radioactive Waste Operations Benchmarking System was designed, developed, tested and launched. The system is used to collect, analyse, and report on waste management data from WWER-type NPP sites and enables member organizations to share their data and to determine how they rank among all participants in terms of commonly agreed and accepted waste management parameters. Data collection is conducted annually, but benchmarking reports and analysis can be accessed throughout the year. The system allows:

- Identification of the relative position of individual plants in terms of their LILW management performance;
- Identification of top performers and the waste management parameters they are applying to achieve top performance;
- Identification of alternative liquid processing parameters similar plants are using to improve performance;
- Quantification of annual storage volumes (liabilities) and disposal volumes on an industry-wide and national basis;
- Periodic summary reports of benchmarked data and what that data means to the industry;
- Direct discussion and exchange of detailed information between the participants concerning the differences of waste management generation and management techniques used/employed at their respective NPPs.

This system is currently restricted to users who are officially participating in the Benchmarking Project and is not available to regular public users of NUCLEUS.

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ABBREVIATIONS

BDBA	Beyond Design Basis Accident
BMS	WWER Radioactive Waste Benchmarking System
BWR	Boiling Water Reactor
CMEA	Council for Mutual Economic Assistance
DSW	Dry Solid Waste
ERPI	Electric Power Research Institute
IAEA	International Atomic Energy Agency
ICRP	International commission on radiological protection
ILW	Intermediate Level Waste
INPO	Institute for Nuclear Power Operations
LILW	Low and Intermediate Level Waste
LLW	Low Level Waste
MTIT	Division of Information Technology
NIAEP	NIZHNY NOVGOROD ENGINEERING COMPANY «Atomenergoproekt»
NUCLEUS	The IAEA Nuclear Knowledge and Information Portal
NPP	Nuclear Power Plant
PWR	Pressurized Water Reactor
UGU	Deep Evaporation of Concentrate
US AEC	United States Atomic Energy Commission
VLLW	Very Low Level Waste
WANO	World Association of Nuclear Operators
WSW	Wet Solid Waste
WWER	Water cooled Water moderated Energy Reactor

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