

2013



# [ISOE Country Reports]



## FOREWORD

Throughout the world, occupational exposures at nuclear power plants have steadily decreased since the early 1990s. Regulatory pressures, technological advances, improved plant designs and operational procedures, ALARA culture and experience exchange have contributed to this downward trend. However, with the continued ageing and possible life extensions of nuclear power plants worldwide, ongoing economic pressures, regulatory, social and political evolutions, and the potential of new nuclear build, the task of ensuring that occupational exposures are as low as reasonably achievable (ALARA), taking into account operational costs and social factors, continues to present challenges to radiation protection professionals.

Since 1992, the Information System on Occupational Exposure (ISOE), jointly sponsored by the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA), has provided a forum for radiological protection professionals from nuclear power utilities and national regulatory authorities worldwide to discuss, promote and co-ordinate international co-operative undertakings for the radiological protection of workers at nuclear power plants. The objective of ISOE is to improve the management of occupational exposures at nuclear power plants by exchanging broad and regularly updated information, data and experience on methods to optimise occupational radiation protection.

As a technical exchange initiative, the ISOE Programme includes a global occupational exposure data collection and analysis programme, culminating in the world's largest occupational exposure database for nuclear power plants, and an information network for sharing dose reduction information and experience. Since its launch, the ISOE participants have used this system of databases and communications networks to exchange occupational exposure data and information for dose trend analyses, technique comparisons, and cost-benefit and other analyses promoting the application of the ALARA principle in local radiological protection programmes.

This special edition of country reports presents dose information and principal events of 2013 in each ISOE country and will be incorporated into Twenty-Third Annual Report of the ISOE Programme in October 2013.



## Table of Contents

FOREWORD .....	1
INTRODUCTION .....	3
PRINCIPAL EVENTS IN PARTICIPATING COUNTRIES .....	4
ARMENIA .....	4
BELGIUM .....	6
BULGARIA .....	7
CANADA .....	8
CHINA .....	11
CZECH REPUBLIC .....	12
FINLAND .....	14
FRANCE .....	16
GERMANY .....	20
HUNGARY .....	22
ITALY .....	24
JAPAN .....	25
LITHUANIA .....	27
MEXICO .....	29
THE NETHERLANDS .....	32
REPUBLIC OF KOREA .....	33
ROMANIA .....	35
RUSSIAN FEDERATION .....	38
SLOVAK REPUBLIC .....	41
SLOVENIA .....	43
SPAIN .....	44
SWEDEN .....	47
SWITZERLAND .....	49
UKRAINE .....	50
UNITED KINGDOM .....	51
UNITED STATES .....	52



## INTRODUCTION

Since 1992, the Information System on Occupational Exposure (ISOE) has supported the optimisation of worker radiological protection in nuclear power plants through a worldwide information and experience exchange network for radiation protection professionals at nuclear power plants and national regulatory authorities, and through the publication of relevant technical resources for ALARA management. This special edition of country reports presents dose information and principal events of 2013 from 21 ISOE countries and will be incorporated into Twenty-Third Annual Report of the ISOE Programme in October 2013.

ISOE is jointly sponsored by the OECD NEA and IAEA, and its membership is open to nuclear electricity utilities and radiation protection regulatory authorities worldwide who accept the programme's Terms and Conditions. The current ISOE Terms and Conditions for the period 2012-2015 came into force on 1 January 2012. As of September 2014, the ISOE programme includes 76 Participating Utilities in 29 countries (349 operating units; 57 shutdown units), as well as the regulatory authorities of 18 countries. The ISOE occupational exposure database itself includes information on occupational exposure levels and trends at 401 operating reactors; covering about 91% of the world's operating commercial power reactors. Four ISOE Technical Centres (Europe, North America, Asia and IAEA) manage the programme's day-to-day technical operations.

In addition to information from operating reactors, the ISOE database contains dose data from 81 reactors which are shut down or in some stage of decommissioning. As these reactor units are generally of different type and size, and at different phases of their decommissioning programmes, it is difficult to identify clear dose trends. However, work continued in 2013 to improve the data collection for such reactors in order to facilitate better benchmarking.

While ISOE is well known for its occupational exposure data and analyses, the programme's strength comes from its objective to share such information broadly amongst its participants. In 2013, the ISOE Network website ([www.isoe-network.net](http://www.isoe-network.net)) continued to provide the ISOE membership with a comprehensive web-based information and experience exchange portal on dose reduction and ISOE ALARA resources.

The annual ISOE ALARA Symposia on occupational exposure management at nuclear power plants continued to provide an important forum for ISOE participants and for vendors to exchange practical information and experience on occupational exposure issues. The technical centres continued to host international / regional symposia, which in 2013 included the ISOE International symposium in Tokyo, Japan, organised by the Asian Technical Centre, North American regional symposium in Fort Lauderdale, USA, organized by the North American Technical Centre. Regional and international symposia provide a global forum to promote the exchange of ideas and management approaches for maintaining occupational radiation exposures as low as reasonably achievable.

## PRINCIPAL EVENTS IN PARTICIPATING COUNTRIES

### ARMENIA

#### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
VVER	1	730
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·Sv/unit]
VVER	1	<i>No separate data is available</i>

#### 2) Principal events

##### Summary of national dosimetric trends

For the year of 2013, the dosimetric trends at the Armenian NPP have not essential changed and were mainly contributed with works in controlled area, such as works with spent fuel removal and transportation, works with activated in reactor equipment, nondestructive testing of pipes and other control works during the outage, decontamination works and the works with radioactive wastes. The maximum individual dose was recorded as 15.0 mSv.

The collective dose for outside workers was recorded as 0.035 man·Sv, which is quite low. The reason is that the operators perform their repair workers with the utility stuff. The collective dose for repair and outage was planned in terms of dose constraints and the real doses constituted at 86 % of planned doses.

- *Events influencing dosimetric trends*

No significant events were registered for the impact on dosimetric trends.

- *Number and duration of outages*

For the 2013, one outage (full refuelling) with 83 days was performed.

- *New plants on line/plants shut down*

The new plant construction and siting considerations are currently on-going, however the new safety improvement approaches in relation to Fukushima Daiichi NPP accident were considered on plant design with regulatory requirements and site evaluation. The new regulations on site and design requirement were approved by the Government of Armenia.



- *Major evolutions*

The “Dose reduction program including ALARA culture implementation” for 2013 was established, improvement of old radiation control system was completed. The new radiation control pass system has been put in operation.

- *Component or system replacements*

During the outage in 2013, no components or systems were replaced.

- *Safety-related issues*

Some safety related issues are still existed due to medium activity radioactive waste treatment and storage activities. The concept (policy) on radioactive waste management in Armenia has already been approved by the Government of Armenia and the drafting of National Strategy has been started and will be completed with the EU assistance program at the end of 2015.

- *Unexpected events*

For the year 2013, unexpected events were not registered.

- *New/experimental dose-reduction programmes*

No new/experimental dose-reduction programmes were applied for the year 2013.

- *Organisational evolutions*

The dose planning and the dose constraint approach for the reduction of individual doses of staff is remaining the main tool for the ALARA implementation.

For 2014

- *Issues of concern*

The modification of some safety systems are implemented due to life extension program implementation.

- *Technical plans for major work*

Modernization of Radiation Control System for airborne and liquid releases, modernization and safety improvement measures of some safety system.

- *Regulatory plans for major work*

Review of Inspections procedures and special works related new Check list preparation for inspections at Armenian NPPs to control compliance with license conditions and regulatory requirements and follow -up actions.

Review of the safety assessment report (SAR) in terms of radiation protection and safety of radioactive waste management, submitted by Armenian NPP in their yearly reports and preparation of follow up actions.



## BELGIUM

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	7	200.4

### 2) Principal events

- *Events influencing dosimetric trends*

There were extended outage durations due to the discovery of indications in the Doel 3 and Tihange 2 vessels. Only one normal revision for Doel 1 was performed during the annual period. Concrete conditioning of the radioactive waste at Doel was stopped, after the discovery of an unexpected alkali-silicate reaction.

- *New/experimental dose-reduction programmes*

It is too early to identify the dosimetric impact of Zinc injection in the primary circuit of Doel 3, taking into account the extended shutdown.

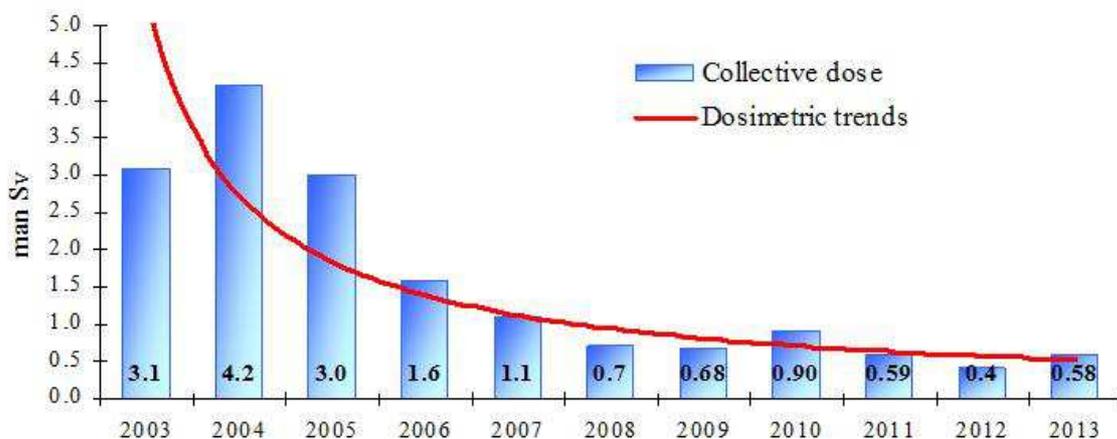
## BULGARIA

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
VVER-1000	2	228.0
REACTORS IN COLD SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
VVER-440	4	3.3

### 2) Principal events

#### Summary of national dosimetric trends



#### Number and duration of outages

Unit No.	Outage duration - days	Outage information
Unit 5	39 d	Refuelling and maintenance activities
Unit 6	37 d	Refuelling and maintenance activities

#### Technical plans for major work

Refuelling and maintenance at unit 5 and 6

## CANADA

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PHWR	19	850
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PHWR	3	17

#### Summary of national dosimetric trends

- 16.12 man·Sv for 19 operating units in 2013
- Average annual dose per unit 0.85 man·Sv in 2013

The total collective effective doses and the average collective dose per unit at operating Canadian nuclear plants decreased significantly in 2013 compared to previous years. The reduction in occupational dose is due to completion of reactor refurbishment activities at Pt. Lepreau and Bruce Power Units 1, 2 in 2012 and also extensive outage work in some other CANDU units in 2012.

In 2013, outage dose accounted for approximately 87 % of the total collective dose. The implementation of several ALARA initiatives at Canadian nuclear plant played a role in the reduction of annual occupational dose.

The average calculated dose for 2013 includes nineteen (19) units. The Dose associated with activities performed at two units in safe storage (Pickering Units 2 and 3) is negligible and therefore not included in the calculated average. Gentilly-2 transitioned from an operational site to safe storage in 2013.

The implementation of the radiation protection at Canadian Nuclear Power Plants (NPPs) met applicable regulatory requirements and doses to workers are maintained below regulatory dose limits. No reported individual dose above 15 mSv in 2013.

Distribution of annual effective doses to workers at Canadian NPPs showed that approximately 85 percent of the workers received an annual effective dose below 1 mSv.

### 2) Principal Events

#### **Bruce Power**

In 2013, all four units were operational at Bruce A. After refurbishment, Unit 1 returned to service on September 19, 2012 and Unit 2 returned to service on October 16, 2012.

Bruce A, Units 1-4 routine operations dose for 2013 was 0.334 man·Sv and the maintenance outage dose was 0.954 man·Sv (one planned outage and forced outages). The internal dose for Bruce A Units 1-4 was



0.073 man·Sv and the external dose was 1.215 man·Sv. The total collective dose for Bruce A Units 1-4 was 1.288 man·Sv which resulted in an average collective dose 0.334 man·Sv /unit.

Bruce B Units 5-8 routine operations dose was 0.525 man·Sv. The outage dose was 5.138 man·Sv in 2013. The internal dose was 0.323 man·Sv. The external dose was 5.340 man·Sv. The total dose was 5.663 man·Sv which resulted in an average collective dose 1.416 man·Sv /unit. Bruce B had increased number of planned outages (three planned outage in 2013) in comparison with one outage in 2012.

#### **Darlington Units 1-4**

In 2013, all four units were operational at Darlington. Darlington Units 1-4 had routine operations dose of 0.382 man·Sv. The Darlington site had two planned outages (Units 2 & 4) in 2013. The outage dose was 4.067 man·Sv. The routine operation dose was 0.382 man·Sv. The internal dose for 2013 was 0.576 man·Sv. The external dose was 3.873 man·Sv. The total collective dose was 4.449 man·Sv which resulted in an average collective dose 1.112 man·Sv /unit. Darlington site experienced an increase in annual collective dose compared to 2012 due to an increase in the number of planned and forced outages with major scope.

#### **Pickering Nuclear**

In 2013, Pickering A Units 1 and 4, and Units 5-8 were operational, while Units 2 and 3 remained in safe storage state. The routine collective dose for operational units was 0.682 man·Sv in 2013. The outage dose for the operational units was 3.764 man·Sv (accounted for approximately 84% of the total station dose). The internal dose was 0.696 man·Sv. The external dose was 3.750 man·Sv. The total dose was 4.446 man·Sv which resulted in an average of collective dose 0.741 man·Sv /unit.

The dose associated with radiological activities performed at Pickering Units 2 and 3 (in safe storage since 2010) is negligible when compared to collective dose of the operational units. Therefore, this dose is not reported separately but instead included under operational Pickering Units.

#### **Point Lepreau**

Point Lepreau is a single unit CANDU station. In 2013 Point Lepreau was fully operation. The unit was returned to service from extended refurbishment activities in the spring of 2012. The routine collective dose for operational activities was 0.178 man·Sv in 2013. The forced outage dose was 0.047 man·Sv (accounted for approximately 21% of the total station dose). The internal dose was 0.033 man·Sv. The external dose was 0.192 man·Sv. The total dose was 0.225 man·Sv. The reduction in the collective dose is attributed to the reduction in the source term due to the installation of new plant components.

3) Component or system replacements, Unexpected events/incidents, New reactors on line, Reactors definitively shutdown...)

#### **Gentilly-2**

Gentilly-2 is a single unit CANDU station. In 2013, Gentilly-2 transitioned from operation to safe storage state. The reactor was shut down in December 28, 2012. The station collective dose is only attributed to safe storage transition activities. The internal collective dose in 2013 was 0.015 man·Sv. The external dose was 0.037 man·Sv. The total site collective dose in 2013 was 0.052 man·Sv. The reduction in the collective dose is attributed to the cessation of normal operations.



### **Summary**

After over four years of extensive plant refurbishment activities at Point Lepreau and Bruce A 1, 2, the Canadian nuclear fleet achieved significant dividends in occupational dose. In fact, the 2013 Canadian average collective dose for the Canadian fleet was 0.85 man·Sv, nearly achieving the CANDU WANO dose target of 0.80 man·Sv. The refurbishment activities executed in 3 of the 19 operational is already showing benefits by providing excellent dose reduction in the units where new plant components were installed.

Not only total unit annual dose for 2013 was reduced significantly but internal average collective dose was also reduced (approximately 11% of the total dose with: tritium as the main contributor).

## CHINA

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	11	659.61
VVER	2	233.35
PHWR	2	315.00
All types	15	556.83

### 2) Principal events

- *Events influencing dosimetric trends*

In 2013, there were no INES 2 or above events in any operational nuclear power plant. The monitoring index over the year showed that the integrity of three safety barriers was sound. Post-Fukushima improvement actions and regulatory requirements imposed by the Chinese NNSA have been implemented smoothly in operational nuclear power plants.

- In operational nuclear power plants, the dose information in the table above is summarized only for 15 reactors operating before the end of 2012. In those reactors, refuelling outages were completed for 10 of 11 PWR units, 1 of 2 PHWR units, and 2 of 2 VVER units in 2013.
- Five new PWR units began to operate in 2013.

- *New/experimental dose-reduction programmes*

- An ALARA programme is well implemented in the design and operation of all nuclear power plants. Particularly, in the operation of nuclear power plants, annual collective dose is mainly from refuelling outages. So, it is very essential to effectively control workforce and work time in the outage workplace, and to optimize the outage work plan and procedures.

- *Regulatory requirements*

After the Fukushima accident, some new safety requirements for nuclear power plants have been imposed by the Chinese NNSA. "General technical requirements of improvement actions for nuclear power plants after the Fukushima accident (Probationary)" was issued and began to be implemented in June 2012. "New regulation requirements for the safety of nuclear power plants during National Twelfth Five-Year Plan period" is planned to be issued in 2014. That is to be applied to siting, design and construction, and review and supervision of new nuclear power plants.

## CZECH REPUBLIC

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
VVER	6	125
All types	6	125

### 2) Principal events

- *Events influencing dosimetric trends*

The main contributions to the collective dose were 6 planned outages.

NPP, Unit	Outage information	CED [man.mSv]
Temelin, Unit 1	60 days, standard maintenance outage with refuelling	61
Temelin, Unit 2	52 days, standard maintenance outage with refuelling	65
Dukovany, Unit 1	26 days, standard maintenance outage with refuelling	108
Dukovany, Unit 2	33 days, standard maintenance outage with refuelling	109
Dukovany, Unit 3	44 days, standard maintenance outage with refuelling	141
Dukovany, Unit 4	31 days, standard maintenance outage with refuelling	168

The collective effective dose (CED) increased slightly in comparison with the previous year mainly due to extended work load during the outage of Unit 4 at Dukovany NPP. The repair work on heterogeneous weld of SG during the outage at Unit 2 also contributed to the increase.

CED stayed nearly at the same level at Temelin NPP.

There were no unusual or extraordinary radiation events in the year 2013 at Temelin NPP or Dukovany NPP.

Very low values of outage and total effective doses represent results of good primary chemistry water regime, well organised radiation protection structure and strict implementation of ALARA principles during the work activities with high radiation risk. All CED values are based on electronic personal dosimeter readings.

- *New/experimental dose-reduction programmes*

There were no new/experimental dose reduction programmes.

- *Organisational evolutions*

Two working groups (WG) were established by the RP department managers:

- o Personal Contamination Events reduction WG, which aims for overall improvement of personnel perception of PCEs and ultimate reduction of PCE numbers
- o Radiation Work Permit WG which is focused on revision of the RWP system, RCA areas classification and EPD alarm settings



- *Regulatory requirements*

Post-Fukushima National Action Plan is implemented progressively at Temelin and Dukovany NPPs.

3) Report from Authority

The State Office for Nuclear Safety (SUJB) carried out 51 inspections of radiation protection at NPPs and contractors in 2013. No serious shortcomings were identified.

The SUJB has started with the evaluation of the implementation of measures set out in the Post-Fukushima National Action Plan. SUJB was provided, among others, with preliminary analyses of the habitability of both main and emergency control rooms of both NPPs during a severe accident. The full analysis should be completed in 2014.

In 2013, the SUJB was reviewed by IAEA's Integrated Regulatory Review Service (IRRS) with the outcome of 11 good practices, 17 suggestions and 20 recommendations.

A new Atomic Act and its implementing regulations are being prepared. The interdepartmental review procedure was initiated in 2013, and the process continues in 2014.

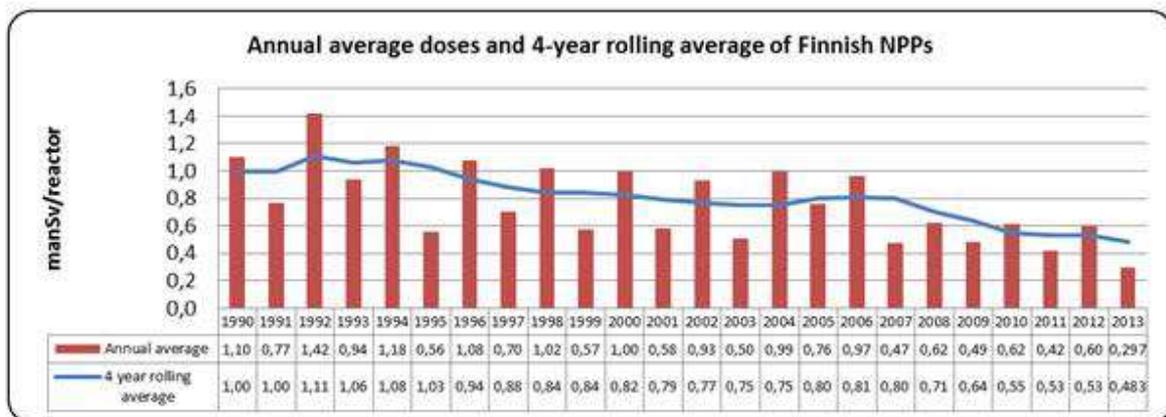
## FINLAND

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
VVER	2	270.5
BWR	2	324.5
All types	4	297.5

### Summary of national dosimetric trends

The annual collective dose strongly depends on the length and type of annual outages. The 2013 collective dose (1.19 man.Sv) of Finnish NPPs was the lowest in the operating history, mainly due to short refuelling outages at three of four reactors. In the long run the 4-year-rolling average of collective doses shows a slightly decreasing trend since the early 1990's.



### 2) Principal events

#### **Olkiluoto**

The annual outage of 2013 at Olkiluoto 1 was a short 8-day refuelling outage. In addition to refuelling it included periodic inspections and annual maintenance activities, leak rate tests of isolation valves and replacement of two main seawater pumps. The collective outage dose 0.091 man·Sv was the lowest outage dose ever of a plant unit in Olkiluoto.

The maintenance outage at Olkiluoto 2 took about 18 days including refuelling, replacement of the low voltage switchgears in two subsystems, repair of the generator stator, leak tightness test of the containment and replacement of two main seawater pumps. The replacement of the switchgears is a part of the systematic long-term development of the plant units. The collective dose was 0.466 man·Sv. Just three weeks before the outage a fuel leak was detected at Olkiluoto 2.

On both units a Risk-Informed In-Service Inspection (RI-ISI) approach has been implemented on ASME piping inspection programs. The RI-ISI program is expected to reduce dose in future years.



## Loviisa

On both units the 2013 outages were short refuelling outages with durations of 19 and 16 days respectively. Outage collective doses were the lowest in plant operating history; 0.296 and 0.180 man-Sv respectively. Main contributors to collective dose accumulation were reactor related tasks (disassembly, assembly), cleaning/decontamination and auxiliary work such as radiation protection, insulation and scaffolding. During the Lo1 outage a significant operating event was noticed as some lead blankets used as radiation shielding during the outage of 2012 were found inside the reactor's thermal shield. The lead blankets were exposed to intense heat during the operating period and thus the material was partially melted on the primary piping. Cleaning and inspections caused an unplanned exposure of some 0.04 man-Sv to the working group.

Source term reduction: After 5 years of studies, testing and approval, antimony-free mechanical sealing was installed in one of Loviisa 1's six primary coolant pumps in 2012. During the 2013 outage this sealing was inspected and approved. Followed by approval, six additional antimony-free sealing were installed on units 1 and 2. The aim is to replace all five remaining antimony-containing sealing during the 2014 outage. Currently radioactive antimony causes about 50% of doses at both units and after the sealing replacement the dose rates of primary components are expected to decrease by nearly 50% during the following three years as the amount of antimony decreases in the primary coolant.

### 3) Report from Authority

The renewal process of regulatory guides is completed and the implementation of new requirements will start in 2014.

The implementation process of the new BSS directive has also started, and it will still require some updating of the current legislation.

The power companies of operating plants are planning modernisations as well as safety improvements, some of which are originating from lessons learned from the Fukushima Dai-ichi accident. A periodic safety review will be carried out at Loviisa NPP by the end of 2015.

Olkiluoto 3 is under construction and it is nearing the commissioning and operating license phase. At least one new unit is planned to enter the construction license phase by mid-2015.

In other sectors of the nuclear cycle there are activities. One research reactor will be decommissioned and the final repository for spent fuel is currently in the construction license phase.

## FRANCE

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	58	790
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	1	189
GCR	6	49
HWGCR	1	16
SFR	1	2

### Collective dose

For 2013, the average collective dose of the French nuclear fleet (58 PWR) is 0.79 man·Sv /unit (2013 annual EDF objective: 0.74 man·Sv /unit). The average collective dose for the 900 MWe 3-loop reactors (900 MWe – 34 reactors) is 1.05 man·Sv /unit and the average collective dose for the 4-loop reactors (1300 MWe and 1450 MWe – 24 reactors) is 0.43 man·Sv /unit.

#### Type and number of outages

Type	Number
ASR – short outage	22
VP – standard outage	19
VD – ten-year outage	7
No outage	10
Forced outage	1

#### Specific activities

Type	Number
SGR	2
RVHR	0

The outage collective dose represents 84% of the total collective dose. The collective dose received when the reactor is operating represents 16% of the total collective dose. The collective dose due to neutron is 0.259 man·Sv; 77% of that dose (0.183 man·Sv) is due to spent fuel transport.

### Individual doses

In 2013, no worker received an individual dose higher than 16 mSv in 12 rolling months on the EDF fleet. 75% of the exposed workers received a cumulative dose lower than 1 mSv and 99% of the exposed workers received less than 10 mSv.

### 2) Principal events

The main 2013 events with a dosimetric impact are the following;

- RHRS Hydrostatic test:

This activity which is demanded by regulation on nuclear equipment under pressure has been prepared for the first time at Dampierre. The occupational exposure for this activity is relatively high.



- Control of braking on valves important in terms of safety:  
Compliance control of braking on air-operated and electrically-operated valves important in terms of safety have been realized on the fleet. Following these controls, many renewals have been conducted on these valves.
- Controls on 4-loop reactors sumps (P'4 and N4):  
Controls of the leak tightness of sumps stainless steel liner have been performed on some of the 4-loop reactors. In order to realize these controls, sumps have to be emptied and washed.
- Maintenance issues on replacement of control rod drive mechanism:  
Some issues were encountered concerning welding on CRDM replacements at Dampierre and Gravelines.

### 3-loop reactors – 900 MWe

In 2013, Bugey 4 had no outage. Fessenheim 2 had a forced outage with an occupational dose of 39.9 man.mSv.

The 3-loop reactors outage program was composed of 13 short outages, 13 standard outages, and 6 ten-year outages. 2 Steam Generator Replacements were performed. 1 outage of the 2012 program ended in 2013 (standard outage and steam generator replacement at Chinon B2 for 0.950 man·Sv). Moreover 2 outages of the 2013 program ended in 2014: the 3rd ten-year outage with SGR at Blayais 2 (collective dose in 2013: 0.950 man·Sv) and the 3rd ten-year outage at Dampierre 3 (collective dose in 2013: 0 man·Sv).

The lowest collective doses for the various outage types and specific activities were:

- Short outage: 0.169 man·Sv at Chinon B4,
- Standard outage: 0.524 man·Sv at Chinon B3,
- Ten-year outage: 1.405 man·Sv at Chinon B1,
- SGR: 0.481 man·Sv at Blayais 2.

### 4-loop reactors – 1 300 MWe and 1 450 MWe

In 2013, 8 units had no outage.

The 4-loop reactors outage program was composed of 9 short outages, 6 standard outages, and 1 ten-year outage. 1 outage of the 2012 program ended in 2013 (standard outage at Nogent 2 for 0.166 man·Sv). Moreover 2 outages of the 2013 program ended in 2014: a short outage at Civaux 2 (collective dose in 2013: 0.04 man·Sv) and a standard outage at Cattenom 3 (collective dose in 2013: 0.05 man·Sv).

The lowest collective doses for the various outage types were:

- Short outage: 0.196 man·Sv at Chooz B2,
- Standard outage: 0.627 man·Sv at Belleville 2,
- Ten-year outage: 1.274 man·Sv at Cattenom 4,

### **Main radiation protection significant events (ESR)**

In 2013, 4 ESR have been classified at the INES scale (3 at level 1 and 1 at level 2).

- Belleville NPP (rated level 1 at the INES scale)  
1 ESR on unit 1: skin dose to a worker higher than one quarter of the regulatory dose limit during maintenance activity
- Cruas NPP (rated level 1 at the INES scale)



1 ESR on unit 3: a diver received a significant dose (about one quarter of the regularity dose limit) due to inappropriate move in order to avoid being under a moving charge

- Cruas NPP (rated level 1 at the INES scale)

1 ESR on unit 4: subcutaneous contamination of a worker, leading after one year with the model used by doctors to an annual dose of 50% of the annual limit to extremities.

- Blayais NPP (rated level 2 at the INES scale)

1 ESR on unit 4: body contamination of a worker occurring during brushing on RHRS filters.

### **Other events in 2013**

#### **Concerning radiographic inspection**

- Gravelines

1 ESR on unit 1: Presence of two workers in the area of radiographic inspection whereas the exposure was authorized and the source was not ejected.

- Flamanville

1 ESR on unit 2: Intervention of a worker in a radiographic inspection area with a permit covering another area of radiographic inspection.

- Saint Alban

1 ESR on unit 2: No respect of the organization of radiographic inspection process.

- Blayais

1 ESR on unit 2: Anticipation of a radiographic inspection without prior agreement.

#### **Concerning red zone**

- Gravelines

1 ESR on unit 2: Absence of double condemnation and regulatory signalization on red zone access to the reactor cavity.

### **2014 goals**

For 2014, the collective dose objective for the French nuclear fleet is set at 0.82 man.Sv/unit.

For the individual dose, one of the objectives is to reduce the individual dose of the most exposed workers by 10% over 3 years. The other objectives are the following related to dose over 12 rolling months:

- 0 worker with a dose > 18 mSv,
- Less than 20 workers with a dose > 14 mSv,
- Less than 370 workers with a dose > 10 mSv.

### **Future activities in 2014**

Collective dose: continuation of the activities initiated in 2012 and 2013.

- Implementation of the actions plan on radiography inspection
- Source term management (oxygenation and purification during shutdown, management and removal of hotspots)
- Decontamination of the most polluted circuits
- Optimization of biologic shielding (CADOR)
- Organizational preparation of the RMS, deployment of the fleet planned from 2016 to 2018.

### **3) Report from Authority**

In 2013, ASN conducted, as in 2012, an in-depth inspection of two sites of the same area (Fessenheim and Cattenom) regarding radiation protection and radiological cleanliness. This inspection gave the



opportunity to observe discrepancies in implementation of the radiation protection requirements on these sites.

Some events related to radiation protection of personnel should be mentioned:

- contamination on a worker at Blayais NPP (estimated dose received by the worker on his neck above the regulatory limit for the skin which is 500 mSv per cm<sup>2</sup> of skin ; event rated at level 2 on the INES scale);
- overexposure of a diver in the spent fuel pool of the Cruas NPP (dose higher than one quarter of the annual regulatory limit ; event rated at level 1 on the INES scale);
- contamination on a worker at Belleville NPP (estimated dose received by the worker on his head higher than one quarter of the annual regulatory limit for the skin ; event rated at level 1 on the INES scale);
- contamination on a worker on Cruas NPP following a finger injury (estimated dose received by the worker on his hand higher than one quarter of the annual regulatory limit for “extremities”; event rated at level 1 on the INES scale).

ASN proceeded to inspections to ensure that all the necessary measures had been taken following these events.

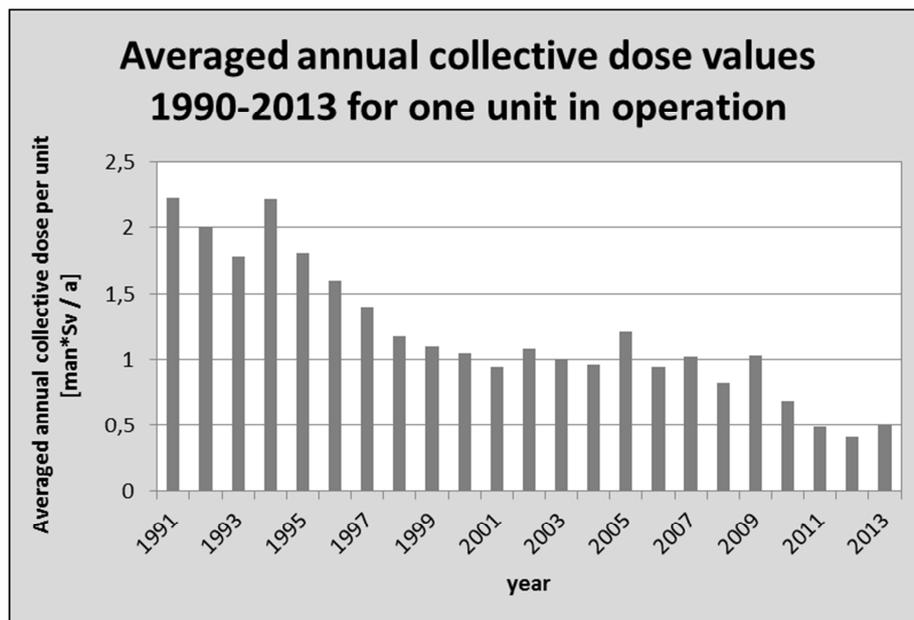
Finally, since EDF confirmed the likely rise of individual and collective exposures due to the increase of the volume of maintenance work in the coming years, ASN has requested the Advisory Committee for reactors to issue an opinion on the optimization principle implemented by EDF (mid 2015).

## GERMANY

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	7	320
BWR	2	1090
All types	9	490
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	6	40
BWR	4	60
All types	10	50

### 2) Principal events



#### Summary of national dosimetric trends

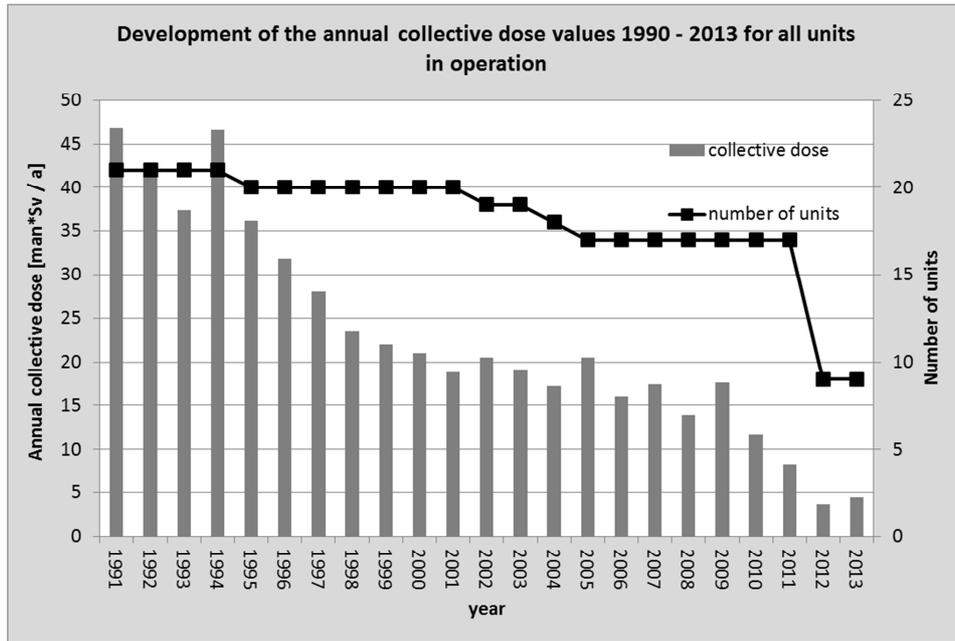
Due to the political decisions after the Fukushima accident in 2011 the eight nuclear power plants Unterweser, Biblis A, Biblis B, Neckarwestheim 1, Philippsburg 1, Krümmel, Brunsbüttel and Isar 1 are taken from the net in the middle of the year 2011.



In 2013 the average annual collective dose per unit in operation was 0.49 man·Sv and so comparable to the value of 0.41 man·Sv in the year 2012. The trend in the average annual collective dose from 1990 to 2013 is presented in the figure below.

Because some of the plants are already preparing for the decommissioning, a lot of work (for example a full system decontamination etc.) has already been done and so the average annual collective dose is a little higher than in the year before.

For the decommissioning plants, the value of the average annual collective dose is with 0.05 man·Sv even lower.



## HUNGARY

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
VVER	4	632 (with electronic dosimeters;); 558 (with TLDs)

### 2) Principal events

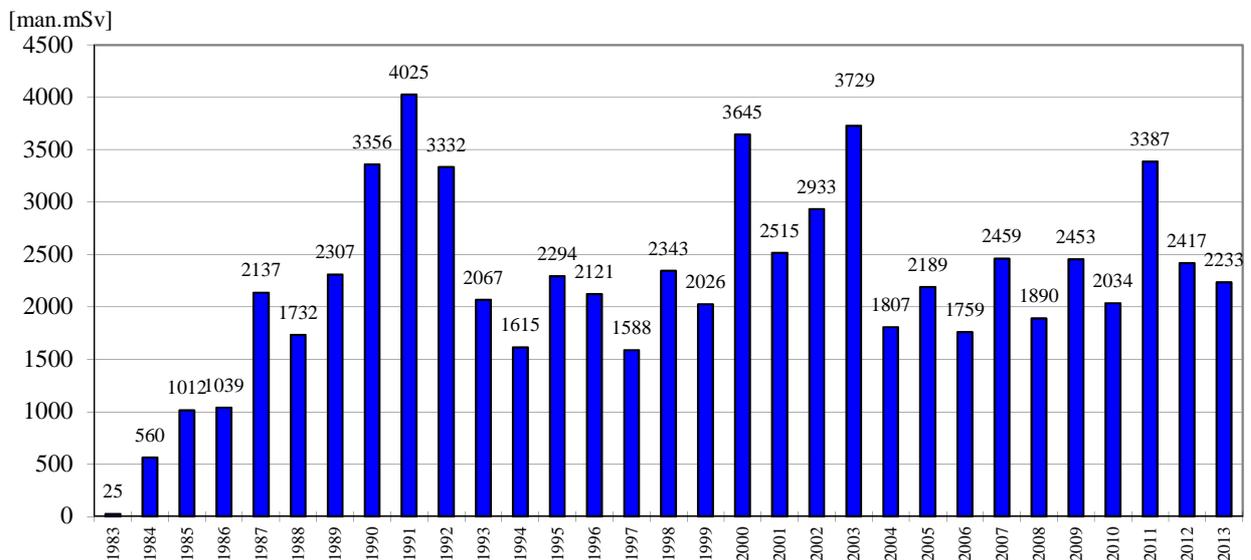
#### Summary of national dosimetric trends

Using the result of operational dosimetry, the collective radiation exposure was 2526 man.mSv for 2013 at Paks NPP (1990 man.mSv with dosimetry work permit and 536 man.mSv without dosimetry work permit). The highest individual radiation exposure was 12.3 mSv, which was well below the dose limit of 50 mSv/year, and the dose constraint of 20 mSv/year.

The collective dose increased in comparison to the previous year. The higher collective exposures were mainly ascribed to the collective dose of investment activities being more in 2013 than in previous years.

The cause of the difference between electronic dosimeters and TLD data was the change in the TLD monitoring by the authorities.

#### Development of the annual collective dose values at Paks Nuclear Power Plant (using the results of the TLD monitoring by the authorities)



From 2000, this data shall be quoted as individual dose equivalent /Hp(10)/

#### - Events influencing dosimetric trends

There was one general overhaul (long maintenance outage) in 2013. This outage was 105 days long, to repair leakage in the spent fuel storage pool cooling system. The collective dose of the



outage was 1140 man·mSv on Unit 3 in 2013, but this outage lasted until 1/11/2014, and generated an additional 56 man·mSv collective dose of this outage in 2014. The significant part of the collective dose came from the activities of the lifetime extension, which resulted in 362 man·mSv collective dose.

- *Number and duration of outages*

The durations of outages were 31 days on Unit 1, 28 days on Unit 2, 105 days on Unit 3 and 27 days on Unit 4.



## ITALY

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	1	5.16 man.mSv (1 unit - Trino NPP)
BWR	2	34.24 man.mSv (1 unit Caorso NPP [14.29 man.mSv] and 1 unit Garigliano NPP [54.18 man.mSv])
GCR	1	2.23 man.mSv ( 1 unit – Latina NPP)

## JAPAN

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	24	229
BWR	24	203
All types	48	216
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
BWR	8	9,696
GCR	1	10
LWCHWR	1	134

### 2) Principal events

- *Outline of national dosimetric trend*

The average annual collective dose for shutdown BWRs increased from 41 man·mSv /unit of the previous year to 9,696 man·mSv /unit due to the inclusion of occupational dose of the Fukushima Daiichi NPP accident response. The average annual collective dose excluding Fukushima Daiichi NPP of this year was 64 man·mSv /unit, and that of Fukushima Daiichi NPP was 12,907 man·mSv /unit.

The average annual collective dose of operating reactors was almost the same level as the last year. This is because many nuclear reactors have stopped for a long time after the accident of Fukushima Daiichi NPP.

- *Operating status of nuclear power plants*

During fiscal year 2013, only two PWRs were operated.

From April 1 to September 1: 2 units (Ohi unit 3,4)

From September 2 to September 14: 1 unit (Ohi unit 4)

From September 15 to March 31, 2014: no unit operated

- *Exposure dose distribution of workers in Fukushima Daiichi NPP*

Exposure dose distributions at Fukushima Daiichi NPP for cumulative dose until March 2014 and for dose during FY2013 are shown below.

As of July 17, 2014

Classification (mSv)	Cumulative dose (March 2011 – March 2014)			Fiscal year 2013 (April 2013 – March 2014)		
	TEPCO	Contractor	Total	TEPCO	Contractor	Total
> 250	6	0	6	0	0	0
200 ~ 250	1	2	3	0	0	0
150 ~ 200	25	2	27	0	0	0
100 ~ 150	118	20	138	0	0	0
75 ~ 100	268	129	397	0	0	0
50 ~ 75	318	949	1,267	0	0	0
20 ~ 50	614	4,457	5,071	31	629	660
10 ~ 20	551	4,173	4,724	95	2,067	2,162
5 ~ 10	444	3,901	4,345	195	1,897	2,092
1 ~ 5	727	7,248	7,975	670	3,739	4,409
<1	1,066	8,245	9,311	702	4,721	5,423
<b>Total</b>	<b>4,138</b>	<b>29,126</b>	<b>33,264</b>	<b>1,693</b>	<b>13,053</b>	<b>14,746</b>
<b>Max. (mSv)</b>	<b>678.80</b>	<b>238.42</b>	<b>678.80</b>	<b>41.90</b>	<b>41.40</b>	<b>41.90</b>
<b>Ave. (mSv)</b>	<b>23.66</b>	<b>11.04</b>	<b>12.61</b>	<b>3.24</b>	<b>5.51</b>	<b>5.25</b>

- \* TEPCO use integrated value of APD data that was measured every time when enter into area. These data sometimes fluctuate due to replacing these data to monthly dose data measured by integral dosimeter.
- \* There has been no significant internal radiation exposure reported since October 2011.
- \* Internal exposure doses may be revised due to the reconfirmation.

- *Regulatory requirements*

The examination of the new safety standards began in July 2013, and still goes on. On September 10, 2014, the NRA granted permission to make changes to the reactor installation of Sendai NPS Units 1 and 2, Kyushu Electric Power Company. After this step, the NRA will review the detailed design and construction of the nuclear reactors and related facilities as well as Operational Safety Programs including organization systems and procedures for nuclear accident response.

## LITHUANIA

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
LWGR	2	327.34

### 2) Principal events

#### - *Events influencing dosimetric trends*

In 2013, the occupational doses at the Ignalina NPP (INPP) were maintained as low as possible, taking into account all economic and social conditions: 933 man·mSv in 2009, 521 man·mSv in 2010, 631 man·mSv in 2011, 587 man·mSv in 2012 and 655 man·mSv (54% of planned dose) in 2013. The collective dose for INPP personnel was 607.4 man·mSv (59% of planned dose) and for outside workers was 47.3 man·mSv (26% of planned dose). The external dosimetry system used was Thermoluminescence dosimeters (TLD).

The 20 mSv individual dose limit was not exceeded. The average annual individual effective dose for INPP staff was 0.38 mSv, and for outside workers was 0.06 mSv. The highest annual individual effective dose for INPP staff was 12.20 mSv, and for outside workers it was 10.25 mSv.

The main work that contributed to the collective dose during the technical service and decommissioning of Units 1 and 2 at the INPP were fuel handling; in-service inspection of DN300 pipeline, repairing of the hot cell, maintenance work at the spent fuel storage pool hall, reactor hall and reactor auxiliary buildings; waste and liquid waste handling; and the radiological monitoring of workplaces.

In 2013 there were no component or system replacements, nor were there any unexpected events.

#### - *New/experimental dose-reduction programmes*

The doses were reduced by employing new principles of organization of work, by doing extensive work on modernization of plant equipment, and by using automated systems and implementing programs for introduction of the ALARA principle in practice during work activities.

#### - *Organisational evolutions*

The year 2013 was significant for Ignalina Nuclear Power Plant; much essential work for safe and world-unique project implementation was performed. Over the year, progress in decommissioning project implementation was reached, dismantling work was ongoing and the Buffer Storage Facility B19/1 was placed into operation. The progress in key INPP decommissioning projects shall be highlighted as well: Project B1 (Interim Spent Fuel Storage Facility) funding was renewed, significant progress in resolving of problematic issues related to spent fuel storage casks and other B1 components was reached, and the Project B2/3/4 (Solid Radioactive Waste Management and Storage Facility) Contract Amendment was signed. Transition to the project management process was commenced in 2013. The aim of the



transition is to optimize project management, seeking that planning of activities would help to complete the strategic projects efficiently.

INPP implements its world-unique decommissioning project using in-house staff experience, recognizing that challenges and tasks having no analogue in the world practice are faced constantly. Our goal is not just to shut down the INPP safely, efficiently and effectively, but to gain the experience that will help to be competitive at the international level and to facilitate the staff's taking part in other international nuclear facilities decommissioning projects as well.

### 3) Report from the Authority

In 2013 VATESI carried out radiation protection inspections at Ignalina NPP in accordance with an approved inspection plan. It was assessed how radiation protection requirements are fulfilled in the following areas and activities: operation of Very Low Level Radioactive Waste Storage Facility (Project B19-1), monitoring of individual occupational exposure and workplaces, dismantling and decontamination of equipment, implementation of measures prescribed in the programme of optimisation of radiation protection (ALARA).

Inspections results showed that Ignalina NPP activities were carried out in accordance with the established radiation protection requirements. During the inspection of implementation of the ALARA programme, areas for improvement were identified, and recommendations regarding review of the corresponding Ignalina NPP procedures were provided. The corrective measures were implemented in due time.

In 2014 VATESI will continue supervision and control of nuclear safety during the decommissioning of INPP, management of radioactive waste, including the construction and operation of new nuclear facilities, as well as the radiation protection of these activities and facilities. To enhance radiation protection during decommissioning of the INPP, review of the legal documents related to radiation protection is foreseen in 2014-2015.



## MEXICO

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
BWR	2	575

### 2) Principal events

#### Summary of national dosimetric trends

The nuclear reactors existing in Mexico are two BWR/GE units at the Laguna Verde Nuclear Power Station located in Laguna Verde, State of Veracruz, Mexico.

Laguna Verde's historical collective dose both on line and during refuelling outages is higher than the BWRs average. On line collective dose is high because of failures in equipment reliability - some examples are steam leakage, reactor water clean-up system pump failures, radioactive waste treatment systems failures. Refuelling outage collective dose is high mainly because the radioactive source term ( $^{60}\text{Co}$ ), that causes high radiation fields in-plant.

The collective dose in 2013 was relatively low, mostly because there was a LV Vice President's strong commitment to keep collective dose ALARA.

2013 collective dose was the lowest for on line (normal operation) - for unit 1 it was 0.59175 man.Sv and for unit 2, 0.5585 man.Sv. Despite this achievement, site personnel recognize routine operational dose is high when compared with those from other BWRs.

#### - Events influencing dosimetric trends

##### a) Increase of radioactive source term:

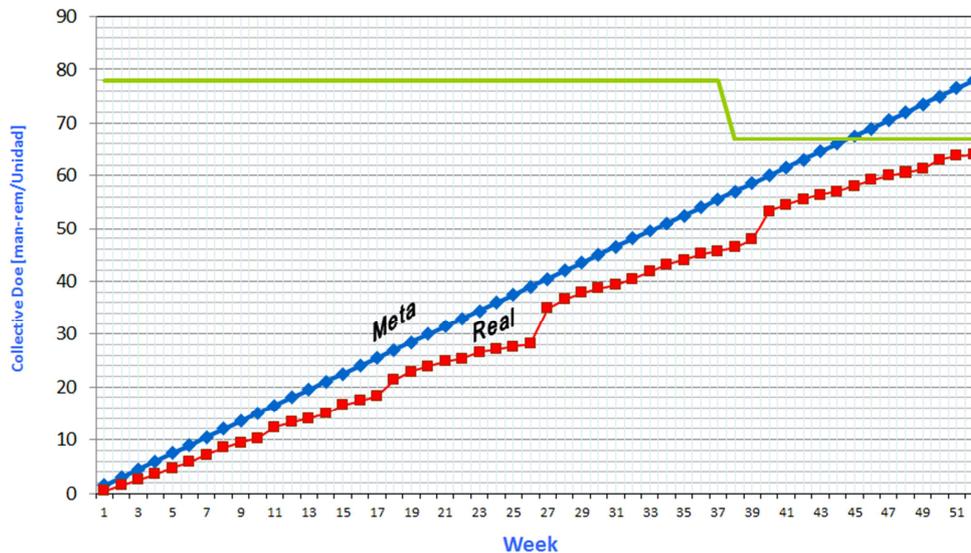
This factor was originated by the reactor water chemical instability induced in turn by the application of noble metals and hydrogen since 2006 to prevent the stress corrosion cracking of reactor internals. This factor is still strongly influencing dose rates at the plant and specifically in the drywell during refuelling outages.

Since 2011 LV's Chemistry Manager took the responsibility for hydrogen injection, iron control in feed water and any other condition that can result in a chemical instability inside the reactor vessel. That year Laguna Verde's new VP assigned a Source Term Control and Reduction Project Manager (STPM), supported by the Radiological Protection Manager (RPM) and the Chemistry Manager (CM).

In January 2012, in a WANO Technical Support Mission, Laguna Verde's Source Term Control Team went to Atlanta, and is developing a program focused on reducing the quantity of soluble and insoluble cobalt moving in the primary systems.

Additionally, a weekly average collective dose goal for both units has been established. The trend of this behaviour is shown in the graph

**Laguna Verde Collective Dose 2013**  
**Average DLD**  
**Goal 78 man-rem**  
**Challenge (2013.sept.18): 67 man-rem**



**Number and duration of outages**

- From July 2<sup>nd</sup> to July 5<sup>th</sup> a forced outage in Unit 2 was necessary to repair piping leakage inside the drywell. Collective dose was 0.09685 man.Sv.
- From October 1<sup>st</sup> to October 5<sup>th</sup> a forced outage in Unit 2 was necessary to repair similar piping leakage inside the drywell. Collective dose was 0.1023 man.Sv.

**New/experimental dose-reduction programmes**

The main problem associated with the high collective dose at Laguna Verde NPS is the continued increase of the radioactive source term (insoluble Cobalt deposited in internal surfaces of piping, valves and equipment in contact with the reactor water coolant).

Control and optimisation of reactor water chemistry plays a fundamental role in the control and eventual retraction of the source term. The main strategies / actions aiming such purpose are:

- On Line Noble Metal Chemistry (OLNC), 3rd application.
- Cobalt selective removal resins, continuous application to reactor water.
- Continued application of Zinc to the reactor water.
- Iron concentration control in feed water control
- Reactor Water Cleanup System (RWCU) continuous operation.
- Fuel Pool Cooling and Cleanup System (FPCC) hydrolysing.
- Optimisation of continuity and availability of Hydrogen injection to the reactor.
- CRUD pumps with high flow (600 gpm) during the outages (2014)
- Portable demineralizer during the outages (2014)
- RWCU system modifications to improve efficiency



- Chemical decontamination of recirculation loops during refuelling outages: to be applied until all of the other reactor water chemistry parameters become stabilized and optimised, in order to avoid a recontamination next cycle after the decontamination (estimated year 2015).

#### **For 2014**

#### **Issues of concern in 2014**

Two refuelling outages: 16 RFO Unit 1 and 13 RFO Unit 2.

#### **Technical plans for major work in 2014**

Work on the mentioned strategies for the radioactive source term reduction.



## THE NETHERLANDS

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	1	830
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	1	0

### 2) Principal events

In 2013, two outages took place (one unplanned) with significantly more work in execution and a higher collective dose than for the previous year.

## REPUBLIC OF KOREA

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	19	534.76
PHWR	4	490.31
All types	23	527.03

### 2) Principal events

#### Summary of national dosimetric trends

For the year 2013, 23 NPPs were in operation, including 19 PWR units and 4 PHWR units. The average collective dose per unit for the year 2013 was 527.03 man·mSv. The dominant contributors of the collective dose were the works carried out during the outages, resulting in 85.2% of the total collective dose. 14,786 people were engaged in radiation works in 23 operating units and the total collective dose was 12,122 man·mSv.

#### - *Number and duration of outages*

Overhauls were performed at 15 PWRs and 3 PHWRs. The total duration for the outages was 1,764 days for PWRs and 141 days for PHWRs. Total outage duration was lengthened compared to previous years due to the component replacements and unexpected events.

#### - *Component replacements*

- Two steam generators were replaced at Hanul unit 4 in 2013 during the outage, resulting in 180 man·mSv of total collective dose.
- Kori unit 1 replaced Reactor Vessel Head (RVH), resulting in 120 man·mSv of total collective dose. The new pipe of RVH was made of Alloy 690 which is stronger against PWSCC.

#### - *Unexpected events/incidents*

- Hanul unit 3 and 4 started their outages in 2011. Flaws on steam generator U tubes caused by PWSCC were founded during ECT. KHNP decided to replace the steam generators, so Hanul unit 4 had to be shut down over the whole year of 2012 until the new steam generators were replaced in 2013, while Hanul unit 3 finished its outage and started re-operation after plugging. Steam generators of Hanul unit 3 are also scheduled to be replaced in 2014.
- Indications of flaws were founded on 6 CEDM penetration tubes of reactor head while conducting non-destructive test at Hanbit unit 3 during its 14th outage from 18 October 2012. Hanbit unit 3 repaired the damaged CEDM penetration tubes and conducted non-destructive test in 2013. Also, Korean Utility inspected the integrity of CEDM penetration tubes for several units, which caused unexpected exposure.



- *New reactors on line*

None of new reactors were on line in 2013.

- *New dose-reduction programmes*

A trial application of zinc injection to reduce source term has been applied in Hanul unit 1 from 2010 and as a result of this attempt, there was 32% decrease of radiation exposure rate at RCS pipe and steam generator chambers. So KHNP is planning to extend zinc injection to other reactors. Zinc injection will be applied at Kori unit 3, Kori unit 4 and Hanbit unit 4 from 2015.

## ROMANIA

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
CANDU	2	255

### 2) Principal events

#### Summary of national dosimetric trends

Occupational exposure at Cernavoda NPP (200-2013)			
Year	Internal effective dose [man·mSv]	External effective dose [man·mSv]	Total effective dose [man·mSv]
2000	110.81	355.39	466.2
2001	141.42	433.44	574.86
2002	206.43	344.04	550.48
2003	298.02	520.27	818.28
2004	398.26	258.45	656.71
2005	389.3	342.29	731.59
2006	302.27	258.79	561.06
2007	83.34	187.49	270.83
2008 (2 units)	209.3	479.34	688.6
2009 (2 units)	67.6	417.7	485.3
2010 (2 units)	210.3	577	787.3
2011 (2 units)	56.0	337	393
2012 (2 units)	250.8	667.1	917.9
2013 (2 units)	92.3	416.8	509.1

#### - Events influencing dosimetric trends

Normal operations of the plant (U1 & U2)

At the end of 2013:

- there were 132 employees with individual doses exceeding 1 mSv; 9 with individual doses exceeding 5 mSv; none with individual dose over 10 mSv (unplanned exposure) and none with individual dose over 15 mSv;
- the maximum individual dose for 2013 was 5.81 mSv;
- the contribution of internal dose due to tritium intake is 18.1%.

Planned Outage

A 24 day planned outage was done at Unit#2 between May 10<sup>th</sup> and June 03<sup>rd</sup> 2013. Activities with major contribution to the collective dose were as follows:

- Fuel Channel Inspection

- Fuelling machine bridge component preventive maintenance;
- Fuelling machine bridge permanent extension (installation)
- Steam Generator eddy current inspection;
- Feeder thickness measurements, feeder clearance measurements, feeder-yoke measurements, elbow UT examination;
- Snubber inspections; piping support inspections.

Total collective dose at the end of the planned outage was 235 man.mSv (185.8 man.mSv external doses and 49.2 man.mSv internal doses due to tritium intakes).

This planned outage had a 46% contribution to the collective dose of 2013.

#### Planned Outages dose history

Year	Unit	Interval	External collective dose received [man·mSv]	Internal collective dose ( <sup>3</sup> H intakes) received [man·mSv]	Total collective dose received [man·mSv]
2003	1	15.05-30.06	345	161	506
2004	1	28.08-30.09	153	179	332
2005	1	20.08-12.09	127	129	256
2006	1	9.09-4.10	103	107	210
2007	2	20-29.10	16	0	16
2008	1	10.05 – 03.07	187	111	298
2009	2	09.05 – 01.06	122	11	133
2010	1	08.05 – 01.06	319	95	414
2011	2	07.05 - 01.06	117.2	13	130.2
2012	1	04.05 – 11.06	396.9	177.7	574.6
2013	2	10.05 – 03.06	185.8	49.2	235

#### Unplanned outages

- Unit 2 from July 1 - 3: The unit was shut down in an orderly manner to repair the Failed Fuel Location System (63105) pipe lines F16 and K12, identified with leaks. (7.11 man.mSv external dose and 2.8 man.mSv internal tritium dose for all the activities performed, including leak searches).
- Unit 2 from December 12 – 14: The unit was shut down in an orderly manner to repair a Shut Down cooling motorized valve, 3341 MV1. (2.52 man.mSv total dose);
- Unit 1 from October 28 – 30: The unit was shut down due to a shutdown System #1 trip. Work was performed on Defective Fuel Location System tubing and piping supports in feeder cabinets for 7.6 man.mSv collective dose.

#### Radiation protection-related issues

Transuranic (TRU) alpha-emitting radionuclides, which are normally contained within the fuel elements, may contaminate certain areas of a CANDU plant during the transfer of failed fuel or during maintenance activities on some components of the Primary Heat Transfer Circuit or auxiliaries. Identification and quantification of TRU is critical for radiation protection because of high internal dose



conversion factors for the inhalation pathway, and of the detection difficulties. Some industry events when alpha contamination monitoring and controls were not consistently performed produced significant radiological consequences which triggered a significant review of contamination control programs in the nuclear industry.

Areas and equipment / systems / activities with significant TRU contamination potential have been identified in both Unit#1 and Unit#2. COG research and development research program results and CANDU plant operating experience have been used to do this.

Extensive sampling for TRU contamination identification and quantification was done beginning in 2011. Technical support has been provided by a Romanian research institute to measure low level TRU in contamination samples. Based on these results potentially contaminated areas have been classified using EPRI criteria.

Radiation protection procedures and radiological risks data base have been revised to accommodate alpha contamination monitoring.

The dosimetry program has been revised to include internal dosimetry of TRU and was approved by the regulatory body.

Basic knowledge regarding TRU radiological risks, control and monitoring were introduced in radiation protection training programs for workers and RP technicians.

### **Issues of concern in 2013**

The main concerns for 2013 were important works, with high radiological impact, performed during the Planned Outage of Unit 2.

### **For 2014**

The main concerns for 2014 are activities with high radiological impact, to be performed during a 30 day Planned Outage of Unit 1:

- Fuel channel inspections;
- Fuelling machine bridge component preventive maintenance;
- Reactor Building Leak Rate Test;
- Piping support inspections;
- Snubber replacements;
- Feeder–yoke clearance measurements and correction;
- Inspection for tubing and support damages in the feeder cabinets;
- Planned outage systematic inspections.

## RUSSIAN FEDERATION

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
VVER	17	518.0
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
VVER	2	49.6

### 2) Principal events

#### Collective doses

In 2013, the total effective annual collective dose of utilities employees and contractors at 17 operating VVER type reactors was 8806.5 man·mSv. This result presents 1700.8 man·mSv (16%) decrease from the year 2012 total collective dose of 10507.3 man·mSv.

Comparative analysis shows a considerable difference between average annual collective doses for the groups of VVER-440 MWe and VVER-1000 MWe reactors. In 2013, the results were as follows:

- 992.5 man·mSv/unit with respect to the group of 6 operating VVER-440 reactors.
- 259.2 man·mSv/unit with respect to the group of 11 operating VVER-1000 reactors.

- *Events influencing dosimetric trends*

The principal factors influencing on the total collective dose change at Russian VVERs are annual outages durations and amount of repairing and maintenance works. In 2013, the total planned outages duration of all Russian VVERs-440 and VVERs-1000 was 641 days in comparison to 747 days in 2012. With this, the total planned outages collective dose decreased from 8494.5 man·mSv in 2012 to 7444.6 man·mSv in 2013.

In comparison to the year 2012, next changes should be taken into consideration for the year 2013:

- Balakovo –no outage at Unit 1, beginning of outage in the end of December (10 days) with outage finish in 2014 at Unit 2, major outage in 2013 (standard outage in 2012) at Unit3, standard outage at Unit 4 (for this unit, there was no outage in 2012).
- Kalinin – no maintenance and repairing works with radioactive contaminated equipment at Unit 1 and 2, planned outages at Unit 3 and 4 (for this unit, there was no outage in 2012).
- Kola – standard outages at Unit 1, 3 and 4, collective dose increasing at 98% was caused by major outage at Unit 2 in 2013 (standard outage in 2012).
- Novovoronezh – major outage at Unit 3, standard outages at Units 4 and 5.
- Rostov – no outage at Unit 1 and standard outage at Unit 2.

### Individual doses

In 2013, individual effective doses of all utilities employees and contractors were not exceeded the control dose level of 18 mSv per year at VVER-440 and VVER-1000 reactors.

The maximum recorded individual dose was 16.6 mSv. This dose was gradually received during full-year by the worker of Kola plant maintenance department during repairing of reactor component equipment at Units 1-4.

The maximum annual effective individual doses at other plants with VVER type reactors in 2013 were:

- Balakovo – 11.6 mSv.
- Kalinin – 12.1 mSv.
- Novovoronezh – 15.8 mSv.
- Rostov – 5.5 mSv.

The annual individual doses over 10 mSv received 159 persons (6 persons at Balakovo, 2 persons at Kalinin, 65 persons at Kola, 86 persons at Novovoronezh). Nobody exceeded 5 mSv levels at Rostov NPP.

#### Planned outages duration and collective doses

Reactor	Duration [days]	Collective dose [man·mSv]
Balakovo 1	no outage	--
Balakovo 2	10, finish in 2014	94.5
Balakovo 3	54	683.3
Balakovo 4	37	365.3
Kalinin 1	no outage	--
Kalinin 2	no outage	--
Kalinin 3	83	408.0
Kalinin 4	68	196.0
Kola 1	36	399.0
Kola 2	57	859.2
Kola 3	88	857.6
Kola 4	65	372.9
Novovoronezh 3	51	1795.7
Novovoronezh 4	35	912.3
Novovoronezh 5	42	464.3
Rostov 1	no outage	--
Rostov 2	25	83.4

#### Unplanned outages duration and collective doses

Reactor	Duration [days]	Collective dose [man·mSv]
Kalinin 1	77	0.0
Rostov 1	7	15.3

#### Issues of concern in 2013

New documents, manuals and models were developed and implemented:

- New regulation concerning radiation protection management system in Concern Rosenergoatom.
- Manual for providing radiation safety during of NPP operation.
- Method of radionuclides determination in human body in the case of radiation accident.



- Special model for calculation of internal exposure individual doses.
- Software for direct estimation of personal radiation risk coefficients for personal dosimetry of NPP employees.
- Software based on IAEA safe principles and ICRP recommendations for situations of potential exposure.

#### **New dose-reduction programmes planning in 2014**

- Estimation of NPP personal radiation risk coefficients. Development of ARMIR programme based on individual and generic risk.
- Development and certification of optimized set of standard sources (phantoms) for whole body monitors calibration based on gamma radiation efficiency registration factor.

## SLOVAK REPUBLIC

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
VVER	4	130.365
All types	4	130.365
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
VVER	2	Not included in ISOE
GCR	1	Not included in ISOE

### 2) Principal events

- *Events influencing dosimetric trends*

Bohunice NPP (2 units): The total annual effective dose in Bohunice NPP in 2013 calculated from legal film dosimeters was 203.448 man·mSv (employees 103.450 man·mSv, outside workers 99.998 man·mSv). The maximum individual dose was 2.409 mSv (NPP employee) without internal contamination and anomalies in radiation conditions.

Mochovce NPP (2 units): The total annual effective dose in Mochovce NPP in 2013 evaluated from legal film dosimeters and E<sub>50</sub> was 317.852 man·mSv (employees 143.235 man·mSv, outside workers 174.617 man·mSv). The maximum individual dose was 5.790 mSv (NPP employee).

Continuing work on Fukushima severe accidents measures on both NPPs

#### Outage information (number and duration)

#### Bohunice

##### Unit 3

- 20 day standard maintenance outage. The collective exposure was 112.271 man·mSv from electronic operational dosimetry; 49,164 RWP man-hours.
- 2 day forced outage. The collective exposure was 0.652 man·mSv from electronic operational dosimetry; 268 RWP man-hours.
- 1 day forced outage. The collective exposure was 0.429 man·mSv from electronic operational dosimetry; 255 RWP man-hours

##### Unit 4

- 19 day standard maintenance outage. The collective exposure was 103.918 man·mSv from electronic operational dosimetry; 48,827 RWP man-hours.

#### Mochovce

Unit 1 - 23.5 day major maintenance outage. The collective exposure was 141.349 man·mSv from electronic operational dosimetry.



Unit 2 - 20 day standard maintenance outage. The collective exposure was 87.130 man-mSv from electronic operational dosimetry.

- New reactors on line  
Mochovce 3+4, VVER 440MW under construction
- Organisational evolutions – decrease of RP personnel number (Bohunice by 3 workers, Mochovce by 4 workers)



## SLOVENIA

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	1	1351

### 2) Principal events

#### Summary of national dosimetric trends

The last three years' collective dose average rose from 0.60 man·Sv to 0.77 man·Sv.

Maximum individual annual dose was 11.28 mSv. The average dose per person was 0.86 mSv.

- Events influencing dosimetric trends
- The outage collective dose was 1.28 man·Sv. It was a refuelling outage with RTD by-pass elimination (0.71 man·Sv).
- Number and duration of outages
- One planned outage performed in 49 days.
- Major evolutions and dose-reduction programme
- The RTD by-pass elimination will have future impact on dose reduction.

#### **For 2014**

Revision of procedures related to alpha monitoring and control, training and self-assessments. Implementation of a new computer radiological survey programme and preparation for remote control features for outages.

## SPAIN

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	6	382.1
BWR	2	1140.80
All types	8	571.77
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	1	468.89
GCR	1	0

### 2) Principal events

#### Santa María de Garoña

- *Events influencing dosimetric trends*

Date	Event	Mean activity (if it exists)	Collective Dose [man·mSv]
19 Feb to 31 Dec	Design modification. Trolley replacement of the bridge crane and maintenance, in the reactor building	--	4.965
15 April to 20 Nov	Fuel Pool Cooling System (FPC) maintenance	Pump B-1905A. Engine replacement.	2.263
6 July	Reactor definitively shutdown	--	--

- *Organisational evolutions*

New radiation protection manual adapted to the situation of definitive shutdown, from July 6<sup>th</sup>.

- *Regulatory requirements*

Specific requirements associated with definitive shutdown and pre-decommissioning, from July 6<sup>th</sup>.

#### Cofrentes

- *Events influencing dosimetric trends*

Increase of the term source in the pipes of the reactor water cleanup system (G33), with a tendency to an increase in radiation levels of approximate 30% with regard to the 18<sup>th</sup> outage. There is foreseen the need for the chemical decontamination of the pipes of system G33 in the dry well in the 20<sup>th</sup> outage.

The levels of radiation in the pedestal of the vessel in the initial measurements of the 19<sup>th</sup> outage presented an increase of 33% with regard to those levels seen in the 18<sup>th</sup> outage. One proceeded to the cleanliness of 15 pipes of the PRM's with major levels of radiation, diminishing the rates of dose to values similar to those of the 17<sup>th</sup> outage.

The source term in the refueling plant after the decontamination of the cavity in the 19<sup>th</sup> outage presents results lower than in the 18<sup>th</sup> outage and with the same order of magnitude to those obtained in the 16<sup>th</sup> outage. The attainment of the objectives of reduction of the source term derived with the workgroup created after the 18<sup>th</sup> outage has been possible thanks to the action plan carried out in the refueling plant: installation of auxiliary system of filtration, shut down of the plant with the model "soft stop" and the system of cleaning floors using robotics.

#### **Number and duration of outages**

- 19<sup>th</sup> outage
  - Duration of 40 days
  - There was no forced outage.
  - Reductions in power have been realized for actions in bridge of feedwater pipe .
- *New/experimental dose-reduction programmes*

#### **Decontamination of the reactor cavity**

Implementation of improvements to minimize the numbers of personal contaminations during the decontamination of the reactor cavity. (Installation of sprayers in the walls north, east and west of cavity to reduce the environmental contamination and to avoid the generation of aerosols by drying of the walls, utilization of a robot to eliminate deposited activity, assembly of new sheets of protection using materials which are easily decontaminable and filling with 5 cm of water level in the area between bridge of the dry well and bridge of vessel).

#### **Cleanliness of platforms and floors of swimming pools**

Employment of a new system of suction for swimming pool floors, with remote system of monitoring, small size and TV camera, with better results being obtained than for ones using conventional systems for cleaning.

#### **Flushing of nozzles being inspecting in the outage**

Replacement of the flushing methods for the nozzles as used in previous outages with a new and more effective method.

#### **Use of remote machinery in inspection of nozzles and pipelines**

For this outage improved equipment is being used for inspection of nozzles and pipelines, reducing the quantity of necessary tools to realize the adjustments, as well as the quantity of cables associated with the same ones.

#### **3D Modeling of the plant**

Installation in the door of the dry well of television screens to view work locations from the low radiation area. Additionally, this tool has been used during the early stages of planning of the work. During the 19<sup>th</sup> outage phase II of 3D modeling of the plant has been implemented.

#### **Temporary and permanent shielding**

The program of implementation of permanent shielding in different zones of the plant has been continued. In the outage temporary shielding was installed in different locations of the plant with an approximate weight of 5 tons.

#### - *Organisational evolutions*

Reinforcement of the organization of the Service of Radiological Protection. In the period 2012-2013 two top graduates, a middle graduate and three expert technical personnel have joined the Service of Radiological Protection CN Cofrentes.

#### - *Regulatory requirements*

Application of the Technical Instruction of the CSN by which there is checking of compliance with the criteria of signposting of the zones of free access.



## Almaraz

- *Events influencing dosimetric trends*
  - a) Number and duration of outages :
    - 21<sup>st</sup> outage of Almaraz Unit 2:
      - Duration 63 days.
      - Collective dose 541.948 man·mSv
      - Maximum individual dose: 4.449 mSv
    - 22<sup>nd</sup> outage of Almaraz Unit 1:
      - Duration 60 days.
      - Collective dose 459.826 man·mSv
      - Maximum individual dose: 4.735 mSv
  - b) Component or system replacements
    - During 21<sup>st</sup> outage of unit 2 and 22<sup>nd</sup> outage of unit 1 two reactor coolant pump motors (one per unit) were replaced.
    - Replacement during outages of external nuclear instrumentation system.
  - c) New/experimental dose-reduction programmes
    - Reduction by 5% is the annual collective dose objective for 2014.
    - Reduction by 4% in the maximum individual dose is the objective during outage.
    - Use of Centralized Aspiration Units for contamination control.
    - Modification and upgrade of the cavity purification system.
    - Continuous optimization of radiation protection procedures and measures.
  - d) Organizational evolutions
    - Incorporation of a Radiation Protection technician in the Department.

## Ascó

- Events influencing dosimetric trends (Outage information (number and duration), Component or system replacements, Unexpected events/incidents, New reactors on line, Reactors definitively shutdown...)

### Number and duration of outages

- 21<sup>th</sup> outage (Ascó 2)
- Duration of 46 days
- Collective dose: 573.315 man.mSv.

## Vandellòs 2

- Events influencing dosimetric trends (Outage information (number and duration), Component or system replacements, Unexpected events/incidents, New reactors on line, Reactors definitively shutdown...)

### Number and duration of outages

- 19<sup>th</sup> outage
- Duration of 43 days
- 18 Special Guide Plates of the upper internals removed.
- Vessel head surface Inspection.
- Increase of the radiation levels in the reactor cavity during the removal of the special guide plates. The origin is the drain of SG water in the reactor cavity.
- Increase of the radiation level in the vessel head.

## SWEDEN

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	3	520
BWR	7	713
All types	10	655
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
BWR	2	4

### 2) Principal events

- *Events influencing dosimetric trends*

#### **Ringhals**

The collective dose of Ringhals 1 was dominated by maintenance of RH ball valve repair (158 man.mSv). Conversion to Forward Pump Heat Drain (FPHD) was completed on the second turbine during 2013. Trends in water chemistry and source term have been carefully followed during operation, and the overall image is that the predicted consequences going to FPHD were correct or over-estimated to some extent.

The collective dose for Ringhals 2 was mainly dominated by service work during thermal insulation and scaffolding work related to RH and RCS pressure relief modifications.

In Ringhals 3 there was a major increase of Ag-110m which has been identified as probably caused by leakage from control rods. In some local areas Ag-110m was one of the main contributing nuclides to the CRE.

At Ringhals 4 the collective dose was dominated by periodic and corrective maintenance.

#### **Oskarshamn**

In June 2013 the Plant Life Extension (Plex) of Oskarshamn 2 started and will continue to September 2014. The total collective dose for the project was calculated to be 3300 man.mSv. Before the work started a system decontamination was performed of the main primary systems with an average decontamination factor of 50. The dose saving is calculated to be 2000 man.mSv.

At Oskarshamn3 a main contribution to the collective dose was the segmentation of internals and loading into special canisters for dry storage.

#### **Barsebäck**

Housekeeping and cleaning of pools in the reactor halls was performed for project HINT, segmentation of internals on both units.



## **Forsmark**

In 2013 the collective dose for the whole site was the lowest since the start-up of Forsmark 3 in the mid-eighties.

Forsmark 1 and 2 still benefit from very low moisture content in the steam and hence low dose rates in the steam systems. This is mainly due to new steam separators and steam dryers that were installed some years back in preparation for future possible power uprates.

Forsmark 2 started trial operation at 3253 MWth in March 2013. This power increase equals going from 108% of the original power up to 120%.

Unexpectedly high dose rates were encountered in the containment during outage at Forsmark 2. Very high regrowth of surface activity discovered after the 2012 UV-CORD system decontamination of the cooling system for cold shutdown reactor and the reactor water cleanup system.

- *New/experimental dose-reduction programmes*

As part of the SG replacement at Ringhals 4 in 2011 it was decided to perform High Efficiency Ultrasonic Fuel Cleaning (HEUFC) in 2012 as a measure to reduce source term rebuild and to decrease CRE. In 2013 HEUFC was performed on 101 fuel elements.

- *Organisational evolutions*

In cooperation with ISOE (CEPN) an ALARA- benchmarking was prepared for 2014. The basic reason for planning a benchmarking was to evaluate if Ringhals NPP and Forsmark NPP had optimised ALARA programs which had been implemented in the organisation, from the top to the bottom. This included questions as to how small annual individual doses (<1 mSv) are managed. Large numbers of small doses can significantly contribute to the CRE, as the source terms are showing decrease and the ALARA programme is potentially more well developed for larger-dose jobs.

### 3) Report from Authority

The Swedish Radiation Safety Authority (SSM) continues working with the development of new regulations. The regulations concerning new buildings are expected to be published in 2015.

SSM performed a series of theme-inspections during 2013. The reason for the theme-inspection is to achieve mutual approach and a comparable assessment and the series will involve all the nuclear power facilities in Sweden.

SSM initiated an assessment of the conformity of dosimeters used to measure dose to the lens of the eye at the Swedish nuclear facilities in April 2013. The assessment was to be completed and reported to SSM by the end of January 2014. SSM is currently in process of reviewing the submitted documents.

## SWITZERLAND

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	3	351
BWR	2	1112

### 2) Principal events

- *Events influencing dosimetric trends:*

In NPP Mühleberg two additional short interim outages in 2013 were necessary in order to repair the floating ring seal of circulation pump B, which gave rise respectively to 9 and 7 man·mSv. The design of the ring seals was modified in the last year with a small change to the prior design, causing higher temperatures of the seal water. The annual outage at the plant started on 11 August and stopped on 8 September (656 man·mSv).

The outage in NPP Leibstadt lasted 25 days and caused 797 man·mSv of dose to be accrued. The average dose rate on the circulation loop increased by a factor of 10% related to last year.

The dose rate on the primary cooling loop of NPP Gösgen decreased by a factor of 2 in relation to the rate in 2005, due to the Zn injection chemistry. However, the accumulated collective dose during the outage rose to 602 man·mSv because of the long outage duration (60 days in contrast to fewer days in recent years).

Collective doses in NPP Beznau were 85 man·mSv in unit KKB 1 for a 12-day short outage (fuel replacement) and 220 man·mSv in unit KKB 2 for a 33-day normal outage (predominantly maintenance).



## UKRAINE

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
VVER	15	580

## UNITED KINGDOM

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	1	385.442
GCR	15 <sup>(Note 1)</sup>	33.265
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
GCR	19 <sup>(Note 2)</sup>	57.307

Notes: (1) 14 Advanced Gas-Cooled Reactors and 1 Magnox Reactor.

(2) 19 Magnox Reactors.

### 2) Principal events

The Collective Radiation Doses for the Advanced Gas Cooled Reactors, operated by EDF Energy, were generally low, ranging from 26.9 man·mSv for Torness NPP to 193.9 man·mSv for Heysham 2 NPP. (All UK gas reactor sites have two reactors.) The highest collective radiation doses were recorded by the AGRs performing inspection and repairs inside the Reactor Vessel.

Sizewell B, the only PWR, recorded an annual collective radiation dose of 385.4 man·mSv. The plant carried out its twelfth refuelling outage, with a duration of 48 days, in the Spring of 2013. Around 90% of the annual collective radiation dose was recorded during this refuelling outage.

Of the first generation gas-cooled reactors in the United Kingdom there is now only one Magnox reactor left operating, Wylfa Unit 1. The reactor is currently licensed to operate until September 2014. The majority of the Magnox reactor sites are now completely defueled and are at various stages of decommissioning.

### 3) Plans for New Nuclear Build

EDF Energy has plans to construct two new nuclear power plants at Hinkley Point and Sizewell, each with two EPRs. The Generic Design Assessment (GDA) for the EPR has been completed by the regulatory body, allowing an outline nuclear site license to be granted to EDF New Nuclear Build. Work continues to develop a site-specific safety case and to complete the detailed design.

Hitachi UK Ltd has acquired the rights to develop new nuclear build at two existing nuclear licensed sites, at Oldbury and Wylfa. GDA for the Hitachi Advanced Boiling Water Reactor design began in 2013.

## UNITED STATES

### 1) Dose information

ANNUAL COLLECTIVE DOSE		
OPERATING REACTORS		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	65	22,998.26 / 65 units = 353.812 man.mSv/unit
BWR	35	44,518.52 / 35 units = 1271.97 man.mSv/unit
All types		67,516.78 / 100 units = 675.168 man.mSv/unit
REACTORS DEFINITELY SHUTDOWN OR IN DECOMMISSIONING		
Reactor type	Number of reactors	Average annual collective dose per unit and reactor type [man·mSv/unit]
PWR	7	565.10 / 7 units = 80.728 man.mSv/unit
BWR	3	275.32 / 3 units = 91.77 man.mSv/unit
FBR	1	0.07 man.mSv/unit * Fermi 1

### Summary of USA Occupational Dose Trends in 2013

The USA PWR and BWR occupational dose averages for 2013 reflected a continued emphasis on dose reduction initiatives at the 100 operating commercial reactors: Also, four (4) units transitioned to the decommissioning phase.

Reactor Type	Number of Units	Total Collective Dose	Avg Dose per Reactor
PWR	65	22,998.26 man.mSv	0.35 man.Sv/unit
BWR	35	44,518.52 man.mSv	1.27 man. Sv/unit

The total collective dose for the 100 reactors in 2013 was 67,516.78 person mSv, a decrease of 16% from the 2012 total. The resulting average collective dose per reactor for USA LWR was 675 person mSv/unit. Only two individuals received between 20-30 mSv in 2013 (within the current 50 mSv annual dose limit in the USA).

#### US PWRs

The total collective dose for US PWRs in 2013 was 22,998 person mSv for 65 operating PWR units. The 2013 average collective dose per reactor was 350 person mSv/PWR units. US PWR units are generally on 18- or 24-month refueling cycles. The US PWR sites that achieved annual site doses of under 100 person mSv in 2013 were:

- Davis Besse                      25 man.mSv              Waterford                      31 man.mSv
- Ginna                                34 man.mSv              Watts Bar 1                    26 man.mSv
- Seabrook                            24 man.mSv



## US BWRs

The total collective dose for US BWRs in 2013 was 44,518 man.mSv for 35 operating BWR units. The 2013 average collective dose per reactor was 1.27 person mSv/BWR unit. Most US BWR units are on 24-month refueling cycles. This level of average collective dose is primarily due to power up-rates and water chemistry challenges at some US BWR units in 2013.

### 2) Principal events of the year 2013

#### a. New plants on line/plants shut down

- Watts Bar 2 is being prepared to commence initial operations in the near future. Southern Company is continuing the construction of two new PWRs at the Vogtle site in Georgia. South Carolina Electric & Gas is constructing two new PWRs on the V.C. Summer site.
- Zion Units 1 and 2 located on Lake Michigan in Northern Illinois started decommissioning in 2010. Energy Solutions is responsible for the decommissioning of the site. Kewaunee, San Onofre 2, 3 and Crystal River transitioned into the decommissioning phase.

#### b. Unexpected events

- A tornado struck and disabled power lines providing off-site power to Arkansas ONE Unit 1 which required a shutdown of the unit.

#### c. New/experimental dose-reduction programmes

- US RPMs continue to participate in the CZT detector measurement program initially used at EDF PWR sites.
- Several RPMs are also implementing the H3D CZT detector system developed by the University of Michigan which achieves individual isotopic identification in plant RP surveys.

#### d. Organisational evolutions

- Exelon Nuclear completed the merger with Constellation Energy, making Calvert Cliffs 1,2, Nine Mile Point 1,2 and Ginna Exelon fleet units.

#### e. Technical plans for major work in 2013

- Davis Besse replaced steam generators in 2013. PWRs continue to perform MSIP treatments on plant piping to relieve stress.

### 3) Regulatory plans for major work in 2013

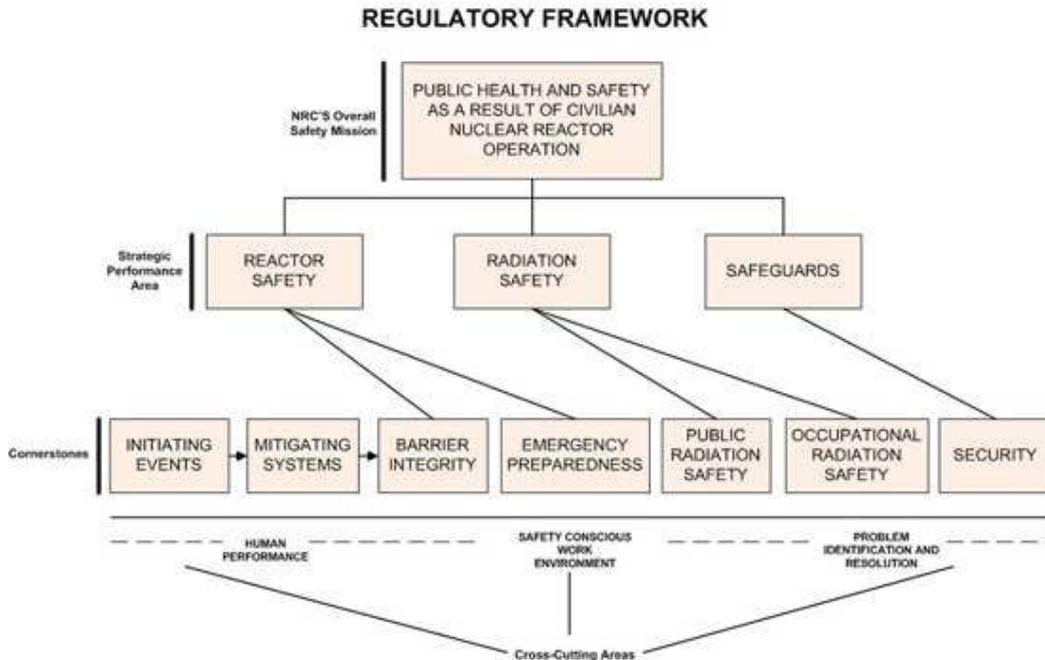
#### **NRC's Reactor Oversight Program - Regulatory Framework**

The U.S. Nuclear Regulatory Commission's (NRC) regulatory framework for reactor oversight is shown in the diagram below. It is a risk-informed, tiered approach to ensuring plant safety. There are three key strategic performance areas: reactor safety, radiation safety, and safeguards. Within each strategic performance area are cornerstones that reflect the essential safety aspects of facility operation. Satisfactory licensee performance in the cornerstones provides reasonable assurance of safe facility operation and that the NRC's safety mission is being accomplished.

Within this framework, the NRC's operating reactor oversight process provides a means to collect information about licensee performance, assess the information for its safety significance, and provide for appropriate licensee and NRC response. The NRC evaluates plant performance by analyzing two



distinct inputs: inspection findings resulting from NRC's inspection program and performance indicators (PIs) reported by the licensees.



### Occupational Radiation Safety Cornerstone and 2013 Results

Occupational Radiation Safety - The objective of this cornerstone is to ensure adequate protection of worker health and safety from exposure to radiation from radioactive material during routine civilian nuclear reactor operation. This exposure could come from poorly controlled or uncontrolled radiation areas or radioactive material that unnecessarily exposes workers. Licensees can maintain occupational worker protection by meeting applicable regulatory limits and ALARA guidelines.

**Inspection Procedures** - There are five attachments to the inspection procedure for the occupational radiation safety cornerstone:

IP	<a href="#">71124</a>	Radiation Safety-Public and Occupational
IP	<a href="#">71124.01</a>	Radiological Hazard Assessment and Exposure Controls
IP	<a href="#">71124.02</a>	Occupational ALARA Planning and Controls
IP	<a href="#">71124.03</a>	In-Plant Airborne Radioactivity Control and Mitigation
IP	<a href="#">71124.04</a>	Occupational Dose Assessment
IP	<a href="#">71124.05</a>	Radiation Monitoring Instrumentation

### Occupational Exposure Control Effectiveness

The performance indicator for this cornerstone is the sum of the following:

- Technical specification high radiation area occurrences
- Very high radiation area occurrences
- Unintended exposure occurrences



Occupational Radiation Safety Indicator	Thresholds		
	(White) Increased Regulatory Response Band	(Yellow) Required Regulatory Response Band	(Red) Unacceptable Performance Band
Occupational Exposure Control Effectiveness	> 2	> 5	N/A

Those units that do not cross the thresholds receive a green finding or no findings. Of the 103 units evaluated in 2013 only one unit in the first quarter received an elevated finding due to findings found in 2012. The latest ROP Performance Indicator Findings can be found at [http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/pi\\_summary.html](http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/pi_summary.html).

Additional background information can be found on the [Detailed ROP Description page](http://www.nrc.gov/reactors/operating/oversight/rop-description.html) at <http://www.nrc.gov/reactors/operating/oversight/rop-description.html>.