Radiological Protection

Occupational Exposures at Nuclear Power Plants

Nineteenth Annual Report of the ISOE Programme, 2009

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NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 30 OECD member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, the Republic of Korea, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information.

The NEA Data Bank provides nuclear data and computer program services for participating countries. In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

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.

The Nineteenth Annual Report of the ISOE Programme (2009) presents the status of the ISOE programme for the year of 2009.

"... the exchange and analysis of information and data on ALARA experience, dose-reduction techniques, and individual and collective radiation doses to the personnel of nuclear installations and to the employees of contractors are essential to implement effective dose management programmes and to apply the ALARA principle." (ISOE Terms and Conditions, 2008-2011).

2009 ISOE International ALARA Symposium (at IAEA, Vienna)

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EXECUTIVE SUMMARY

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 19th Annual Report of the ISOE Programme (2009) presents the status of the ISOE programme for the calendar year 2009.

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 2008-2011 came into force on 1 January 2008. At the end of 2010, the ISOE programme included 66 Participating Utilities in 26 countries (320 operating units; 40 shutdown units), as well as the regulatory authorities of 24 countries. The ISOE occupational exposure database itself included information on occupational exposure levels and trends at 401 operating reactors in 29 countries, 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.

Based on the occupational exposure data supplied by ISOE members for operating power reactors, the 2009 average annual collective doses per reactor and 3-year rolling averages per reactor (2007-2009) were:

	2009 average annual collective dose (man·Sv/reactor)	**3-year rolling average for 2007-2009 (man·Sv/reactor)**
Pressurised water reactors (PWR)	0.77	0.74
Pressurised water reactors (VVER)	0.49	0.59
Boiling water reactors (BWR)	1.41	1.39
Pressurised heavy water reactors (PHWR/CANDU)	1.43	1.16
All reactors, including gas cooled (GCR) and light water graphite reactors (LWGR)	0.93	0.88

In addition to information from operating reactors, the ISOE database contains dose data from 81 reactors which are shutdown 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 2009 to improve the data collection for such reactors in order to facilitate better benchmarking. Details on occupational dose trends for operating reactors, and reactors undergoing decommissioning are provided in Section 2 of the report.

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 2009, the ISOE Network website (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 final development and testing of data input modules for the on-line submission of members' occupational exposure data was completed in 2009, for implementation and data collection in 2010.

The annual ISOE International 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 2009 ISOE International ALARA Symposium, organised by the IAEA Technical Centre, was held in Vienna, Austria. The technical centres also continued to host regional symposia, which in 2009 included the ISOE North American Regional ALARA Symposium in Fort Lauderdale, USA, organised by the North American Technical Centre in co-operation with EPRI, and the ISOE Asian Regional ALARA Symposium organised by the Asian Technical Centre in Aomori, Japan. These symposia provide a global forum to promote the exchange of ideas and management approaches for maintaining occupational radiation exposures as low as reasonably achievable.

Of importance is the support that the technical centres supply in response to special requests for rapid technical feedback and in the organisation of voluntary site benchmarking visits for dose reduction information exchange between ISOE regions. The combination of ISOE symposia and technical visits provides a means for radiation protection professionals to meet, share information and build links between ISOE regions to develop a global approach to occupational exposure management.

The ISOE Working Group on Data Analysis (WGDA) continued its activities in support of the technical analysis of the ISOE data and experience, focusing largely on the integrity and consistency of the ISOE database, and the migration of the ISOE database resources to the ISOE Network website.

Principal events in the ISOE participating countries are summarised in Section 6 of this report. Details of ISOE participation and the programme of work for 2009 are provided in the Annexes.

SYNTHÈSE DU RAPPORT

Depuis 1992, le programme ISOE (système d'information sur les expositions professionnelles) facilite la mise en œuvre de l'optimisation de la radioprotection des travailleurs dans les centrales nucléaires par le biais d'un réseau d'échange d'information et d'expériences entre les responsables de la radioprotection des centrales nucléaires et les représentants des autorités réglementaires du monde entier ainsi que par la publication de produits techniques spécifiques pour la mise en œuvre d'ALARA. Ce dix-neuvième rapport annuel du système ISOE (2009) fait le point sur le programme ISOE à la fin de l'année 2009.

ISOE est conjointement sponsorisé par l'AEN de l'OCDE et l'AIEA, et est ouvert à l'adhésion d'exploitants des centrales nucléaires de production d'électricité et des autorités réglementaires de radioprotection qui acceptent les conditions de mise en œuvre du programme. Les conditions de mise en œuvre actuelles pour la période 2008-2011 sont entrées en vigueur le 1er janvier 2008. À la fin de 2010, 66 exploitants de 26 pays participaient au programme ISOE (320 réacteurs nucléaires en fonctionnement; 40 réacteurs arrêtés) ainsi que les autorités réglementaires de 24 pays. La base de données ISOE contient des informations sur les expositions professionnelles et leurs tendances pour 401 réacteurs en exploitation dans 29 pays, représentant ainsi près de 91% de l'ensemble des réacteurs de puissance en fonctionnement dans le monde. Quatre centres techniques ISOE (Europe, Amérique du Nord, Asie et AIEA) gèrent au jour le jour les opérations techniques du programme.

Sur la base des données sur les expositions professionnelles fournies par les membres ISOE, la dose collective moyenne par réacteur annuelle pour 2009 et la dose collective par réacteur moyennée sur trois ans (2007-2009) des réacteurs en fonctionnement étaient de :

	Dose collective moyenne annuelle 2009 (Homme·Sv/réacteur)	**Dose collective moyennée 3 ans pour 2007-2009 (Homme·Sv/réacteur)**
Réacteurs à eau pressurisée (REP)	0.77	0.74
Réacteurs à eau pressurisée (VVER)	0.49	0.59
Réacteurs à eau bouillante (REB)	1.41	1.39
Réacteurs à eau lourde pressurisée (PHWR/CANDU)	1.43	1.16
Tous les réacteurs, y compris les graphite gaz (GCR) et les réacteurs à eau graphite (RBMK)	0.93	0.88

La base de données ISOE contient également des données concernant les doses collectives de 81 réacteurs en arrêt à froid ou en phase de démantèlement. Etant donné que les réacteurs présents dans la base de données sont de type et de taille différents, et qu'ils sont généralement à des phases différentes de leurs programmes de démantèlement, il est difficile de mettre en évidence des tendances sur l'évolution des expositions. Toutefois, un travail a été entrepris en 2009 pour améliorer la collecte de données pour ces réacteurs en vue de faciliter les comparaisons. Des détails sur l'évolution de la dose des réacteurs en exploitation, et des réacteurs en cours de démantèlement sont fournis à la section 2 de ce rapport.

Bien qu'ISOE soit connu pour ses données et ses analyses des expositions professionnelles, la force du système provient de son objectif de partager largement ces informations parmi ses participants. En 2009, le site internet du Réseau ISOE (www.isoe-network.net) a continué de fournir aux membres ISOE une information complète ainsi qu'un portail d'échange d'expérience sur la réduction des doses et sur les documents ALARA. Le développement du module de saisie des données pour la soumission sur le Web des données d'exposition professionnelle des participants s'est achevé en 2009 afin d'effectuer la mise en œuvre du module et la saisie des données en 2010.

Les symposiums ISOE ALARA annuels internationaux sur la gestion des expositions professionnelles dans les centrales nucléaires constituent des rendez-vous importants permettant aux participants ISOE et aux entreprises exposantes d'échanger des informations et des bonnes pratiques sur les expositions professionnelles dans les centrales nucléaires. Le symposium international ISOE ALARA de 2009, organisé par le centre technique ISOE de l'AIEA, s'est tenu à Viennes en Autriche. Les centres techniques continuent également à organiser des symposiums régionaux : en 2009 un symposium a été organisé par le centre technique ISOE d'Amérique du Nord en coopération avec l'EPRI à Fort Lauderdale aux Etats-Unis et un symposium a été organisé par le centre technique asiatique à Aomori au Japon. Ces symposiums perpétuent la tradition de fournir un large forum pour promouvoir les échanges d'idées et d'expériences de gestion en vue de maintenir les expositions professionnelles aussi basses que raisonnablement possibles.

L'appui offert par les centres techniques en réponse aux demandes spéciales de retour d'expérience technique, et pour l'organisation de visites de type benchmarking afin d'échanger entre les régions ISOE des informations sur les réductions des doses revêt une importance croissante. L'organisation conjointe de symposiums ISOE avec des visites techniques fournit aux professionnels de la radioprotection un intéressant forum pour se rencontrer, discuter et partager des informations, construisant ainsi des liens et des synergies entre les régions ISOE pour développer une approche globale de l'organisation du travail.

Le groupe de travail ISOE sur l'analyse des données (WGDA) a poursuivi ses activités d'appui pour l'analyse technique des données et de l'expérience, en se focalisant principalement sur l'intégrité et la cohérence de la base de données ISOE ainsi que sur sa migration sur le site internet ISOE.

Les principaux événements qui ont eu lieu dans les pays participants à ISOE sont résumés dans la section 6 de ce rapport. Les détails concernant la participation et le programme de travail d'ISOE pour 2009 sont fournis dans les annexes.

ZUSAMMENFASSUNG

Seit 1992 fördert ISOE die Optimierung des Strahlenschutzes in Kernkraftwerken durch weltweiten Informations- und Erfahrungsaustausch für beruflich strahlenexponierte Personen und nationale Aufsichtsbehörden und die Veröffentlichung von wichtigen technischen Erkenntnissen das ALARA – Management. Dieser 19. Jahresbericht (2009) stellt den Status des ISOE-Programms für das Kalenderjahr 2009 vor.

ISOE wird gemeinsam durch OECD/NEA und IAEA unterstützt, eine Mitgliedschaft ist für alle Kernkraftwerksbetreiber und Strahlenschutzaufsichtsbehörden unter Beachtung und Anerkennung der ISOE- Geschäftsordnung weltweit offen. Die geltenden Geschäftsbedingungen für die Zeit von 2008 bis 2011 traten am 01. Januar 2008 in Kraft. Am Ende des Jahres 2010 waren 66 Betreiber aus 26 Ländern (320 in Betrieb befindliche KKW, 40 im Rückbau befindliche Anlagen) sowie Aufsichtsbehörden aus 24 Ländern im ISOE Programm eingebunden. Die ISOE-Datenbank zur beruflichen Strahlenexposition enthält Informationen zu Dosisdaten und Dosistrends von 401 in Betrieb befindlichen Reaktoren in 29 Ländern, die etwa 91% der weltweit kommerziell genutzten Leistungsreaktoren darstellen. Vier ISOE Zentren (Europa, Nordamerika, Asien und IAEA) sind für die technisch-organisatorische Umsetzung des ISOE Programms zuständig.

Basierend auf den von den ISOE- Mitgliedern gelieferten Daten zeigt die nachfolgende Tabelle die durchschnittliche jährliche Kollektivdosis für das Jahr 2009 und die gleitenden 3-Jahres Mittelwerte für in Betrieb befindliche Leistungsreaktoren (2007-2009) pro Block:

	2009 mittlere Jahreskollektivdosis (man·Sv/Block)	**3-Jahresmittelwerte 2007-2009 (man·Sv/Block)**
Druckwasserreaktoren (DWR)	0.77	0.74
Druckwasserreaktoren (WWER)	0.49	0.59
Siedewasserreaktoren (SWR)	1.41	1.39
Schwerwasserreaktoren (PHWR/CANDU)	1.43	1.16
Alle Reaktoren, inkl. gasgekühlte (GCR) und Leichtwasser Graphitreaktoren (LWGR)	0.93	0.88

In Ergänzung zu Informationen über in Betrieb befindliche Reaktoren enthält die Datenbank auch Dosisangaben von 81 endgültig abgeschalteten oder im Rückbau befindlichen Anlagen. Da diese Reaktoren sich weitestgehend in Typ und Größe unterscheiden und sich in unterschiedlichen Stadien der Stilllegung befinden, ist es schwierig, eindeutige Dosistrends zu bestimmen. Allerdings wurden in 2009 Arbeiten fortgeführt, um die Datenbasis für solche Anlagen zu verbessern, mit dem Ziel, ein besseres Benchmarking zu ermöglichen. Einzelheiten zu Dosistrends für in Betrieb befindliche und im Rückbau befindliche Anlagen werden in Sektion 2 dieses Berichts dokumentiert.

Neben den bekannten ISOE- Daten zur beruflichen Strahlenexposition und zugehörigen Datenanalysen, liegt die Stärke des ISOE- Programms im breit angelegten Informationsaustausch unter den Mitgliedern. Auf der ISOE Netzwerk – Webseite (www.isoe-network.net) wurde in 2009 die Unterstützung der ISOE Mitglieder weiter mit einer umfangreichen internetgestützten Information und einem Portal für Erfahrungsaustausch zur Strahlenschutzoptimierung und Nutzung von ALARA-Methoden fortgeführt. Die abschließende Entwicklung und das Testen der Dateneingangsmodule für die online Datenerfassung von Strahlenexpositionsdaten wurden in 2009 beendet, für die Implementierung und Datensammlung des Jahres 2010.

Das jährliche internationale ALARA Symposium zum Management der beruflichen Strahlenexposition in Kernkraftwerken stellte erneut ein wichtiges Forum für die ISOE Teilnehmer und für Hersteller dar, um Informationen und Erfahrungen aus der Strahlenschutzpraxis auszutauschen. Das durch IAEA (Technisches Zentrum) organisierte internationale ISOE ALARA Symposium 2009 fand in Wien, Österreich, statt. Die technischen Zentren haben auch weiter regionale Symposien begleitet, so das nordamerikanische regionale ISOE ALARA Symposium in 2008 in Fort Lauterdale, organisiert vom nordamerikanischem technischen Zentrum in Zusammenarbeit mit EPRI und asiatische regionale ISOE ALARA Symposium organisiert durch das asiatische technische Zentrum in Aomori, Japan. Diese Symposien bilden ein globales Forum, um den Austausch von Ideen und Methoden des Managements im Sinne von ALARA zu fördern.

Von besonderer Bedeutung ist die Unterstützung durch die Technischen Zentren, wenn es um spezielle Fragestellungen von Mitgliedern und deren schnelle Beantwortung geht. Außerdem organisieren und unterstützen die Zentren Anlagenbesuche zu Benchmarkzwecken auf freiwilliger Basis. Die Kombination von ISOE Symposien und technischen Besuchen stellt für Strahlenschutzexperten ein gutes Hilfsmittel zur überregionalen Zusammenarbeit dar.

Die ISOE -Arbeitsgruppe, die sich mit Datenanalysen (WGDA) befasst, führte ihre Aktivitäten bei der Unterstützung der technischen Analyse von ISOE- Daten und Erfahrungen fort, mit dem Focus auf Integrität und Konsistenz der ISOE Datenbank und des Übertrags der ISOE Datenbank zur ISOE Webseite.

Wesentliche Ereignisse aus den in ISOE beteiligten Ländern sind in Sektion 6 dieses Berichtes zusammengefasst. Einzelheiten zur ISOE- Teilnahme und zum Arbeitsprogramm 2009 sind in den Anhängen dokumentiert.

内容提要

自 1992 年以来，职业辐射暴露信息系统（ISOE）通过向核电厂辐射防护专业人员和国家监管部门提供全球信息与经验交流网络，出版关于辐射防护最优化管理的相关技术资源，从而向核电厂工作人员的辐射防护最优化提供支持。《职业辐射暴露信息系统计划年度报告》第 19 期（2009 年）介绍了 2009 年度 ISOE 计划的情况。

ISOE 由经济合作与发展组织核能机构（OECD/NEA）和国际原子能机构(IAEA) 共同提供經濟支持，参加 ISOE 成员的资格向世界各国的核电公司和辐射防护监管部门开放，只要接受该计划的“条款和条件”，均有资格成为它的成员。2008-2011 年期间适用的 ISOE“条款和条件”于 2008 年 1 月 1 日生效。截止 2010 年底，ISOE 计划包括了来自 26 个国家的 66 个电力公司（320 台运行机组，40 台关闭机组）和 24 个国家的监管部门。ISOE 的职业辐射暴露数据库中载有 29 个国家的 401 座运行反应堆的职业辐射暴露水平和趋势的资料，占到了全世界运行商用动力堆的 91%。该计划的四个技术中心（欧洲、北美、亚洲和国际原子能机构）管理着该计划的日常技术工作。

根据 ISOE 成员提供的在运动力堆的职业辐射暴露数据，每座反应堆的 2008 年平均集体剂量和每座反应堆的三年（2007－2009 年）滚动平均数据如下：

	2009 年平均集体剂量（man·Sv/堆）	**2007-2009 三年滚动平均值（man·Sv/堆）**
压水堆（PWR）	0.77	0.74
压水堆（VVER）	0.49	0.59
沸水堆 （BWR）	1.41	1.39
加压重水堆 (PHWR/CANDU)	1.43	1.16
所有反应堆，包括气冷（GCR）和轻水石墨反应堆（LWGR）	0.93	0.88

除来自运行反应堆的信息外，ISOE 数据库还包括了已经关闭的或处于某一退役阶段的 81 座反应堆的剂量数据。由于这些反应堆机组基本上是屬於不同类型，而且都处在退役计划的不同阶段，因此很难确定清晰的剂量趋势。虽然如此，2009 年仍继续改进对这些反应堆的数据收集工作，以便更好地确定基准。报告第二部分提供了运行反应堆和正在執行退役反应堆的职业辐射暴露剂量趋势的详细资料。

ISOE 以职业辐射暴露的数据和分析而知名，而该计划的重点则在于其目标是促使各成员广泛共享这些信息。2009 年，ISOE 网站（www.isoe-network.net）继续为其成员提供有关剂量降低和辐射防护最优化资源的综合信息与经验交流的网上窗口。2009 年完成了供成员在线

提交职业辐射暴露数据的输入模块的最终开发与测试工作，以便在 2010 年实施和开展收集数据。

ISOE 关于核电厂职业辐射暴露管理的年度国际”合理可行盡量低原則（ALARA）”辐射防护最优化年度讨论会继续为该系统的参加者和供应商提供关于交流职业辐射暴露问题的实用信息和经验交流的重要论坛。由 IAEA 技术中心组织的 2009 年度 ISOE 国际 ALARA 辐射防护最优化讨论会在奥地利维也纳举行。各技术中心还继续主办地区讨论会，包括 2009 年由北美技术中心与电力研究所（EPRI）在美国劳德尔代堡联合举办的 ISOE 北美地区 ALARA 辐射防护最优化讨论会，以及由亚洲技术中心在日本青森组织召开的 ISOE 亚洲地区 ALARA 辐射防护最优化讨论会。这些专题讨论会为使职业辐射辐射暴露保持在可以合理达到的尽可能的低的理念和管理方式，提供了全球交流的论坛。

具有重要意义的是，各技术中心通过对要求进行快速技术反馈的特别请求进行答复来提供支持，还在组织自愿的现场基准访问，开展 ISOE 地区之间的剂量降低信息交流方面提供支持。通过 ISOE 专题讨论会和技术访问两种形式，为辐射防护专业人员汇聚一堂，共享信息，建立 ISOE 各地区之间的联系，形成职业辐射暴露管理的全球化方式，提供了手段。

ISOE 数据分析工作组(WGDA)继续从事有关支持 ISOE 数据和经验的技术分析的活动，重点在于 ISOE 数据库的完整性和一致性、以及 ISOE 数据资源向 ISOE 网站的转移。

报告第六部分概述了 ISOE 参加国所发生的主要事件。附录中提供了 ISOE 参加国的详细情况和 2010 年工作计划。

概　　略

1992 年以来、ISOE（職業被ばく情報システム）は、原子力発電所の放射線防護専門家と規制当局による世界規模での情報と経験交換ネットワーク、及び関連した ALARA 管理の技術的な資源の公表を通じて、原子力発電所作業員の放射線防護の最適化を支援している。この ISOE プログラムの第 19 年次報告書（2009）は、2009 年の ISOE プログラムの状況を示したものである。

ISOE は OECD/NEA と IAEA が共同出資をしており、ISOE メンバーの資格はプログラムの規約を承認した電気事業者と規制当局に開かれている。2008-2011 年に適用される現在の規約は 2008 年 1 月 1 日に発効した。2010 年末では、ISOE プログラムには 26 ヵ国から 66 の加盟電気事業者（320 基は運転中； 40 基は操業停止）並びに 24 ヵ国の規制当局が参加している。ISOE 職業被ばくデータベース自体には 29 ヵ国、401 基の運転中原子炉の職業被ばくレベル及び傾向に関する情報が含まれおり、全世界の商用運転中の原子炉の約 91%が扱われている。 4 つの技術センター（欧州、北米、アジア、IAEA）はプログラムの技術的な運営を日々管理している。

ISOE メンバーから提供された職業被ばくデータによれば、運転中原子炉における 2009 年の一炉あたりの平均集団線量及び一炉あたりの 3 年平均年間集団線量(2007-2009 年)は以下の通りである。

	2009 年 平均集団線量 (MAN･Sv/炉)	2007-2009 年 3 年平均 (MAN･Sv/炉)
加圧水型原子炉 (PWR)	0.77	0.74
加圧水型原子炉 (VVER)	0.49	0.59
沸騰水型原子炉 (BWR)	1.41	1.39
加圧重水型原子炉 (PHWR/CANDU)	1.43	1.16
ガス冷却炉 (GCR)と軽水黒鉛炉(LWGR)を含む全ての原子炉	0.93	0.88

運転中の原子炉からの情報に加え、ISOE データベースには、操業停止または廃止措置段階にある 81 基の原子炉からの線量データが含まれている。 データベースに含まれる原子炉は通常、型や規模が異なっており、また、廃止措置計画の段階が異なっているので、明確な線量傾向を特定するのは難しい。しかし、効果的なベンチマーキングの促進のため、このような原子炉のデータ収集整備を 2009 年も継続した。運転中原子炉及び廃止措置段階の原子炉の職業被ばく傾向の詳細は報告書の第 2 章に記載されている。

ISOE はその職業被ばくデータと分析においてよく知られているが、システムの強みは加盟者の間でこのような情報を広く共有するという目的によるものである。2009 年において ISOE ネットワーク・ウェブサイト（www.isoe-network.net）は、線量低減と ISOE の ALARA 資源に関する包括的なウェブベースの情報と経験交換の窓口を ISOE メンバーに提供することが継続されている。メンバーの職業被ばくデータのオンライン提出のためのデータ入力モジュールの最終的な開発及びテストは、2010 年のデータ収集及び実装に向け、2009 年に完了した。

原子力発電所での職業被ばく管理に関する年次 ISOE 国際 ALARA シンポジウムは、職業被ばく問題について実用的な情報と経験を交換するために ISOE メンバーとベンダーに重要なフォーラムの提供を続けている。IAEA 技術センターによる 2009 年 ISOE 国際 ALARA シンポジウムは、オーストリアのウィーンで開催された。また、技術センターは、地域シンポジウムの開催を継続しており、2009 年には米国のフォート・ローダーデールにおいて EPRI 共催、北米技術センターによる ISOE 北米地域 ALARA シンポジウム、日本の青森においてアジア技術センターによる ISOE アジア地域 ALARA シンポジウムが開催された。これらのシンポジウムは職業放射線被ばくを合理的に達成可能な限り低く維持するための考え及び管理方法の交換を促進するために世界的規模のフォーラムを提供している。

迅速な技術的フィードバックを求める特別なリクエストに対する回答、そして ISOE 地域間の線量低減情報交換のための自主的なサイト・ベンチマーキング訪問の実施において、技術センターが提供する支援は重要である。シンポジウムと技術的な訪問を組み合わせることにより、放射線防護専門家が集まり、情報を共有し、ISOE 地域間の連結を築くことができ、作業管理のための世界的規模のアプローチの開発手段が提供されている。

ISOE データ分析ワーキンググループ（WGDA）は、ISOE データベースの完全性、一貫性及び ISOE データベース資源の ISOE ネットワーク・ウェブサイトへの移行に主に焦点を合わせ、ISOE データ及び経験の技術分析の支援活動を継続した。

本報告書の第 6 章で ISOE 加盟国の主な出来事について要約する。ISOE の参加者の詳細、及び 2009 年の作業計画は附属書に提示する。

РЕЗЮМЕ

С 1992 года Информационная система контроля профессионального облучения персонала АЭС (ISOE) направлена на оптимизацию радиационной защиты работников АЭС посредством использования всемирной сети по обмену информацией и опытом между специалистами по радиационной защите на АЭС и в национальных регулирующих органах, а также путем публикации соответствующих технических материалов по управлению работами на основе принципа ALARA. Настоящий 19-й ежегодный доклад о результатах работы по программе ISOE отражает положение дел с осуществлением программы ISOE в 2009 календарном году.

Финансирование программы ISOE осуществляется совместно АЯЭ ОЭСР и МАГАТЭ. Вступление в программу ISOE открыто для всех атомных электростанций, а также национальных регулирующих органов, отвечающих за вопросы радиационной защиты персонала АЭС. Единственным необходимым условием членства является ратификация Положения и Условий этой программы. Нынешние Положение и Условия ISOE на период 2008-2011 годов вступили в силу 1 января 2008 года. В конце 2010 года программа ISOE включала в себя 66 Эксплуатирующую Организацию в 26 странах мира (320 энергоблок, находящийся в промышленной эксплуатации; 40 остановленных энергоблока), а также национальные регулирующие органы 24 стран. База данных по профессиональному облучению ISOE содержала информацию об уровнях и тенденциях профессионального облучения на 401 находящихся в эксплуатации реакторах в 29 странах, охватывая приблизительно 91% находящихся в эксплуатации промышленных энергетических реакторов мира. Управление повседневной технической деятельностью по программе ISOE обеспечивается четырьмя техническими центрами (Европа, Северная Америка, Азия и МАГАТЭ).

На основе данных о профессиональном облучении, полученных от участников программы ISOE, значения средней годовой коллективной дозы в 2009 году, нормированные на один энергоблок, а также средние за трехлетний период (2007-2009 годы) значения коллективных доз, нормированных на один энергоблок, в отношении находящихся в эксплуатации энергетических реакторов составляли:

	Средняя годовая коллективная доза за 2009 г. (чел.·Зв/энергоблок)	Средняя коллективная доза за трехлетний период 2007-2009 г. (чел.·Зв/энергоблок)
Реакторы с водой под давлением (PWR)	0.77	0.74
Реакторы с водой под давлением (ВВЭР)	0.49	0.59
Кипящие водяные реакторы (BWR)	1.41	1.39
Корпусные тяжеловодные реакторы (PHWR/CANDU)	1.43	1.16
Все реакторы, включая газоохлаждаемые (GCR) и легководные реакторы с графитовым замедлителем (LWGR)	0.93	0.88

В дополнение к информации по находящимся в эксплуатации энергоблокам, база данных ISOE содержит также данные о дозах по 81 реакторам, находящимся в стадии останова или снятия с эксплуатации. Поскольку эти энергоблоки, как правило, относятся к различным типам, имеют различные мощности и находятся на различных стадиях снятия с эксплуатации, определение четких тенденции в изменении их дозиметрических показателей представляется затруднительным. Тем не менее, в 2009 году продолжилась работа по улучшению сбора данных по таким реакторам с целью совершенствования методов их сравнительной оценки. Подробная информация о тенденциях уровней профессионального облучения применительно к реакторам, находящимся в промышленной эксплуатации, а также реакторам, находящимся в процессе снятия с эксплуатации, содержится в разделе 2 настоящего доклада.

Целью программы ISOE является максимально широкое распространение данных и аналитической информации о профессиональном облучении персонала АЭС среди всех участников. В 2009 году на интернет веб-сайте ISOE (www.isoe-network.net) было продолжено размещение всеобъемлющей информации, а также обеспечена работа специализированного форума для обмена опытом по различным аспектам снижения доз и применения принципа ALARA. Учитывая успешное завершение работ по созданию модулей ввода данных о профессиональном облучении персонала АЭС в он-лайновом режиме через вэб-сайт ISOE, сбор и обработка дозиметрической информации за 2009 год осуществлялись на основе полномасштабного использования данной системы.

Ежегодно проводимые в рамках программы ISOE международные симпозиумы ALARA по оптимизации профессионального облучения персонала АЭС являются важным средством обмена практической информацией и опытом по вопросам профессионального облучения как для участников программы ISOE, так и для работающих в данной отрасли компаний-поставщиков продукции. В 2009 году в Вене, Австрия был проведен Международный ALARA Симпозиум, организованный техническим центром ISOE в МАГАТЭ. Ряд региональных симпозиумов в 2009 году был организован другими техническими центрами ISOE. Североамериканским техническим центром ISOE совместно с Исследовательским Институтом Электрической Энергии (EPRI) был проведен региональный ISOE ALARA симпозиум в Форт-Лоудердейл, США. Азиатским техническим центром ISOE был проведен региональный ISOE ALARA симпозиум в Аомори, Япония. Проведение таких симпозиумов обеспечивает глобальный форум для содействия обмену идеями и управленческими подходами в отношении поддержания профессионального радиационного облучения на разумно достижимом низком уровне.

Важное значение имеет поддержка, которую технические центры ISOE предоставляют в ответ на специальные запросы, требующие оперативной обратной связи по вопросам технического характера, а также в плане организации технических визитов объектов с целью проведения контрольных сравнений для обмена информацией между регионами ISOE по вопросам снижения доз облучения персонала АЭС. Сочетание симпозиумов и технических визитов ISOE предоставляет специалистам по радиационной защите возможность встретиться, обменяться информацией и установить связи между регионами ISOE для выработки глобального подхода к управлению профессиональным облучением.

Международная рабочая группа по анализу данных ISOE (WGDA) продолжала свою деятельность по техническому анализу данных и опыта ISOE. Основное внимание в работе WGDA было направлено на обеспечение целостности и согласованности базы данных ISOE, а также использование новых возможностей базы данных ISOE на интернет веб-сайте.

Основные показатели состояния радиационной защиты персонала АЭС, полученные в странах-участниках ISOE за отчетный период, кратко излагаются в разделе 6 настоящего доклада. Сведения об участниках ISOE и программа работы на 2010 год содержатся в приложениях.

RESUMEN EJECUTIVO

Desde 1992, el Sistema de Información sobre Exposición Ocupacional (Information System on Occupational Exposure, ISOE), ha apoyado la optimización de la protección radiológica de los trabajadores de las centrales nucleares a través de una red de intercambio de experiencia e información a escala mundial para los profesionales de protección radiológica de centrales y las autoridades reguladoras, y mediante la publicación de informes técnicos relevantes sobre gestión ALARA. Este 19º Informe Anual del Programa ISOE (2009) presenta el estado del programa ISOE para el año 2009.

La participación en el programa ISOE, co-patrocinado conjuntamente por la OCDE/NEA y el OIEA, está abierta a compañías eléctricas y autoridades reguladoras de todo el mundo que acepten los Términos y Condiciones del Programa. Los Términos y Condiciones para el periodo 2008-2011 entraron en vigor el 1 de Enero de 2008. A finales de 2010, el programa ISOE contaba con la participación de 66 compañías eléctricas de 26 países (320 unidades en operación y 40 paradas), así como de las autoridades reguladoras de 24 países. La base de datos de exposición ocupacional del ISOE incluía información sobre niveles de exposición ocupacional y tendencias en 401 reactores en operación en 29 países, cubriendo el 91% del total de reactores comerciales de potencia en el mundo. Cuatro Centros Técnicos del ISOE (Europa, Norteamérica, Asia y el OIEA) gestionan día a día las funciones técnicas del programa.

En base a los datos de exposición ocupacional aportados por los miembros del ISOE y referidos a reactores de potencia en operación, la dosis colectiva media anual por reactor en 2009 y la media trienal (2007-2009) por reactor fueron:

	Dosis colectiva anual media en 2009 (Sv·p/reactor)	**Media de dosis trienal 2007-2009 (Sv·p/reactor)**
Reactores de agua a presión (PWR)	0.77	0.74
Reactores de agua a presión (VVER)	0.49	0.59
Reactores de agua en ebullición (BWR)	1.41	1.39
Reactores de agua pesada a presión (PHWR/CANDU)	1.43	1.16
Todos los reactors, incluyendo los refrigerados por gas (GCR) y los de agua ligera y grafito (LWGR)	0.93	0.88

Además de la información relativa a los reactores en operación, la base de datos del ISOE contiene datos de dosis de 81 reactores parados o en alguna etapa del proceso de clausura. Dado que estos reactores son de diferentes tipos y tamaños y se encuentran en diferentes fases de sus respectivos programas de clausura, es difícil identificar tendencias dosimétricas claras. No obstante, en 2009 se ha continuado mejorando la recopilación de datos de dichos reactores con el fin de proporcionar una mejor comparativa. La sección 2 de este documento presenta información detallada sobre las tendencias de dosis ocupacionales para reactores en operación y reactores en fase de clausura.

Aunque el programa ISOE es bien conocido por sus datos y análisis de exposición ocupacional, su fuerza radica en el objetivo de compartir ampliamente esta información entre sus participantes. En 2009, la página web del ISOE (www.isoe-network.net) continuó poniendo a disposición de los miembros del programa un portal de información amplia y de intercambio de experiencias sobre reducción de dosis y recursos ALARA. La finalización y pruebas de los módulos de entrada on-line de datos de exposición ocupacional se completaron en 2009, para la implementación y recogida de datos en 2010.

Los Simposios anuales Internacionales ALARA del ISOE sobre la gestión de la exposición ocupacional en centrales nucleares, continúan siendo foros importantes para participantes del ISOE y suministradores para intercambiar información práctica y experiencias en temas de exposición ocupacional. El Simposio ALARA Internacional de 2009 del ISOE, organizado por el OIEA fue celebrado en Viena, Austria. Los centros técnicos siguieron albergando simposios regionales, que en 2009 incluyeron el Simposio Regional Norteamericano del ISOE que se celebró en Fort Lauderdale, Estados Unidos, organizado por el Centro Técnico Norteamericano en cooperación con EPRI y el Simposio Regional Asiático organizado por el Centro Técnico Asiático en Aomori, Japón. Estos simposios proporcionan un foro global para la promoción del intercambio de ideas y planteamientos de gestión para mantener los niveles de exposición ocupacional tan bajos como sea razonablemente posible.

Es importante el apoyo que brindan los centros técnicos en respuesta a los requerimientos específicos de realimentación técnica, así como la organización de visitas voluntarias para el intercambio de información sobre reducción de dosis entre regiones del programa ISOE. La combinación de los simposios del ISOE y las visitas técnicas proporciona un valioso foro de encuentro, intercambio de información y establecimiento de relaciones entre las regiones ISOE para los profesionales de la protección radiológica, con el fin de desarrollar un planteamiento global a la gestión de la exposición ocupacional.

El Grupo de Trabajo para el Análisis de Datos (Working Group on Data Analysis, WGDA) del ISOE continuó sus actividades de apoyo al análisis técnico de los datos y experiencias operativas del ISOE, centrándose en gran medida en la integridad y consistencia de la base de datos del ISOE, así como en la migración de sus recursos a la página web.

Los principales sucesos ocurridos en los países participantes en el programa ISOE se resumen en la Sección 6 del presente informe. En los Anexos se ofrecen detalles de las participaciones en el ISOE y el programa de trabajo para 2010.

1. STATUS OF PARTICIPATION IN THE INFORMATION SYSTEM ON OCCUPATIONAL EXPOSURE (ISOE)

Since 1992, 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 from utilities and national regulatory authorities, and through the publication of relevant technical resources for ALARA management. The ISOE programme includes a global occupational exposure data collection and analysis programme, culminating in the world's largest database on occupational exposures at nuclear power plants, and a communications network for sharing dose reduction information and experience. Since the launch of ISOE, participants have used these resources 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 radiation protection programmes, and the sharing of experience globally.

ISOE Participants include nuclear electricity utilities (public and private), national regulatory authorities (or institutions representing them) and ISOE Technical Centres who have agreed to participate in the operation of ISOE under its Terms and Conditions (2008-2011). Four ISOE Technical Centres (Asia, Europe, North America and IAEA) manage the day-to-day technical operations in support of the membership in the four ISOE regions (see Annex 3 for country-technical centre affiliation). The objective of ISOE is to make available to the Participants:

- broad and regularly updated information on methods to improve the protection of workers and on occupational exposure in nuclear power plants; and
- a mechanism for dissemination of information on these issues, including evaluation and analysis of the data assembled, as a contribution to the optimisation of radiation protection.

Based on feedback received by the ISOE Secretariat as of December 2010, the ISOE programme included: 66 Participating Utilities[1] in 26 countries, covering 320 operating units; 40 shutdown units), and the Regulatory Authorities of 24 countries (3 countries participate with 2 authorities). Table 1 summarises total participation by country, type of reactor and reactor status as of December 2010. A complete list of reactors, utilities and authorities officially participating in ISOE at the time of publication of this report is provided in Annex 3.

In addition to exposure data provided annually by Participating Utilities, Participating Authorities may also contribute with official national data in cases where some of their licensees are not ISOE members. The ISOE database thus includes occupational exposure data and information of 472 reactor units in 29 countries (396 operating; 75 in cold-shutdown or some stage of decommissioning; 1 pre-operational), covering about 90% of the world's operating commercial power reactors. The ISOE database is made available to all ISOE members, according to their status as a participating utility or authority, through the ISOE Network website and on CD-ROM.

1. Represents the number of lead utilities; in some cases, plants are owned/operated by multiple enterprises.

Table 1. **The Official ISOE Participants and the ISOE Database (as of December 2009)**

Note: The list of the Official ISOE Participants at the time of the publication of this report is provided in Annex 3.

Operating reactors: ISOE Participants

Country	**PWR**	**VVER**	**BWR**	**PHWR**	**GCR**	**LWGR**	**Total**
Armenia	-	1	–	–	–	–	1
Belgium	7	–	–	–	–	–	7
Brazil	2	–	–	–	–	–	2
Bulgaria	-	2	–	–	–	–	2
Canada	–	–	–	22	–	–	22
China	4	–	–	–	–	–	4
Czech Republic	-	6	–	–	–	–	6
Finland	-	2	2	–	–	–	4
France	58	–	–	–	–	–	58
Germany	4	–	2	–	–	–	6
Hungary	–	4	–	–	–	–	4
Japan	24	–	32[1]	–	–	–	56
Korea, Republic of	16	–	–	4	–	–	20
Mexico	–	–	2	–	–	–	2
The Netherlands	1	–	–	–	–	–	1
Pakistan	1	–	–	1	–	–	2
Romania	–	–	–	2	–	–	2
Russian Federation	–	15	–	–	–	–	15
Slovak Republic	–	6	–	–	–	–	6
Slovenia	1	–	–	–	–	–	1
South Africa, Rep. of	2	–	–	–	–	–	2
Spain	6	–	2	–	–	–	8
Sweden	3	–	7	–	–	–	10
Switzerland	3	–	2	–	–	–	5
Ukraine	–	2	–	–	–	–	2
United Kingdom	1	–	–	–	–	–	1
United States	43	–	28	–	–	–	71
Total	**182**	**36**	**75**	**27**	**–**	–	**320**

Operating reactors: Not participating in ISOE, but included in the ISOE database[2]

Country	**PWR/VVER**	**BWR**	**PHWR**	**GCR**	**LWGR**	**Total**
Canada	–	–	1	–	–	1
China	1	–	–	–	–	1
Lithuania	–	–	–	–	1	1
Pakistan	1	–	1	–	–	2
Ukraine	15	–	–	–	–	15
United Kingdom	–	–	–	14	–	14
United States	37	6	–	–	–	43
Total	**54**	**6**	**2**	**14**	**1**	**77**

Total number of operating reactors included in the ISOE database

	PWR/VVER	**BWR**	**PHWR**	**GCR**	**LWGR**	**Total**
Total	**272**	**81**	**29**	**14**	**1**	**397**

2. Includes Hamaoka Unit No. 1 & No. 2 that have been decommisisionnig since 18 Nov. 2009.

Table 1. **The Official ISOE Participants and the ISOE Database (as of December 2009) (Cont'd)**

Definitively shutdown reactors: ISOE Participants							
Country	**PWR/ VVER**	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Bulgaria	4	–	–	–	–	–	4
Canada	–	–	2	–	–	–	2
France	1	–	–	6	–	–	7
Germany	3	1	–	1	–	–	5
Italy	1	2	–	1	–	–	4
Japan	–	2	–	1	–	1	2
The Netherlands	–	1	–	–	–	–	1
Russian Federation	2	–	–	–	–	–	2
Slovak Republic	2	–	–	–	–	–	2
Spain	1	–	–	1	–	–	2
Sweden	–	2	–	–	–	–	2
United States	–	–	–	9	–	–	9
Total	**12**	**6**	**2**	**19**	–	**1**	**40**
Definitively shutdown reactors: Not participating in ISOE but included in the ISOE database							
Country	**PWR/ VVER**	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Lithuania	–	–	–	–	1	–	1
Ukraine	–	–	–	–	3	–	3
United Kingdom	–	–	–	19	–	–	19
United States	5	6	–	1	–	–	12
Total	**5**	**6**	–	**20**	**4**	–	**35**
Total number of definitively shutdown reactors included in the ISOE database							
	PWR/ VVER	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Total	**17**	**12**	**2**	**39**	**4**	**1**	**75**

Total number of reactors included in the ISOE database							
	PWR/ VVER	**BWR**	**PHWR**	**GCR**	**LWGR**	**Other**	**Total**
Total	**289**	**93**	**31**	**53**	**5**	**1**	**472**

Number of **Participating Countries**	**26**
Number of **Participating Utilities**[3]	**66**
Number of **Participating Authorities**[4]	**24**

3. Represents the number of lead utilities; in some cases, plants are owned/operated by multiple enterprises.
4. Three countries participate with two authorities.

2. OCCUPATIONAL DOSE STUDIES, TRENDS AND FEEDBACK

A key element of the ISOE is the tracking of occupational exposure trends from nuclear power facilities worldwide for benchmarking, comparative analysis and experience exchange amongst ISOE members. This information is maintained in the ISOE Occupational Exposure Database (ISOEDAT) which contains annual occupational exposure data supplied by Participating Utilities (generally based on operational dosimetry systems). The ISOE database includes the following data types:

- Dosimetric information from commercial NPPs in operation, shut down or in some stage of decommissioning, including:
  - annual collective dose for normal operation
  - maintenance/refuelling outage
  - unplanned outage periods
  - annual collective dose for certain tasks and worker categories
- Plant-specific information relevant to dose reduction, such as materials, water chemistry, start-up/shutdown procedures, cobalt reduction programme, etc.
- Radiation protection related information for specific operations, jobs, procedures, equipment or tasks (radiological lessons learned):
  - effective dose reduction
  - effective decontamination
  - implementation of work management principles

Using the ISOE database, ISOE members can perform various benchmarking and trend analyses by country, by reactor type, or by other criteria such as sister-unit grouping. The summary below provides highlights of the general trends in occupational doses at nuclear power plants.

2.1 Occupational exposure trends: Operating reactors

Figures 1 and 2 show the trends in annual average and 3-year rolling average collective dose per reactor, by reactor type, for 1992-2009. In general, the average collective dose per operating reactor unit has consistently decreased over the time period covered in the ISOE database, with the 2009 averages maintaining the levels reached in last few years. In spite of some yearly variations, the clear downward dose trend in most reactors has continued, with the exception of PHWRs, which have shown a slight increasing trend since the lows achieved in the 1996-1998 time period.

With respect to 2009, a summary of average annual collective doses by reactor type is provided in Table 2. Exposure trends over the past three years for participating countries and by technical centre regional groupings, expressed as average annual and 3-year rolling average annual collective doses per reactor are shown in Tables 3 and 4 respectively. These results are based primarily on data reported and recorded in the ISOE database during 2009, supplemented by the individual country reports (Section 6) as required. Figures 3 to 7 provide a detailed breakdown of the 2009 data in bar-chart format, ranked from highest to lowest average dose. In all figures, the “number of units” refers to the number of reactor units for which data has been reported for the year in question.

Figure 1. **Average collective dose per reactor for all operating reactors included in ISOE by reactor type, 1992-2009 (man·Sv/reactor)**

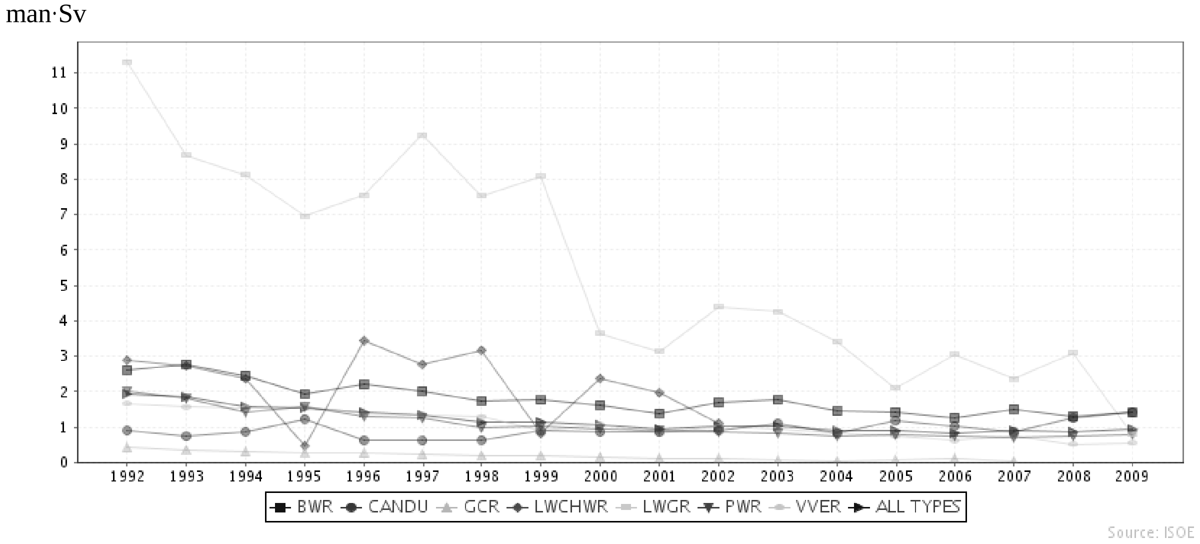


Figure 2. **3-year rolling average per reactor for all operating reactors included in ISOE by reactor type, 1992-2009 (man·Sv/reactor)**

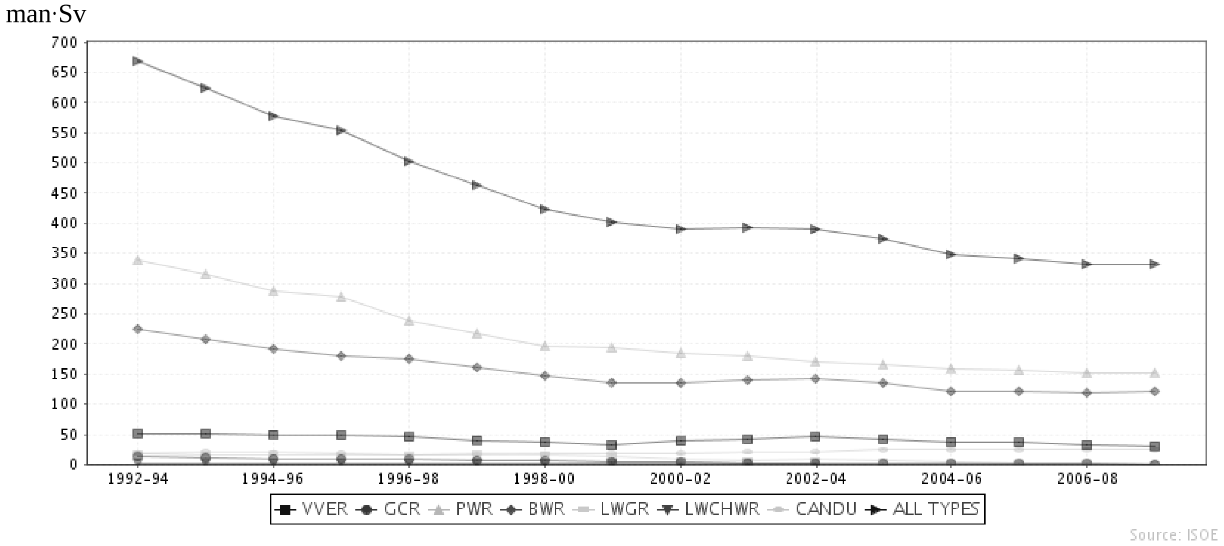


Table 2. **Summary of average collective doses for operating reactors, 2009**

	2009 average annual collective dose (man·Sv/reactor)	3-year rolling average for 2007-2009 (man·Sv/reactor)
Pressurised water reactors (PWR)	0.77	0.74
Pressurised water reactors (VVER)	0.49	0.59
Boiling water reactors (BWR)	1.41	1.39
Pressurised heavy water reactors (PHWR/CANDU)	1.43	1.16
All reactors, including gas cooled (GCR) and light water graphite reactors (LWGR)	0.93	0.88

Table 3. **Average annual collective dose per reactor, by country and reactor type, 2007-2009 (man·Sv/reactor)**

	PWR			VVER			BWR		
	2007	2008	2009	2007	2008	2009	2007	2008	2009
Armenia				0.78	1.24	0.55			
Belgium	0.29	0.39	0.37						
Brazil	1.05	0.74	1.04						
Bulgaria				0.41	0.27	0.28			
Canada									
China	0.66	0.54	0.54						
Czech Republic				0.17	0.13	0.15			
Finland				0.36	0.78	0.38	0.59	0.46	0.59
France	0.62	0.66	0.70						
Germany	1.04	0.62	1.05				0.99	1.19	1.00
Hungary				0.45	0.33	0.44			
Japan	1.35	1.64	1.61				1.48	1.42	1.37
Korea, Republic of	0.60	0.49	0.47						
Mexico							2.74	4.69	2.08
The Netherlands	0.23	0.27	0.24						
Pakistan	n/a	0.59	n/a						
Romania									
Russian Federation				0.91	0.69	0.80			
Slovak Republic				0.24	0.16	0.17			
Slovenia	0.89	0.15	0.65						
South Africa, Rep. of	0.74	0.75	0.74						
Spain	0.50	0.29	0.72				4.15	0.50	2.31
Sweden	0.41	0.56	0.92				1.10	0.85	1.41
Switzerland	0.37	0.46	0.36				1.10	1.16	1.14
Ukraine				1.17	0.65	0.72			
United Kingdom	0.05	0.26	0.34						
United States	0.65	0.68	0.66				1.58	1.23	1.49
Average	**0.71**	**0.73**	**0.77**	**0.74**	**0.74**	**0.49**	**1.51**	**1.31**	**1.41**

	PHWR			GCR			LWGR		
	2007	2008	2009	2007	2008	2009	2007	2008	2009
Canada	0.92	1.36	1.13						
Korea, Republic of	0.80	0.59	2.21						
Lithuania							2.37	3.10	0.79
Pakistan	n/a	3.70	n/a						

Romania	0.27	0.34	0.24						
United Kingdom				0.06	0.14	0.09			
Average	**0.87**	**1.25**	**1.23**	**0.06**	**0.14**	**0.09**	**2.37**	**3.10**	**0.79**

	2007	2008	2009
Global Average	**0.89**	**0.86**	**0.88**

	Europe			**Asia**			**North America**			**IAEA**		
	2007	**2008**	**2009**	**2007**	**2008**	**2009**	**2007**	**2008**	**2009**	**2007**	**2008**	**2009**
PWR	0.62	0.60	0.71	1.04	1.17	1.15	0.65	0.68	0.66	0.78	0.58	0.69
VVER	0.28	0.26	0.25							0.99	0.67	0.72
BWR	1.33	0.91	1.26	1.48	1.42	1.37	1.65	1.42	1.52			
PHWR				0.92	1.36	1.13	0.92	1.36	1.13	0.80	0.59	2.21
GCR	0.06	0.14	0.09									
LWGR										2.37	3.10	0.79

See Annex 3 for the country composition of the four ISOE Regions.

Table 4. **3-year rolling average annual collective dose per reactor, by country and reactor type, 2005-2007 to 2007-2009 (man·Sv/reactor)**

	PWR			VVER			BWR		
	/05-/07	**/06-/08**	**/07-/09**	**/05-/07**	**/06-/08**	**/07-/09**	**/05-/07**	**/06-/08**	**/07-/09**
Armenia				0.83	0.96	0.86			
Belgium	0.36	0.35	0.35						
Brazil	0.74	0.78	0.94						
Bulgaria				0.56	0.37	0.32			
Canada									
China	0.60	0.56	0.58						
Czech Republic				0.17	0.15	0.15			
Finland				0.53	0.66	0.50	0.94	0.72	0.55
France	0.70	0.66	0.66						
Germany	1.06	0.83	0.90				1.05	1.11	1.06
Hungary				0.43	0.38	0.41			
Japan	1.13	1.36	1.53				1.35	1.40	1.42
Korea, Republic of	0.57	0.54	0.52						
Mexico							1.97	2.97	3.17
The Netherlands	0.35	0.38	0.25						
Pakistan	0.22	0.31	0.59						
Romania									
Russian Federation				0.87	0.77	0.80			
Slovak Republic				0.30	0.23	0.19			
Slovenia	0.61	0.63	0.56						
South Africa, Rep. of	0.89	0.76	0.74						
Spain	0.43	0.39	0.50				2.29	1.69	2.32
Sweden	0.52	0.49	0.63				1.08	1.02	1.12
Switzerland	0.46	0.40	0.40				1.02	1.08	1.13
Ukraine				1.04	0.93	0.85			
United Kingdom	0.31	0.28	0.22						
United States	0.76	0.73	0.66				1.54	1.38	1.43
Average	**0.74**	**0.73**	**0.74**	**0.70**	**0.63**	**0.61**	**1.40**	**1.36**	**1.41**

	PHWR			GCR			LWGR		
	/05-/07	**/06-/08**	**/07-/09**	**/05-/07**	**/06-/08**	**/07-/09**	**/05-/07**	**/06-/08**	**/07-/09**
Canada	1.07	1.09	1.14						
Korea, Republic of	0.71	0.66	1.20						
Lithuania							2.51	2.84	2.09
Pakistan	2.96	4.09	3.70						
Romania	0.52	0.38	0.29						
United Kingdom				0.08	0.11	0.10			
Average	**1.04**	**1.06**	**1.12**	**0.08**	**0.11**	**0.10**	**2.51**	**2.84**	**2.09**

	/05-/07	**/06-/08**	**/07-/09**
Global Average	**0.87**	**0.85**	**0.87**

	Europe			Asia			North America			IAEA		
	/05-/07	**/06-/08**	**/07-/09**	**/05-/07**	**/06-/08**	**/07-/09**	**/05-/07**	**/06-/08**	**/07-/09**	**/05-/07**	**/06-/08**	**/07-/09**
PWR	0.66	0.60	0.60	0.90	1.02	1.12	0.76	0.73	0.66	0.66	0.63	0.68
VVER	0.32	0.28	0.26							0.91	0.81	0.79
BWR	1.07	1.02	1.13	1.35	1.40	1.42	1.54	1.38	1.43			
PHWR				1.07	1.09	1.14	1.07	1.09	1.14	0.71	0.66	1.20
GCR	0.08	0.11	0.10									
LWGR										2.51	2.84	2.09

The following discussion provides a brief overview of the results and trends observed in the four ISOE regions. However, it is noted that due to the various power plant designs and the complex parameters influencing collective doses, these analyses and figures do not support any conclusions with regard to the quality of radiation protection performance in the countries addressed. More detailed discussion and analyses of dose trends in individual countries are provided in Section 6.

European Region

In 2009, the average annual collective dose per reactor for all PWRs is increasing compared to in 2008 going from 0.60 man·Sv to 0.71 man·Sv for PWRs and remains stable for VVERs (around 0.25 man·Sv). The average collective dose for all BWRs has also increased compared to 2008, with a value at 1.26 man·Sv compared to 0.91 in 2008. Among the reasons which can explain such an increase, it can be noted that year 2009 was marked by the following situations in the main countries affected:

- Sweden: ongoing projects of modernisation,
- Germany: outages performed for all plants (4 of them with a duration exceeding 10 months),
- Spain: unscheduled BWR outages and a large refuelling PWR outage,
- France: a great number of unforeseen events (with an impact of 0.92 man·Sv), 2 reactor vessel head replacements and 1 steam generator replacement.

The evolution of the 3-year rolling average annual collective dose, which provides a better representation of the general trend in dose, shows a continuity of the decrease for VVERs. An increase of the 2007-2009 value is noticed for PWRs and BWRs compared to the previous period. For these two types of reactors, the value of 2007-2009 still is lower than the 2005-2007 value.

Regarding VVERs, the Czech Republic presents the lowest 3-year rolling average annual collective dose per reactor in 2007-2009 with 0.15 man·Sv per reactor, followed by the Slovak Republic (0.19 man·Sv per reactor), Hungary (0.41 man·Sv per reactor) and Finland (0.50 man·Sv per reactor).

For European PWRs, the data per country show that with respect to the 3-year rolling average annual collective dose for 2007-2009, five main groups can be distinguished:

- The Netherlands, United Kingdom: below 0.25 man·Sv per reactor,
- Belgium and Switzerland: between 0.3 and 0.4 man·Sv per reactor,
- Spain, Slovenia : between 0.5 and 0.6 man·Sv per reactor,
- France, Sweden: between 0.6 and 0.7 man·Sv per reactor,
- Germany: 0.9 man·Sv per reactor.

The 3-year rolling average annual collective dose per reactor for BWRs are quite similar in Germany, Sweden and Switzerland around 1 man·Sv per reactor. Finland is presenting the lowest value with 0.55 man·Sv per reactor and Spain the highest with 2.32 man·Sv per reactor.

Asian Region

In the Asian region, the 2009 average collective dose per reactor showed a decreasing trend for the Japanese BWRs and Korean PWRs over the last two years, with a steady tendency for longer term. However the increasing tendency was observed for the Japanese PWRs and the Korean PHWRs.

The average annual collective doses per reactor for the Japanese BWRs and PWRs were 1.36 man·Sv and 1.61 man·Sv respectively. The PWR collective dose per reactor for 2009 slightly increased from the previous year by 0.04 man·Sv. The increase was mainly due to the modification works in high dose rate areas such as the repairing of a pressuriser and the replacement of equipment and piping during the periodical inspections. Improvement works of the seismic safety margin were also performed in Japanese BWRs and PWRs.

For Korean NPPs, the average collective doses per reactor for PWRs and PHWRs were 0.47 man·Sv and 2.21 man·Sv respectively. The 2009 collective dose per reactor for PHWRs increased from the previous year by 1.62 man·Sv because of the tremendous improvement of facilities for operating life extension in Wolsung Unit 1.

North American Region

In the North American region, the North American Technical Center provided technical radiological engineering and ALARA planning support to the North American ISOE utility and regulator members in 2009. Significant occupational dose challenges due to nuclear plant modernisation initiatives, major component failures and unit refurbishments are described by country below:

Canada: Pickering A, Unit 4 successfully removed a 450,000 R/hr Co-60 particle lodged in the Boiler 6 piping using 4 robots developed for this first-of-kind nuclear plant hot particle removal. Over 20 months of ALARA planning and 102 ALARA meetings were dedicated to this project. Pickering benefited from an extensive peer review of various approaches evaluated to achieve this significant success with very low occupational dose impact.

Mexico: Laguna Verde Nuclear Plant implemented a power uprate programme for both BWR units starting in 2008 and continued in 2009. The work scope included high and low pressure turbine upgrades, replacement of main condenser pipes with titanium pipes, upgraded the HVAC system of primary containment and moisture separator replacement. Laguna Verde also initiated the use of PRC-01 resin and shutdown protocol similar to Peach Bottom Units 2 & 3 approach to colloid mitigation.

USA: Davis Besse replacement reactor head placed in-service in 2004 was discovered to have 24 nozzles which were degraded and required repair. The replacement reactor head had been purchased from the Midland nuclear plant which was cancelled in the 1980s.

The AREVA Sumo Rocky UT robot was used to perform rotating UT exams inside the Control Rod Drive Mechanism nozzles. The reactor head was made of carbon steel about 6 ½ inches thick. The nozzle is about 4 inches in diameter. The flaws were found on the inside of the reactor head at the nozzle penetration. After machining the flaw away, the nozzle was re-welded remotely. Major dose reduction initiatives included use of carbon dioxide to decontaminate the reactor head, use of shadow shield, removal of all CRDMs, use of EDE monitoring, and use of the Westinghouse Grooveman robot, mock-up and testing assembly for Eddy Current testing to determine the extent of the condition of the nozzles. ALARA challenges for the ALARA group and RPM included management of the 2 Rem (20 mSv) rolling 12-month limit for AREVA employees, 80 additional AREVA personnel trained and sent to Davis-Besse for reactor head nozzle repair and additional testing procedures, added scope of the following:

- 2 additional reactor head moves
- 1 additional cavity fill and drain
- 1 additional incore insertion

- 1 additional cavity decon

The additional outage exposure due to the reactor head CRDM nozzle repairs was 120 person·rem.

Crystal River continued to be in an extended shutdown as repairs to the PWR containment concrete continues during 2009. Susquehanna Units 1 and 2 implemented equipment replacement (high and low pressure turbines) and equipment upgrades to achieve a 14% power uprate to be completed in June 2011. The final unit output will be the largest BWR units in the US of 1300 Megawatt-electric output. Cook Unit 1 experienced a major low pressure turbine badge fracture on September 28, 2009. The turbine went from 1800 rpm to “parade rest” in 2 minutes. A hydrogen fire occurred at the generator. Fortunately, there were no injuries during the event and the fire was extinguished. The Unit 1 turbine had to be completely rebuilt from the foundation and up over a 15 month period. Engineers from Japan, Russia, France, German, Canada and S. Korea assisted the Cook engineers in repairing the 3 low pressure rotors and other engineering evaluations. The Siemens turbine blades were replaced and industry operating event notices were provided to the industry. This notice has assisted another US BWR to identify and shutdown for inspection a Siemens turbine blade which was found to experience similar fractures.

US RPMs continue to experience significant shortages in the supply of senior RP technicians for refueling outage support. The shortage in spring and fall outages has been as high as 40% at some US sites. US RPMs are working with junior colleges near their sites to educate more RP technicians into the talent pipeline for future nuclear plant and contractor employment.

Figure 3. **2009 PWR average collective dose per reactor by country (man·Sv/reactor)**

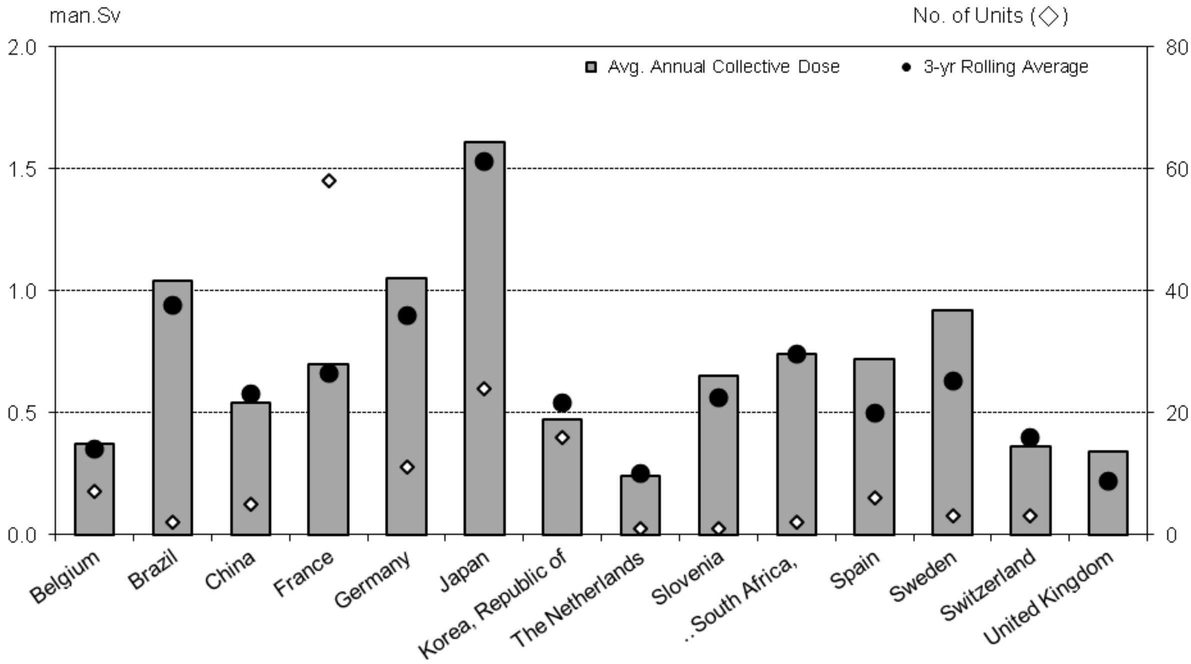


Figure 4. **2009 VVER average collective dose per reactor by country (man·Sv/reactor)**

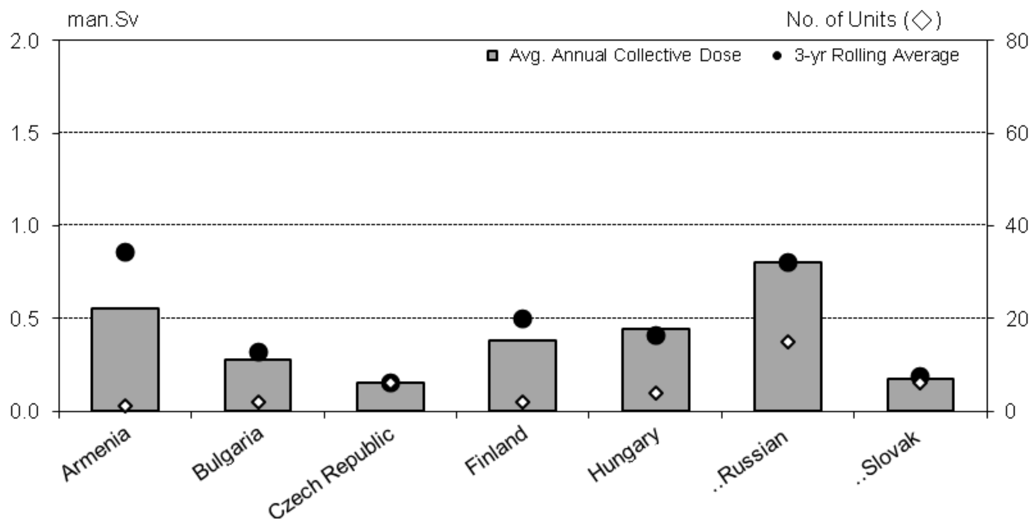


Figure 5. **2009 BWR average collective dose per reactor by country (man·Sv/reactor)**

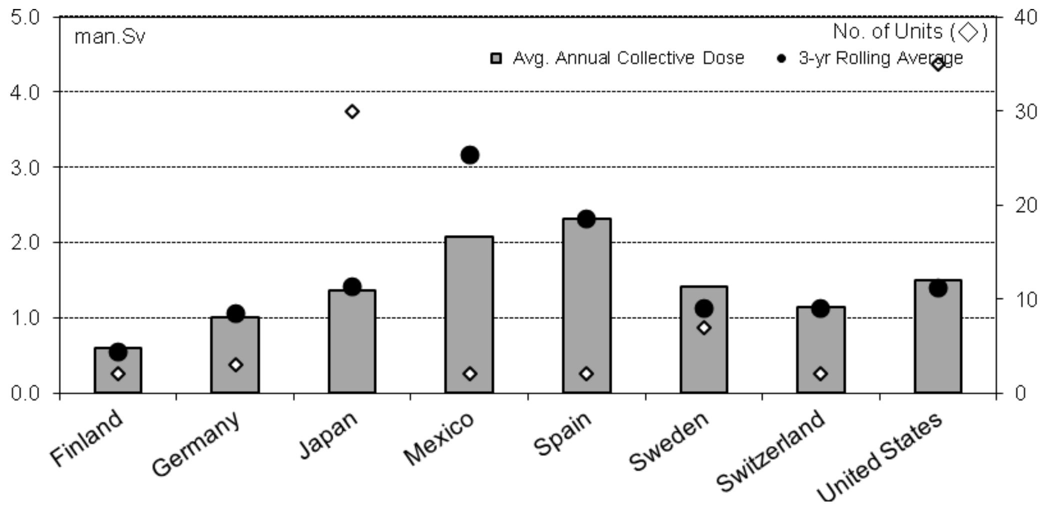


Figure 6. **2009 PHWR average collective dose per reactor by country (man·Sv/reactor)**

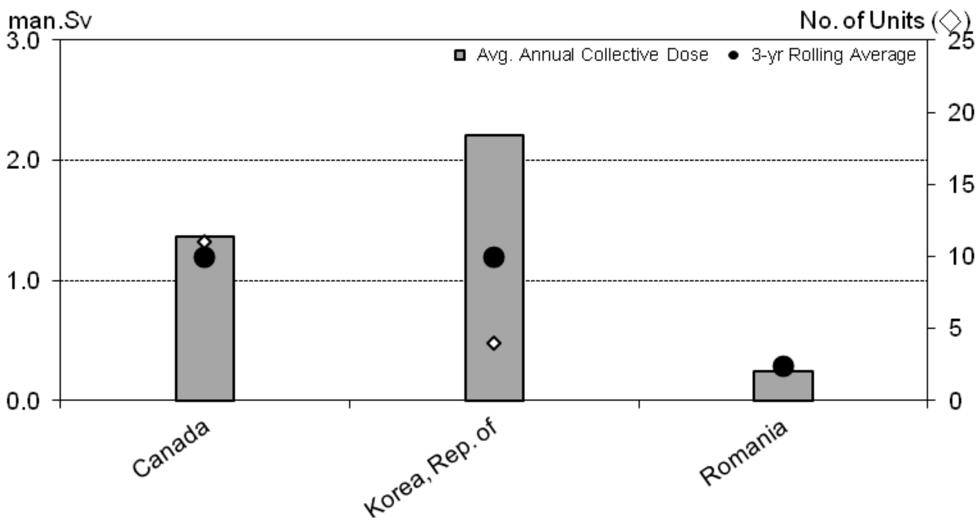
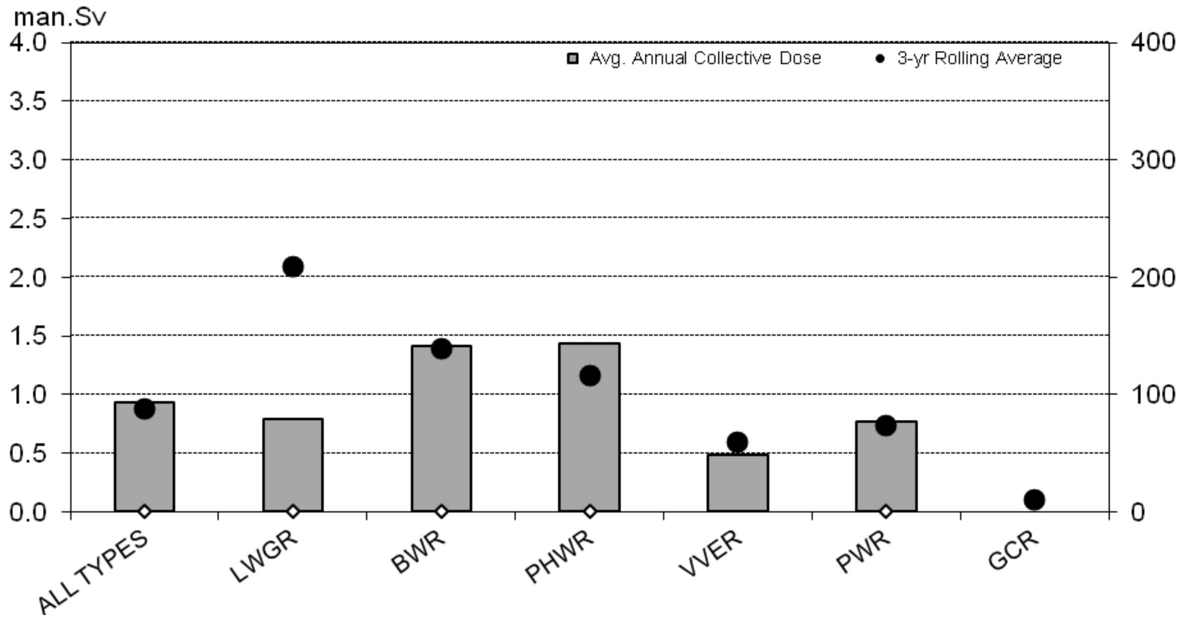


Figure 7. **2009 average collective dose per reactor by reactor type (man·Sv/reactor)**



2.2 Occupational exposure trends: Definitely shutdown reactors

In addition to information from operating reactors, the ISOE database contains dose data from 75 reactors which are shut-down or in some stage of decommissioning. This section provides a summary of the dose trends for those reactors reported during the 2007-2009 period. These reactor units are generally of different type and size, at different phases of their decommissioning programmes, and supply data at various levels of detail. For these reasons, and because these figures are based on a limited number of shutdown reactors, definitive conclusions cannot be drawn. Under the ISOE Working Group on Data Analysis, work continued in 2009 aimed at improving data collection for shut-down and decommissioned reactors in order to facilitate better benchmarking.

Table 5 provides average annual collective doses per unit for definitely shutdown reactors by country and reactor type for 2007-2009, based on data recorded in the ISOE database, supplemented by the individual country reports (Section 6) as required. Figures 8-11 present the average collective dose per reactor for shutdown reactors for 1992-2009 by reactor type (PWR, BWR and GCR). In all figures, the "number of units" refers to the number of units for which data has been reported for the year in question.

Table 5. **Number of units and average annual dose per reactor by country and reactor type for definitely shutdown reactors, 2007-2009 (man·mSv/reactor)**

		2007		**2008**		**2009**	
		No.	**Dose**	**No.**	**Dose**	**No.**	**Dose**
PWR	France	1	10.4	1	23.2	1	62.1
	Germany	3	322.9	5	160.0	5	128.0
	Italy	1	0.5	1	1.1	1	2.0
	Spain	1	292.9	1	134.7	n/a	n/a
	United States	6	26.5	10	7.1	4	1.7
VVER	Bulgaria	4	60.4	4	31.0	4	29.4
	Germany	5	28.6	5	27.0	5	20.0
	Russian Federation	2	100.6	2	78.0	2	84.0
BWR	Germany	1	405.1	3	179.0	3	138.0
	Italy	2	6.5	2	29.1	2	618.0
	Japan					2	674.0
	The Netherlands	1	0.4	1	0.3	1	0.6
	Sweden	2	70.5	2	39.1	2	27.0
	United States	3	137.5	3	13.4	2	9.7
GCR	France	6	2.2	6	2.8	6	8.8
	Germany			2	13	2	17.0
	Italy	1	0.5	1	2.9	1	0
	Japan	1	30	1	20	1	20
	United Kingdom	18	44.1	16	48	16	42
LWGR	Lithuania	1	215.8	1	188.4	1	144.7
LWCHWR	Japan	1	85.7	1	431.3	1	114.6

Figure 8. **Average collective dose per shutdown reactor: PWR/VVERs (man·mSv/reactor)**

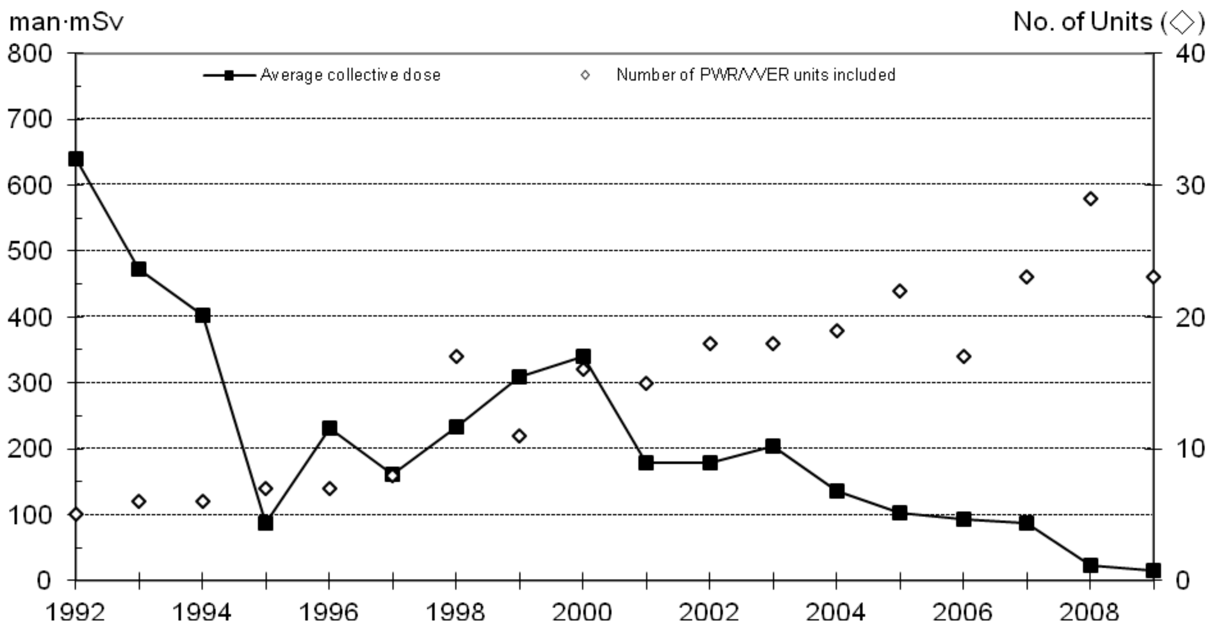


Figure 9. **Average collective dose per shutdown reactor: BWRs (man·mSv/reactor)**

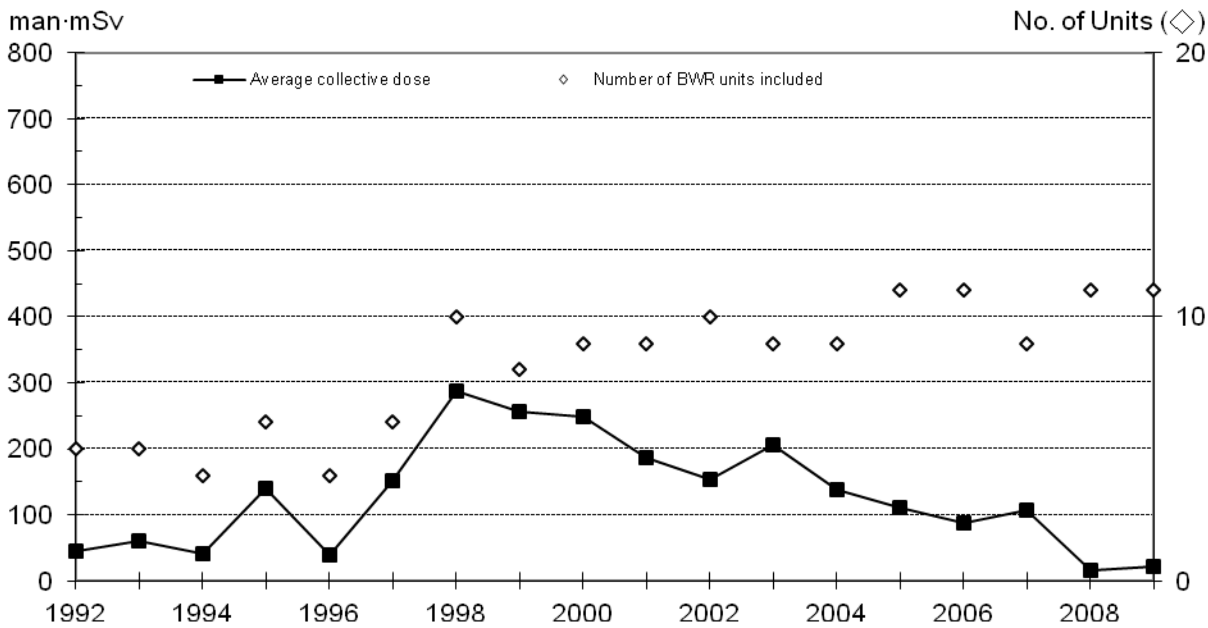


Figure 10. **Average collective dose per shutdown reactor: GCRs (man·mSv/reactor)**

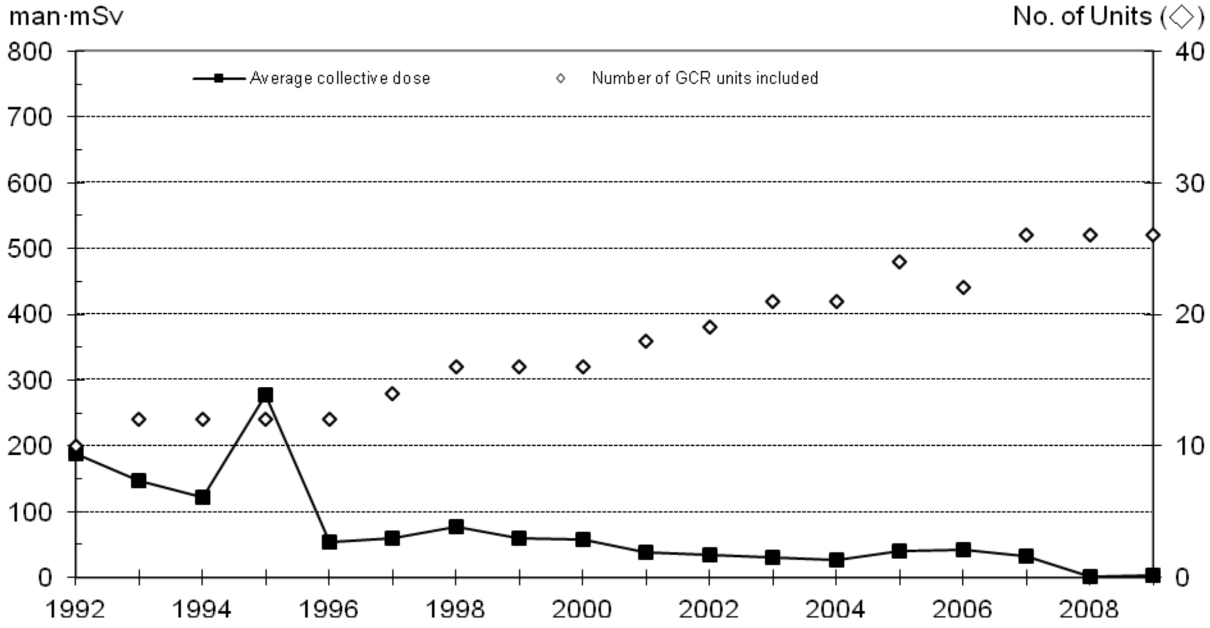
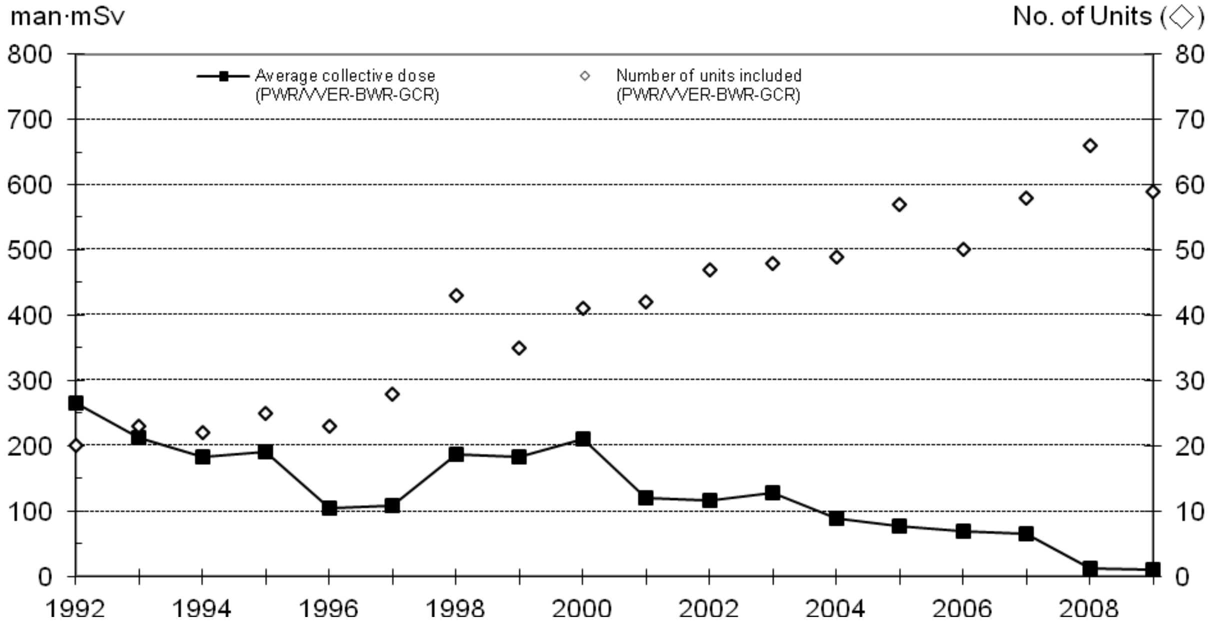


Figure 11. **Average collective dose per shutdown reactor: PWR/VVER, BWR, GCR (man·mSv/reactor)**



2.3 Analysis of the 3 year rolling average annual collective dose (1998-2008) by sister unit groups

This section provides an analysis of the 3 year rolling average annual collective dose by sister unit group in order to compare the dosimetry performances of PWRs and BWRs depending on their design from 1998 to 2008.

Note:

- The 3 year rolling average annual collective dose for each sister unit group has been calculated by averaging all the reactors annual collective dose of a group on a 3-year rolling basis (histogram graph).
- The average of the annual collective dose for the 1998-2008 period has been calculated by averaging all the reactor annual collective doses for a sister unit group (dotted line).
- For BWRs, the analysis takes into account only the reactor design and not the gross power which can vary within a sister group.
- For Japan, the collective dose of each reactors of Genkai, Ikata, Mihama, Ohi, Takahama and Tomari sites for PWRs; and reactors of Fukushima Dai-ichi, Hamaoka, Kashiwazaki, Onagawa, Shika and Shimane sites for BWRs indicated in the ISOE database is equal to the site collective dose divided by the number of NPPs. It thus does not represent the exact annual collective dose of each reactor. Furthermore, the NPPs are not in the same sister unit groups. As a consequence, those sites were not taken into account.

PWR Reactors

For PWRs, only 3 and 4 loop reactors from Framatome, Siemens and Westinghouse designers were considered.

Framatome reactors

The reactors in each sister unit group are provided in the following table.

Sister unit groups	**Country**	**Reactors** (construction start date)
F31 - *Framatome, 3 Loops, 1st generation*	France	Bugey 2, 3, 4, 5 (1972-73-74) Fessenheim 1, 2 (1971-72)
F32 - *Framatome, 3 loops, 2d generation*	China	Daya Bay 1, 2 (1987-88)
	France	Blayais 1, 2, 3, 4 (1977-78) Chinon B1, B2, B3, B4 (1977-80-81) Cruas 1, 2, 3, 4 (1978-79) Dampierre 1, 2, 3, 4 (1975) Gravelines 1, 2, 3, 4, 5, 6 (1975-76-79) Saint-Laurent B1, B2 (1976) Tricastin 1, 2, 3, 4 (1974-75)
	Korea	Ulchin 1, 2 (1983)
	South Africa	Koeberg 1, 2 (1976)
F42 - *Framatome, 4 loops, 2d generation*	France	Belleville 1, 2 (1980) Cattenom 1, 2, 3, 4 (1979-80-82-83) Flamanville 1, 2 (1979-80) Golfech 1, 2 (1982-84) Nogent 1, 2 (1981-82) Paluel 1, 2, 3, 4 (1977-78-79-80) Penly 1, 2 (1982-84)

		Saint-Alban 1, 2 (1979)
F43 - *Framatome, 4 loops, 3^d generation*	France	Chooz B1, B2 (1984-85) Civaux 1, 2 (1988-91)

Excepted F32, all the Framatome reactors are located in France.

- **3 loops reactors**

6 reactors of the F31 sister unit group correspond to the oldest design and are all located in France. An important decrease of the 3-year rolling average annual collective dose can be noticed for this group throughout the period (around 50% decrease from 1998-2000 till 2006-2008) and more particularly between 2000-2002 and 2003-2005.

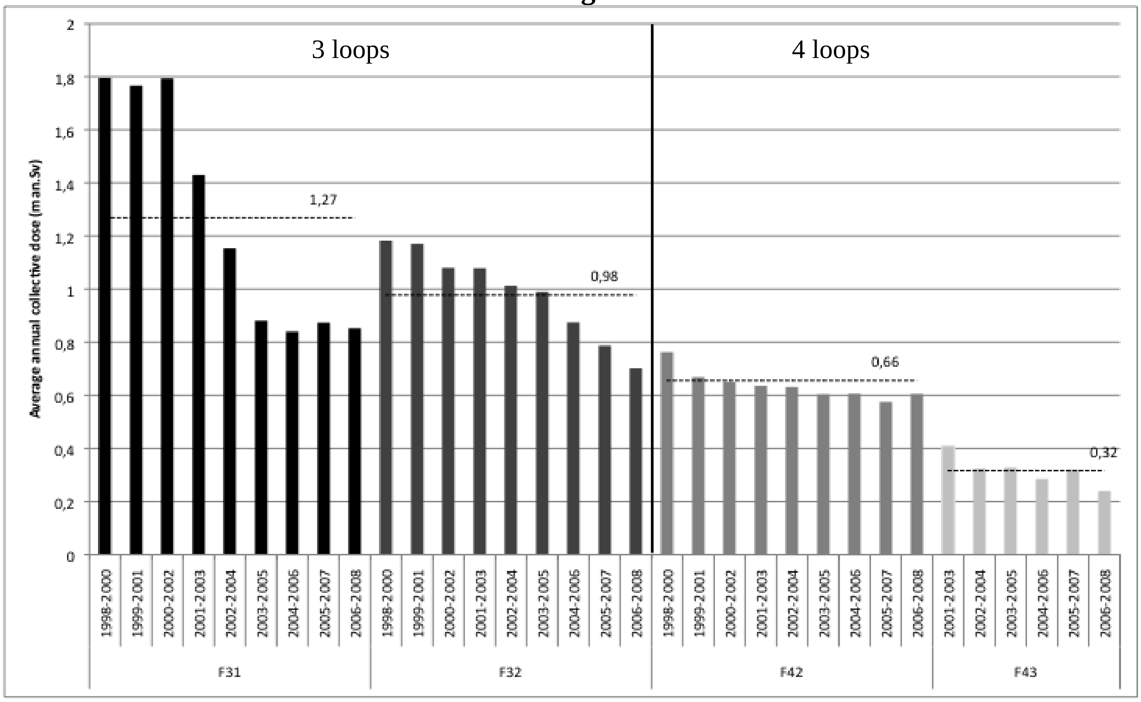
For the F32 sister unit group (34 reactors whom 2 are located in China, 2 in South Africa and 2 in Korea) an important decrease of the 3-year rolling average annual collective dose (around 50% decrease from 1998-2000 till 2006-2008) is also seen and contrary to the F31 trend, the decrease is quite regular.

Moreover, a “generation effect” can be pointed out, a decrease of 30% of the average annual collective dose on the 1998-2008 period is noticed between the first and the second generation of reactors (from 1.3 down to around 1 man·Sv).

- **4 loops reactors**

The 3-year rolling average annual collective dose is quite constant for the F42 sister unit group (20 reactors) for the period (around 0.6 man·Sv). The last generation, F43 sister unit group (only 4 reactors), shows the lowest 3-year rolling average annual collective dose for the Framatome reactors (around 0.2 man·Sv). Between the 2^d and the 3^d generation of the 4 loops reactors, a decrease of 50% of the average annual collective dose on the 1998-2008 periods is noticed indicating an impact of the design on the annual collective dose.

Figure 12. **3-year rolling average annual collective dose per reactor (1998-2008) for Framatome design**



Siemens reactors

The reactors in each sister unit group are provided in the following table.

Sister unit groups	**Country**	**Reactors** (construction start date)
S32 - *Siemens, 3 loops, 2^d generation (pre-Konvoi)*	Germany	Neckar 1 (1972)
	Spain	Trillo 1 (1979)
	Switzerland	Gösgen 1 (1973)
S41 - *Siemens, 4 loops, 1stgeneration*	Germany	Biblis A, B (1970-72) Unterweser 1 (1972)
S42 - *Siemens, 4 loops, 2^d generation (pre-Konvoi)*	Brazil	Angra 2 (1976)
	Germany	Brokdorf 1 (1976) Grafenrheinfeld 1 (1975) Grohnde 1 (1976) Philippsburg 2 (1977)
S43 - *Siemens, 4 loops, 3rdgeneration (Konvoi)*	Germany	Emsland 1 (1982) Isar 2 (1982) Neckar 2 (1982)

Siemens reactors are mostly located in Germany (11 reactors). However, the S32 sister unit group also includes 1 reactor located in Spain and 1 in Switzerland. S42 sister unit group includes 1 reactor located in Brazil.

- **3 loops reactors**

There is only one generation of 3 loops reactors including only 3 reactors for the Siemens design. Those reactors have a pre-Konvoï design and the corresponding average annual collective dose is around 0.6 man·Sv in the 1998-2008 period.

- **4 loops reactors**

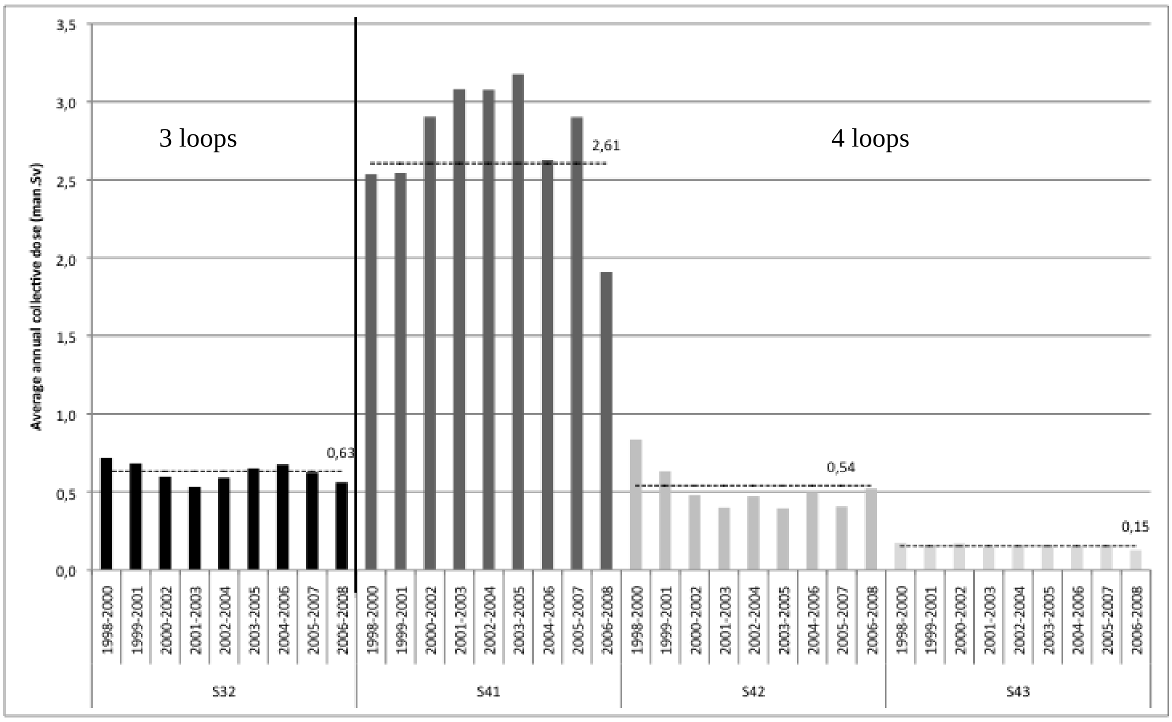
The S41 sister unit group (only 3 reactors), is quite "unusual" with high 3-year rolling average annual collective dose up to 3 man·Sv. This trend could be explained by the fact that some of the reactors of the sister unit group have high source term due to flood problems and numerous maintenance works carried out over the period.

The S42 sister unit group, with 5 pre-Konvoï reactors has an average annual collective dose in the 1998-2008 period of around 0.5 man·Sv. This value has to be considered as an upper bound because only 2 reactors have an average annual collective dose around and above 1 man·Sv for some years, the other reactors having data around 0.2-0.3 man·Sv.

The lowest dose results are obtained by the 3 Konvoï reactors from the S43 sister unit group with an average collective dose for the 1998-2008 period of around 0.15 man·Sv.

The specific design of the pre-Konvoi and Konvoi reactors, defined by a very low source term and compartmented area explains the good performance of the Siemens reactors.

Figure 13. **3-year rolling average annual collective dose per reactor (1998-2008) for Siemens design**



Westinghouse reactors

The reactors in each sister unit groups are provided in the following table.

Sister unit groups	**Country**	**Reactors** (construction start date)
W31 - *Westinghouse, 3 loops, 1st generation*	Sweden	Ringhals 2 (1970)
	USA	Beaver Valley 1, 2 (1970-74) Farley 1, 2 (1972) North Anna 1, 2 (1971) Robinson 2 (1967) Surry 1, 2 (1968) Turkey Point 3, 4 (1967)
W32 - *Westinghouse, 3 loops, 2d generation*	Belgium	Doel 4 (1978) Tihange 3 (1978)
	Korea	Kori 3, 4 (1979, 1980) Yonggwang 1, 2 (1981)
	Spain	Almaraz 1, 2 (1973) Asco 1, 2 (1974-75) Vandellos 2 (1980)
	Sweden	Ringhals 3, 4 (1972-73)
	USA	Harris 1 (1978) Summer 1 (1973)
W41 - *Westinghouse, 4 loops, 1st generation*	USA	Diablo Canyon 1, 2 (1968-70) Indian Point 2, 3 (1966-69) Salem 1, 2 (1968) Watts Bar 1 (1973)
W41-2 (Ice Condenser) - *Westinghouse, 4 loops, 1st generation*	USA	Catawba 1, 2 (1975) Cook 1, 2 (1969) McGuire 1, 2 (1973) Sequoyah 1, 2 (1970)
W42 - *Westinghouse, 4 loops, 2d generation*	UK	Sizewell B1 (1988)
	USA	Braidwood 1, 2 (1975) Byron 1, 2 (1975) Callaway 1 (1976) Comanche Peak 1, 2 (1974) Millstone 3 (1974) Seabrook 1 (1976) South Texas 1, 2 (1975) Vogtle 1, 2 (1976) Wolf Creek 1 (1977)

Westinghouse reactors are mainly located in the United States of America (41 reactors). The other reactors are situated as follows: 5 reactors in Spain (W32), 4 in South Korea (W32), 3 in Japan (W31 and W41), 3 in Sweden (W31 and W32), 2 in Belgium (W32) and 1 in the UK (W42).

- **3 loops reactors**

The 3-year rolling average annual collective dose of the W31 sister unit group (12 reactors), decreases over the period from around 1 man·Sv in 1998-2000 down to around 0.6 man·Sv in 2005-2007 and increases slightly for the last 3 year period.

The W32 sister unit group (14 reactors) also indicates a regular decrease of the 3-year rolling average annual collective dose (from 0.7 man·Sv down to 0.5 man·Sv). A generation effect can be seen between the first and the second generation, the average annual collective dose for the 1998-2008 period being 0.8 man·Sv for W31 and 0.6 man·Sv for W32 indicating an impact of design.

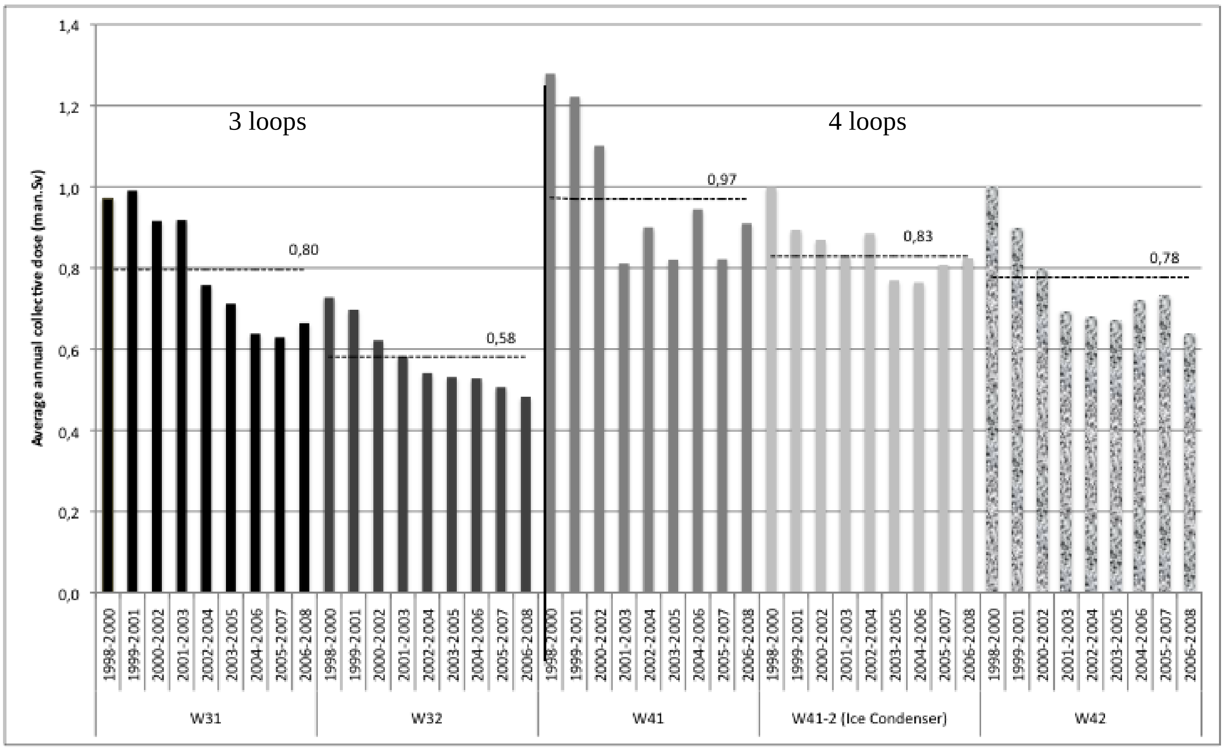
- **4 loops reactors**

The W41 sister unit group (7 reactors) indicates the highest value of the 3-year rolling average annual collective dose (above 1 man·Sv) for the design. Then, the trend decreases down to 0.8 man·Sv in 2001-2003 and oscillates between this value and 0.9 man·Sv, being the result of the differences of annual collective dose from one reactor to another (some reactors having annual collective dose below 0.1 man·Sv and some up to 3 man·Sv).

The W41-2 sister unit group, gathering 8 reactors with an Ice condenser, shows a quite constant 3-year rolling average annual collective dose (around 0.8 man·Sv). The W42 group with 15 reactors has the best values of the 4 loops reactors (around 0.6 man·Sv for the last 3-year period). This sister unit group again gathers reactors with high differences in terms of annual collective dose, lower than 0.1 man·Sv for some, up to 2 man·Sv and above for others.

For the 3 loop and 4 loop reactors respectively, a generation effect can be seen. We can also notice that the last generation of reactors of the 3 loops has better performances than the last generation of the 4 loops (on an average for the 1998-2008 period, respectively 0.6 man·Sv for W32 and 0.8 man·Sv for W42).

Figure 14. **3-year rolling average annual collective dose per reactor (1998-2008) for Westinghouse design**



BWR Reactors

The reactors from ABB atom, General Electric and Siemens were considered. Contrary to PWRs where the sister unit group corresponds to a specific gross power, for BWRs the gross power can vary within a sister group.

ABB Atom reactors

The reactors in each sister unit group are provided in the following table specifying the installed gross power.

Sister unit Group	Country	Reactor		Gross Power (MWe)
ABB1 - *ABB Atom 1st generation*	Sweden	Ringhals 1		780
ABB2 - *ABB Atom 2nd generation*	Sweden	Barsebäck 1, 2	Oskarshamn 2	600
ABB3 - *ABB Atom 3rd generation*	Finland	TVO 1, 2		735
	Sweden	Forsmark 1, 2		1000
ABB4 - *ABB Atom 4th generation*	Sweden	Forsmark 3	Oskarshamn 3	1200

ABB Atom reactors are mainly located in Sweden (8 reactors), only 2 being in Finland.

- **First generation**

ABB1 sister unit group corresponds to only 1 reactor with important variations over the considered period. The 3-year rolling average annual collective dose decreases from 1998-2000 till 2000-2002 (from 1.8 man·Sv down to 1.1 man·Sv) and then increases up to around 2 man·Sv in 2005-2007. The peak above 2 man·Sv in 2003-2005 is due to important maintenance works in 2005 resulting in an annual collective dose of around 3 man·Sv for one reactor which affects the next 3-year rolling average annual collective dose.

- **Second generation**

ABB2 sister unit group (3 reactors) has the lowest 3-year rolling average annual collective dose of the ABB design (0.3 man·Sv in 2004-2006). The high value of 2001-2003 is mainly due to one reactor which had an annual collective dose above 2 man·Sv in 2003.

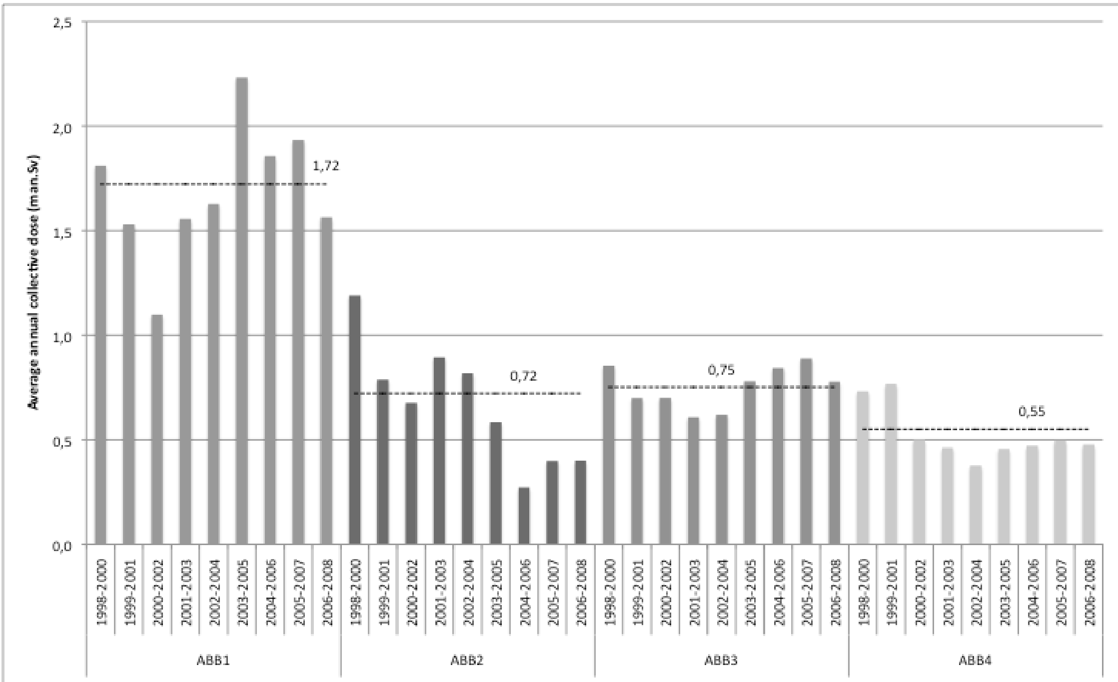
- **Third generation**

ABB3 sister unit group (4 reactors) presents an average annual collective dose for the 1998-2008 period of 0.7 man·Sv which is similar to the value of the second generation of reactors.

- **Fourth generation**

ABB4 sister unit group with 2 reactors indicates the lowest average annual collective dose for the 1998-2008 period (0.5 man·Sv). The high value of 0.7 man·Sv for the 2 first periods is due to 1 reactor which had an annual collective dose above 1 man·Sv in 1999. For ABB Atom design, apart from ABB2 and ABB3 which shows an average annual collective dose equals to 0.7 man·Sv for the 1998-2008 period, a "generation effect" can be noticed between ABB1, ABB2/ABB3, and ABB4.

Figure 15. **3-year rolling average annual collective dose per reactor (1998-2008) for ABB Atom design**



General Electric reactors

The reactors in each sister unit group are provided in the following table.

Sister Group	Country	Reactor		Gross Power (MWe)
GE1 – *General Electric 1st generation*	Japan	Tsuruga 1		
	USA	Nine mile point 1	Oyster Creek 1	650
GE2 – *General Electric 2nd generation*	Spain	Garona 1		460
	USA	Dresden 2, 3	Pilgrim 1	580 to 830
		Monticello 1	Quad Cities 1, 2	
GE3 – *General Electric 3rd generation*	Switzerland	Muhleberg 1		372
	USA	Browns Ferry 1, 2, 3 Brunswick 1, 2 Cooper 1 Duane Arnold 1 Fermi 2 Fitzpatrick 1	Hatch 1, 2 Hope Creek 1 Limerick 1, 2 Peach Bottom 2, 3 Susquehanna 1, 2 Vermont Yankee 1	500 to 1100
GE4 – *General Electric 4th generation*	Japan	Tokai 2		1100
	Mexico	Laguna Verde 1, 2		675
	USA	Lasalle 1, 2	WNP 2	1100
		Nine Mile Point 2		
GE5 – *General Electric 5th generation*	Spain	Cofrentes 1		990
	Switzerland	Leibstadt 1		1000
	USA	Clinton 1 Grand Gulf 1	Perry 1 River Bend 1	985 to 1300

General Electric reactors are mainly located in the USA (35 reactors), the other being located as follows: 2 in Spain (GE2 and GE5), 2 in Switzerland (GE3 and GE5), 2 in Japan (GE1 and GE4) and 2 in Mexico (GE4).

- **First generation**

The GE1 sister unit group corresponds to 3 reactors (2 in the USA and 1 in Japan) and has an average annual collective dose for the 1998-2008 period above 2 man·Sv, the highest of the design. The very high 3-year rolling average annual collective dose above 2.5 man·Sv for 1998-2000 is due to one reactor which had an annual collective dose above 4 man·Sv (due to replacement works) in 1999 which affect the following 3-year rolling averages.

- **Second generation**

The GE2 sister unit group (7 reactors) shows a peak for 2002-2004 at 2.4 man·Sv. This is the result of a high annual collective dose for a site in 2002 (above 17 man·Sv due to extensive repairs) affecting the previous 3-year rolling averages.

- **Third generation**

The GE3 sister unit groups (20 reactors), has the lowest average annual collective dose for the 1998-2008 period for this design, around 1.4 man·Sv. The 3-year rolling average annual collective dose decrease from 1998-2000 down to 2002-2004 (respectively 1.6 man·Sv to 1.2 man·Sv) and then increase up to 1.4 man·Sv. This increase is the result of high annual collective dose for a few reactors (for example, 5 man·Sv in 2003 and 2007).

- **Fourth generation**

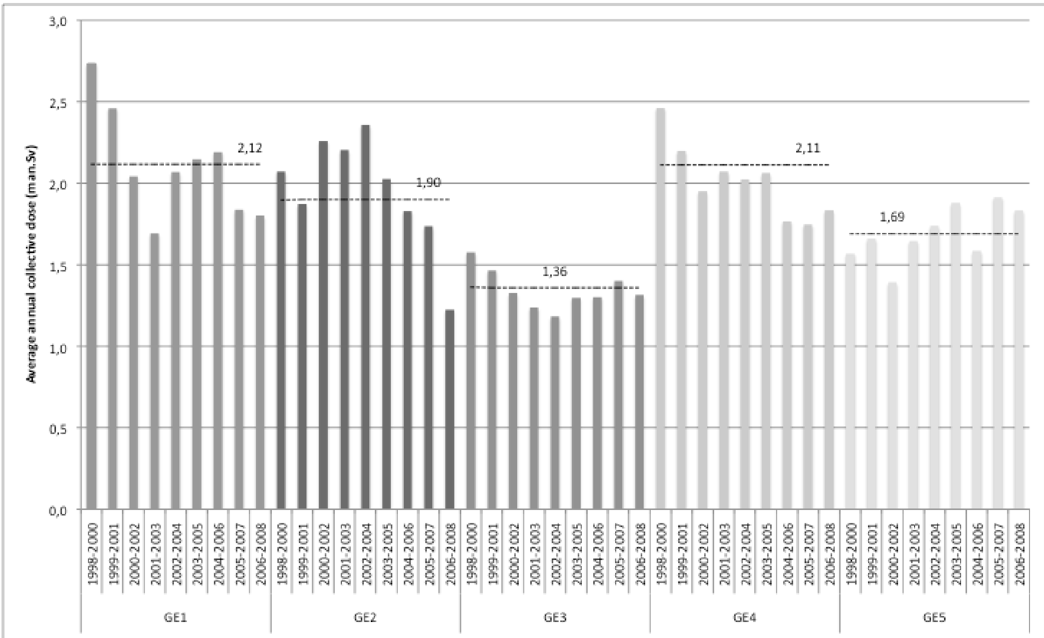
The GE4 sister unit group with 7 reactors has an average annual collective dose for the 1998-2008 period, similar to the GE1, i.e. above 2 man·Sv. The peak in 1998-2000 around 2.5 man·Sv is due to one reactor with an annual collective dose around 6 man·Sv in 1998 and 1999 affecting the next 3-year rolling averages. The same reactor had an annual collective dose around 8.7 man·Sv in 2008.

- **Fifth generation**

The average annual collective dose of the sister unit group GE5 (6 reactors) for the 1998-2008 period is around 1.7 man·Sv.

A generation effect can be seen for the 3 first generations of General Electric reactors, the fourth and fifth generation having similar values to GE1 and GE2 reactors.

Figure 16. **3-year rolling average annual collective dose per reactor (1998-2008) for General Electric design**



Siemens reactors

The reactors in each sister unit group are provided in the following table.

Sister Group	Country	Reactor	Gross Power

				(MWe)
S69	Germany	Brunsbuttel 1	Krummel 1	800 to 1300
		Isar 1	Philippsburg 1	
S72	Germany	Gundremmingen B	Gundremmingen C	1300

The 6 Siemens reactors are located in Germany.

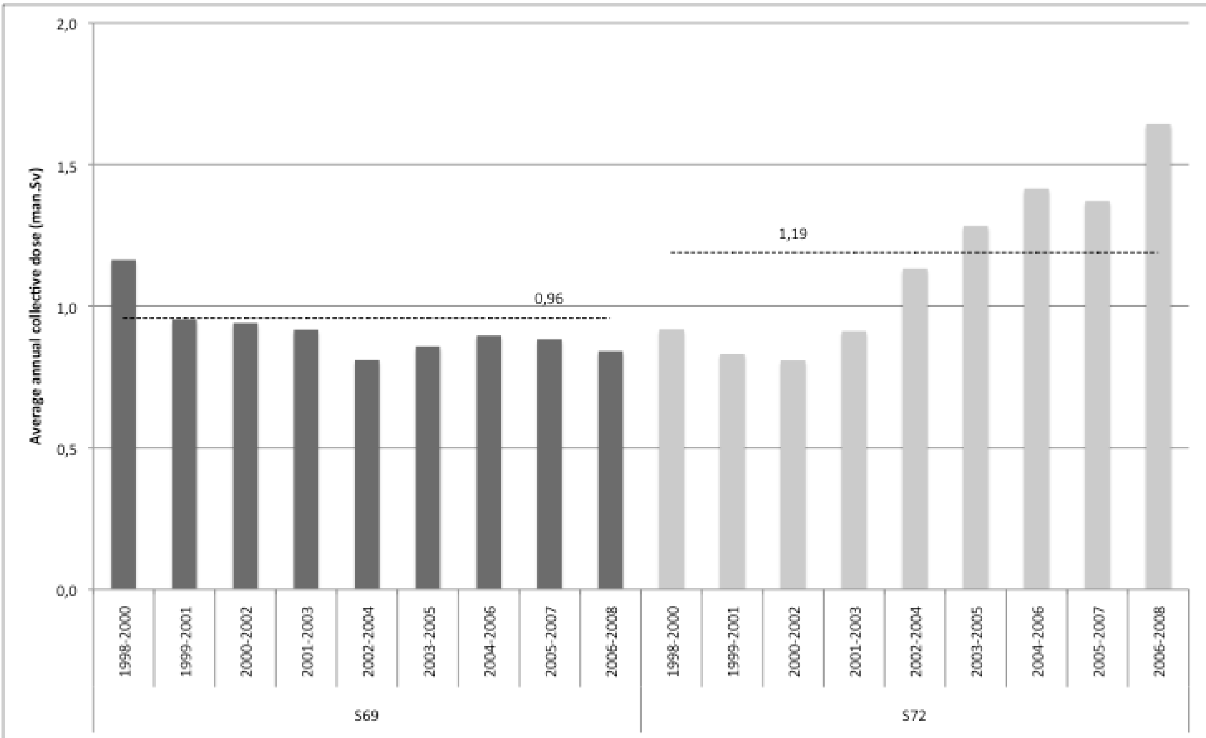
- **First generation**

The S69 sister unit group, corresponding to 4 reactors, has a quite constant 3-year rolling average annual collective dose (around 1 man·Sv).

- **Second generation**

Contrary to the first generation, the S72 sister unit group with 2 reactors indicates an increase of the 3-year rolling average annual collective dose from 0.9 man·Sv up to 1.6 man·Sv for the last 3 years. This increase is the result of additional maintenance works for one of the NPPs resulting in annual collective doses above 2 man·Sv. For the BWRs Siemens reactors, the first generation of reactors has better results in terms of average annual collective dose than the second generation.

Figure 17. **3-year rolling average annual collective dose per reactor (1998-2008) for Siemens design**



Conclusion

This analysis shows that a “generation effect“ can be noticed for the reactors within a designer, resulting in a decrease of the 3-year rolling average annual collective dose between 2 successive generations of 3 or 4 loops reactors for PWRs and from one generation to another for BWRs.

Moreover, similar performances for reactors from the same generation but belonging to different designers can be highlighted for PWRs: for the second generation, S32 and W32 around 0.6 man·Sv and F42 and S42 between 0.5 man·Sv and 0.6 man·Sv. This observation is hard to establish for BWRs.

However, the design effect does not explain all the dosimetric performances differences between reactors for PWRs and BWRs. It is therefore essential to consider other factors that may impact on annual collective dose such as: operating procedures, types of maintenance, radiation protection organisation, etc. This can results in:

- Differences in performances between different reactors within a generation.
- The reactors of the first generations can have better performances than the last generations.

Although these figures only reflect the major trends within groups of reactors, they provide some feedback elements that may be taken into account in the design for future reactors, especially in terms of setting an annual collective dose target. Based on the 1998-2008 average annual collective dose of this study, the annual collective dose for future PWRs reactors may not exceed 0.2 man·Sv, and for future BWRs reactors 0.6 man·Sv.

3 MAJOR EQUIPMENT EXPERIENCE: ALARA EXPERIENCE IN SHUTDOWN CHEMISTRY AND BAFFLE BOLT REPLACEMENT AT COOK UNIT 2

3.1 Introduction

Cook Nuclear Plant is a two unit Westinghouse Ice Condenser located on Lake Michigan in Bridgman, Michigan, USA. The unit has operated since 1974 on Lake Michigan across Lake Michigan from Chicago, Illinois. This ALARA experience case studies demonstrates the importance of immediate access to ISOE RPMs in Europe to prepare for discovery work scope identified in a scheduled refueling outage. Also, the value of a long term commitment to source term reduction can avoid significant outage dose from the additional outage work scope involving baffle bolt replacement on the core barrel.

3.2 Cook's Unit 2 Source Term Reduction Programme Results

Cook's ALARA group's planning efforts focused on repeating the source term reduction successes of past Unit 1 and 2 outages. The combination of providing time in the outage schedule to de-lithiate early in the cooldown, solubilise core deposits, degassing the RCS, maintaining corrosion product solubility, and the use of PRC-01 resin provided by n,p Energy, worked synergistically to produce a successful reactor shutdown. Shutdown chemistry successes included:

- No spent reactor coolant filters were generated during the RCS clean-up/cool down, although 1 filter was generated during startup. This was due to the large amount of EDM/baffle bolt work performed in the cavity.
- RCS cleanup, following the hydrogen peroxide addition, was completed ahead of schedule, without loss of critical path time.
- Lower than projected general area dose rates were experienced in the lower containment.
- The reactor cavity water clarity was considered as good as or better than any past outages.
  - Total Co-58 & 60 removed: 677 Ci
  - Crud Burst Peak: 0.53 uCi/g
  - Crud Burst Estimate: 0.75 uCi/g
  - Total Ni removed: 594 grams
  - Clean up time: 26 hours
  - Nominal Letdown flow rate: 155 gpm

Media Performance: Observations & Results

PRC-01 media technology was used during the planned CRUD burst within 48 hours after reactor shutdown. The purpose of the PRC-01 technology is to remove and mitigate deposition mechanisms of source term in the primary coolant during the crud burst and subsequent cleanup via filtration and ion exchange. Source term can be directly correlated to the amount of crud deposition in the core and its support systems. Based on industry experience at VC Summer, Turkey Point and Beaver Valley, PRC-01 technology has been demonstrated to be effective in removing colloidal Co-58 and Co-60 from the primary coolant. This is the key difference between PRC-01 and all other conventional mixed bed ion exchange resins and macroporous conventional resins.

PRC-01 media has been easily integrated into existing plant reactor cleanup system at Cook and 21 other US PWR reactors. The science of this product combines the applied chemical engineering knowledge of colloid formation and transport in reactor systems with the selective extraction.

The Tri-Nuc filters were used in the reactor cavity to remove particulate contamination which was important during the baffle bolt removal and replacement activities. The core barrel was placed on its stand in the reactor cavity and two Tri-Nucs were used to remove debris created during the EDM and automated baffle bolt removal and replacement discovery work scope.

During a Cook benchmarking visit with the McGuire Station RPM, (sister ice-condenser PWR to Cook), it was noted that McGuire changes out 2 times the number of filter canisters. The canisters also measure 3 times the contact dose rate during refueling operations compared to Cook's. This comparison demonstrates that Cooks Unit 2 source term is being effectively removed and the baffle bolt activities had less initial impact on the unit's source term due to the colloid mitigation.

Cobalt-60 Removal Highlights

Unit 2 Cycle 19 (U2C19) Refueling outage achieved a high water mark for the Cook ALARA Committee and site employees in the success of the multi-cycle effort to remove the Co-60 source term from the plant piping systems. Many planned activities over the past 8 years came together during the Unit 2 refueling outage. The important activities included:

- Early mechanical degassing (one day before reactor shutdown).
- CRUD Burst achieved within 48 hours of unit shutdown.
- Use of PRC-01 specialty resin for the 5th cycle shutdown.
- Use of PRC-01 specialty resin during the start up Unit 2 at the beginning of cycle 19 remove nickel.
- Attention to lessons learned from earlier source term challenges, e.g., rapid reactor coolant temperature reduction from 350-250 degrees F to preclude the release of iron oxides, chromium and cobalt from the fuel assembly cladding.
- Accurate prediction of CRUD Burst peak activity concentration.
- Full turnover of all fuel assemblies over 3 prior cycles. All new fuel assemblies will have the benefit of the specialty resin.

Discussion of Source Term Removal

Crud Burst Results:

The importance of Cobalt-60 removal (not reduction) to reduce outage dose has been a key focus of the Cook ALARA Programme. Use of Specialty Resin (PRC-01) to mitigate colloids achieved satisfactory results for the Unit 2 refueling outage. The CRUD Burst Peak was 0.53 uCi/g (predicted was 0.75 uCi/g). In-plant dose rates are equal to or slightly higher than Cycle 18 refueling outage dose rates in most in-plant areas. Reactor cavity water clarity is very good according to the fuel handling personnel. 15 Electronic Dosimeters (EDs) are placed on the RHR pumps, RHR heat exchangers and letdown lines to monitor crud burst efficiency.

Cobalt Removal from Plant Piping vs. Fuel Cladding:

Plants need to monitor the Co-60 to Co-58 ratio over time to see if the trend is consistent with the Co-60 removal observations from piping from other radiation measurements. The magnitude may not be as important (because of differences in materials from unit to unit) as the historic decrease/increase of the ratio. The U2C19 ratio was 1:70 which may indicate a good release from the plant piping inventory vs. fuel cladding. Co-60 has a 5.27 year half-life while Co-58 has a 70.88 day half-life.

Fuel Assembly Rotation:

Unit 2 Cycle 19 represented a full replacement of the core. For the specialty resin to work most efficiently it is necessary to complete 6 cycles to achieve a full replacement of 3 full core loads and the removal of the associated CRUD inventory on fuel cladding before the specialty resin was in use at Cook.

Westinghouse Standard Radiation Survey Points:

The 9 Westinghouse Post-CRUD survey measurements from Unit 2 Cycle 19 refueling outage were compared with the past 10 Unit 2 refueling outages. The historical Westinghouse steam generator dose rate charts showed the same or reduced dose rates for U2C19.

Benchmarking with Other Specialty Result PWRs:

Cook ALARA staff has maintained close contact with other specialty resin PWRs. The Unit 2 shutdown chemistry and telemetry data results were closely compared to V.C. Summer results with favor similarities noted. Contact with sister ice condensers clearly demonstrate that Cook Unit 2 has achieved significantly more Co-60 removal than sister units. Radiation Protection Managers and chemists from Braidwood, Beaver Valley and McGuire/Oconee conducted benchmark activities at Cook in the spring of 2010. Braidwood initiated the use of PCR-01 resin in the fall of 2010 and achieved the lowest dose rates ever on the regeneration heat exchanger flange and a 35% reduction in dose rates in selected areas of containment and Auxiliary Building. Beaver Valley achieved a 30% reduction in piping dose rates after the 4th use of the PRC-01 resin.

3.3 Personnel Contamination Events (PCE)

There was a total of 28 PCEs during U2C19. They included 26 Level 1, 2 Level 2 and no Level 3 contamination events. Ten of the 28 PCEs were from the Baffle Bolt Emergent Work. Thirteen PCEs were from particles while the other 15 were distributed contaminations. Seventeen PCEs came from the Upper Containment, eight from the Auxiliary Building, and three from the Lower Containment.

Action Level 1:	Personnel contamination level greater than or equal to 100 ccpm and less than 5 000 ccpm.
Action Level 2:	Personnel contamination level greater than or equal to 5 000 ccpm and less than 50 000 ccpm.
Action Level 3:	Personnel contamination level greater than or equal to 50 000 ccpm.

Lessons Learned

- The EDM process left behind a very fine particulate that plated out on all the surfaces of the cavity making it difficult to decontaminate to lower the dose rates to the pre-EDM levels.
- A pair of Tri-Nuc filter systems was in place during the EDM process to minimise the amount of particulate matter being dispersed throughout the cavity and RCS system.

- It was discovered that the hose to the EDM Tri-Nuc could be removed prior to breaking the surface of the water reducing dose rates to a more manageable level and lowered overall tool changes to 15-20 mRem each.
- ALARA was not included in the initial briefings over the first few days of planning. A request was made to have ALARA on the invitation list for all focus meetings involving the Rx Vessel repairs.
- The work on the lower internals baffle bolting issues and mid-loop impacted the radiological performance for the Ice Condenser work increasing the dose rates in the travel path to both upper and lower ice.
- Dose tickets provided increased awareness on the part of each worker.
- The ALARA Outage Incentive Programme was a contributor to the successful outcome of U2C19 outage dose. The effort put forth by the workforce, with an emphasis on dose savings, showed a higher level of engagement than anticipated.
- Utilising experienced insulators on complex and/or in high dose rate areas will maintain doses ALARA.
- RPs enhancement of Remote Coverage applications (tele-dosimetry, telex-communications & CCTV) have proven to be instrumental in reducing the accumulated dose.
- Using experienced contract workers familiar with the job and the work area dose sources results in saved dose during outages.

3.4 Major Work Addition Due to Baffle Bolt Replacement Work Scope

During fuel movement from Unit 2 reactor core to the spent fuel pool, inspections were conducted of fuel and core structures. During inspection of the core plate following completion of the U2C19 core off-load, some lock tabs for baffle bolts were discovered on the core plate. Follow-up visual inspection showed some degradation of core baffle bolts and lock tabs.

The original dose estimate for core unload and reload was 180 mRem and actual of 231 mRem. This was due to the refuel deck inside containment was at a higher dose rate of approximately 0.21 mRem/hour (Average Dose Rate – ADR) than what was anticipated of 0.13 mRem/hour ADR.

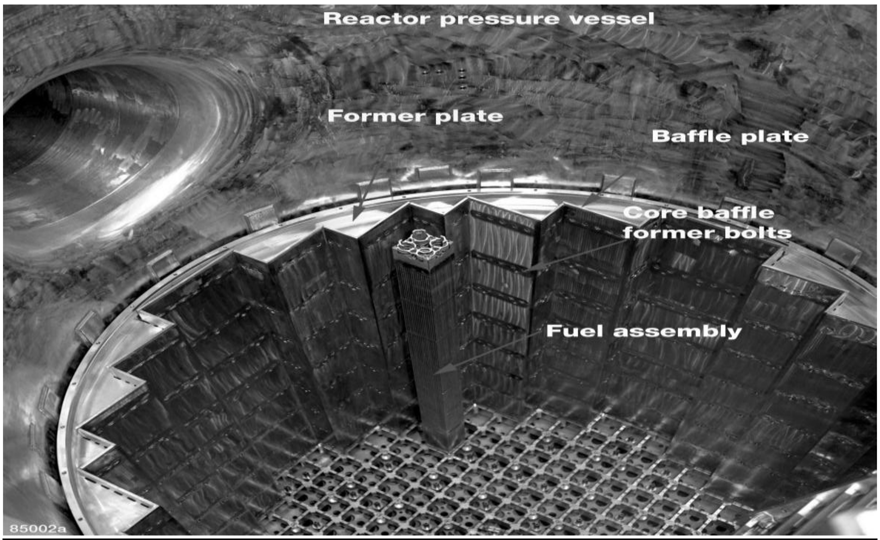
Inspection of the Lower Core Plate was estimated at 1 mRem and received 36.4 mRem. Inspection is typically done using binoculars however engineering requested the use of a camera at the south wall location.

Lessons Learned

- Debris found in 2-OME-1 on the core plate. Debris was found on the core plate at several locations during the lower core plate initial inspection following core off load. Debris looks to be from the core baffle bolt lock tabs and core baffle bolt heads.

3.5 Reactor Vessel Examination/Repairs

During the lower core plate inspection, Operations discovered six pieces of foreign material: four locking tabs and two cap screws identified as pieces of baffle bolts. Baffle bolts hold the vertical baffle plates to the horizontal former plates. The former and baffle plates provide structure for the fuel assemblies and direct water flow through the reactor. Cook’s baffle bolts are 5/8 inch in diameter and about 2 inches long. Once bolted in place, a lock bar is welded across the bolt head to secure the bolt. First phase of work was to remove identified debris and perform extent of condition inspection. Every baffle bolt location was videotaped with a high definition camera. Inspection identified other degraded bolts all located on the "South Wall". The final Engineering evaluation identified the extent of condition to be 52 baffle bolts to be replaced.



The dose associated to this work was not a part of the original outage dose estimate. Cook's ALARA group reviewed Farley's and Point Beach's history and lessons learned and incorporated the information into their ALARA Plan. All work was performed at risk due to the complexity of and unexpected repairs. Phase 1 of this project was to remove debris and perform an extent of condition inspection. Phase 2 was the repair process which required different methods based on each situation the bolting presented. They included simple bolt extraction, stud removal using the (EDM) process, bolt areas that have an indication of a broken lock bar in place will use the EDM (Electrical Discharge Machining) process to remove the welds and attempt to remove the bolt using the same method mentioned above. A highly specialised repair equipment tooling was designed and shipped to Cook by PCI. Shielding was installed on the bridge and was later modified to a configuration to provide a location to allow the tool adjustments to be made using the shield with bringing the entire mast out of the water. A pair of TRI-NUC filter systems was in place during the EDM (Electrical Discharge Machining) process to minimise the amount of particulate matter being dispersed throughout the cavity and RCS system. An area was set up with a tank to allow the tool head to remain under water during extended repairs. Additional ALARA controls were enhanced using a U shape nozzle to rinse the underside of the tool to reduce dose rates prior to breaking the surface of the water. A total of 4 irradiated component shipments were completed to Westinghouse operations in Pittsburgh, PA area for metallurgical analysis.

Lessons Learned

- This work was continuously changing making it difficult to establish an accurate dose estimate.
- ALARA was not included in the initial briefings over the first few days of planning. A request was made and granted to have ALARA on the invitation list for all focus meetings involving the Reactor Vessel Repairs.

3.6 Core Barrel Activities & Core Baffle Bolt Repairs

Repair teams and equipment were mobilised in the United States and Germany. Baffle bolt repairs were completed by Westinghouse Germany Division which required special tooling to machine a new bolt configuration into the lower internals. The new bolts were manufactured without requiring a lock bar. Preparations to pull the core barrel were added to the outage schedule. All repairs were performed in the refueling cavity below the water surface for shielding. Additional radioactive shipments of three large sea vans required dedicated air transport from Germany.

This work involved removing broken shanks, machining new bolt head opening with a lock ring groove, install and torque new bolt and expand the outer lock sleeve into the machined groove.

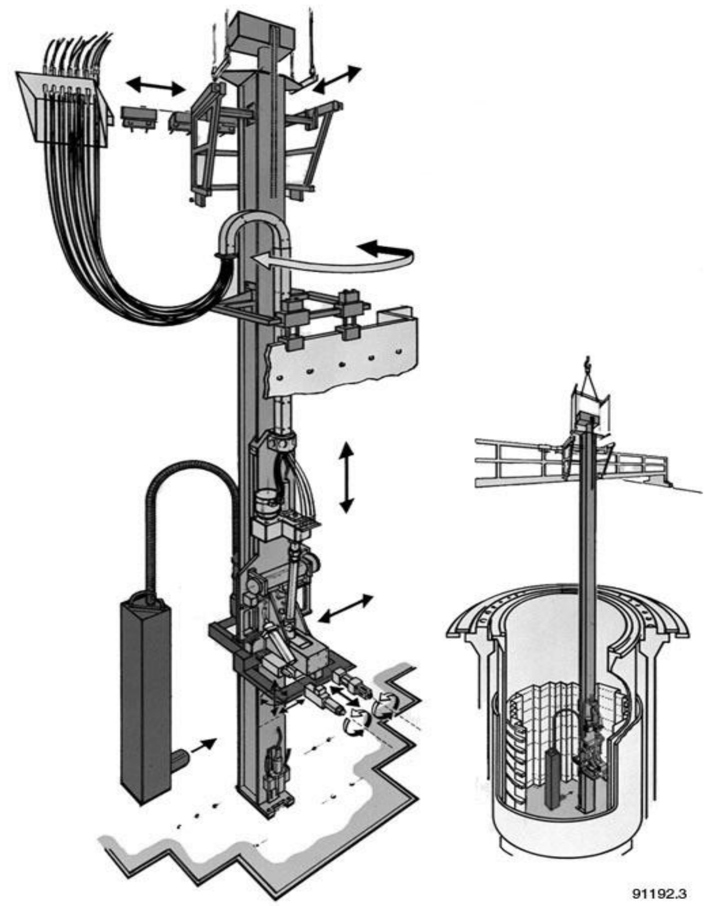
During the removal of the lower internals a shielded booth was constructed on the 650’ elevation that consisted of a see thru water shield and lead blankets as a place for the lift co-ordinator and RP technician to maintain a visual contact with the lower internals.

The 701’ elevation had a shielded hut for the crane operator and RP technician to be positioned during the movement.

Job set up took approximately 6 shifts for the repair equipment due to the complexity of the equipment and specialty tools. Work area conditions were constantly changing and consisted of a temporary bridge, Manipulator Bridge and the polar crane to perform repairs. The equipment utilised several different configurations and tools which required the equipment to be partially removed from the water on a routine basis.

The baffle plate is divided into groups of two or three columns of bolts that make up a group in which the tool can reach for one placement of the mast and head position. This is developed from years of experience in Europe adjusted for our specific population. The first step was to install machining positioning pins into the hole to be machined if the bolts are removed. The second step was to machine off locking bars and remove any location with a bolt. If the head falls or breaks off then they installed the shaft removal tool and removed the shaft from the bolt hole. Next, they installed the machining positioning pin. The third step counter bore machine with a new diameter in the baffle plate for each bolt hole. The fourth step was to remove positioning pins. The fifth step was to vacuum holes for debris. The sixth step was to install crimp lock machining groves. The seventh step was to vacuum the holes.

A TRI-NUC vacuum system was used for the entire process of repairs. The hoses became the source of radiation as the tools were lifted out of the water. The hose configuration was modified and allowed to be left under water during the tool change out process to reduce the dose rate in the work area.



The above diagramme shows the repair tooling from Germany.

Lessons Learned

- The initial procedures for the lower internal repairs were written in German and had to be revised to provide an English version, some of the translations had to be explained in more detail involving the radiological unit conversions and terminology.
- During the lower internal movement operations raised the reactor cavity water level 2 to 3 inches higher than the same evolution during U1C23 allowing for a lower rate field. This allowed the lowest dose ever to be received during a lower internal movement of 120 mRem for both removal and replacement into the reactor vessel.
- Chemistry added approximately 15 gallons of hydrogen-peroxide directly to the reactor cavity water which helped to maintain the water clarity.
- Successfully handled the high dose rate materials (i.e. filters, tools, and equipment) were without incident and 4 shipments of highly irradiated components were sent to Westinghouse for metallurgical testing.

3.7 Cavity Decontamination

The cavity decon RWP was broken into three main tasks, cavity decontamination work, Tri-Nuclear filtration device work and equipment mobilisation/de-mobilisation. The main groups were RP technicians who assisted in the coverage of activities and QNS Deconners who performed high pressure washing and dose reduction rinse downs in both upper and lower cavities.

The Tri-Nuclear system functioned with no issues during this outage. A total of 10-0.3 micron filters and 3-0.2 micron filters were produced for the entire outage ranging from 2 R/hr to 400 R/hr. The use of the multiple slot carousel shielded that the cask unit went well. Refueling cavity water clarity was not an issue for the entire outage.

Lessons Learned

- Tri-Nuclear equipment was installed before core off-load and removed prior to mode 4 post core re-load. Cavity Decon equipment was set up and tested prior to upper cavity decon. The pressure wash units were staged on the 612' auxiliary building with the water supply lines ran through the lower containment to the upper cavity windows. The rinse hose was staged on 650' upper containment. Both water supplies were monitored by the use of a flow totaliser.
- It was noted during the post review that the deconners were under manned for cavity decontamination support from past outages. The deconners usually had double the people for cavity decon and would have had 2 pressure washer guns going at one time. There were also some inexperienced deconners at this outage.
- The EDM (Electrical Discharge Machining) process left behind a very fine particulate that plated out on all the surfaces of the cavity making it difficult to decontaminate to lower the dose rates to the pre-EDM levels.
- RP utilised telex, Gedds, and cameras for RP continuous coverage. Plastics with A06 hoods were used during power washing the cavity. During High Pressure Hose Decontamination Low Volume air samples were 0.06 DAC in lower cavity and 0.05 DAC on the 650 elevation.
- Mop heads from the upender pit reading of 13R/hr contact, and 4 R/hr at 12''. One bag of trash reading 1.2 R/hr contact and 625 mRem at 12".

3.8 Refuel Restoration Radiation Protection Activities

Post core reload for the reactor reassembly process, the dose rates in the reactor cavities doubled in some cases from conditions observed during disassembly. This increase in dose rates in the upper and lower cavity is attributed to the Baffle Bolt Project and this small, fine debris that was a result of the EDM (Electrical Discharge Machining) process.

The Reactor Head Set took longer this time compared to U2C18 outage. The reason for this was that a newer SROCA took additional time while the Reactor Head was in the air and making sure the alignment was correct prior to the final set, an approximate 200 mRem was added.

Lessons Learned

- Vacuuming was not performed around the Reactor studs at this outage due to the schedule pushing and not allowing the time.
- The radiological conditions changed dramatically upon drain down post core reload due to the (EDM) process. The EDM process left behind a very fine particulate that plated out on all the surfaces of the cavity making it difficult to decontaminate to lower the dose rates to the pre-EDM levels.

RPs work force is augmented by Bartlett Nuclear, USA Alliance, and non-traditional role workers with prior RP experience. The Bartlett and the AEP non-traditional technicians received procedure and mock-up qualification training (QVEP) prior to entering the plant. The QVEP process is a valuable tool for assessing technician qualification and proficiency.

The Radiation Protection group continued to sustain their successes realised during previous refueling outages through the use of teledosimetry, cameras and wireless communications equipment to minimise time and exposure in radiation areas. The majority of workers inside containment were monitored with teledosimetry. This policy enabled the RP technicians to observe if any worker in the building had a dose or dose rate concern.

In addition, tele-dose EDs were set up as area monitors in specific (repeatable in the future) locations throughout the auxiliary building and containment for dose trending. Many ALARA techniques were effective in minimising exposure for work activities. The frequency of surveys was closely monitored to ensure that routine surveys were performed only as necessary to avoid redundancy. The use of teledosimetry and tele-dose EDs were used to collect survey information remotely in high radiation areas.

Lessons Learned

- AEP non-traditional roles for RP technicians and supervision assistance was very helpful again at this outage.
- There was a change on how to wear double Anti-C clothing. The inner set was paper coveralls and the outer set was cloth coveralls. This was due to the increase in PCEs about half way through the outage. There were also two Radiation Worker Communication letters sent out during the outage to address the continued adverse trend in personnel contamination events.
- RPs enhancement of Remote Coverage applications (tele-dosimetry, telex-communications & CCTV) have proven to be instrumental in reducing the accumulated dose on this RWP.
- RP needs to take more ownership with their headsets throughout the outage to maintain a constant supply or working communications. Enhance telex communications in lower containment during outages. We had poor or lost communications with RADS during Rx Pit and various Annulus entries.

3.9 Conclusion

The baffle bolt replacement at Cook Unit 2 achieved good ALARA results for discovery- type refueling outage work scope additions, in part, due to the quick access and communication with European RPMs who had completed similar work previously. The new vendor tooling worked well in concert with ALARA good practices and lessons learned obtained for European plants that had previously performed similar baffle bolt replacements. As global nuclear plants continue to age, the ready access to the ISOE global network of RPMs and databases/ALARA reports will become increasingly important for individual plants to complete effective ALARA planning and work execution.

4. ISOE EXPERIENCE EXCHANGE ACTIVITIES

While ISOE is well known for its occupational exposure data and analyses, the programme's strength comes from its efforts to share such information broadly amongst its participants. The combination of ISOE symposia, ISOE Network and technical visits provides a means for radiation protection professionals to meet, share information and build links between ISOE regions to develop a global approach to occupational exposure management. This section provides information on the main information and experience exchange activities within ISOE during 2009.

4.1 ISOE ALARA Symposia

ISOE International ALARA Symposium

The IAEA TC organised the 2009 ISOE International Symposium, held 13-14 October 2009 at IAEA Headquarters in Vienna, Austria and sponsored by the OECD/NEA and IAEA. The symposium was attended by 110 participants from nuclear electricity utilities and national regulatory authorities from twentyseven countries. Distinguished papers selected by the participating technical centres for presentation at the 2010 ISOE International ALARA Symposium in Cambridge, UK included:

- *CANDU 6 Refurbishment and Optimization of Radiation Protection*, S. Alavi, J. Pequegnat (Canada);
- *RP for the Angra 1 Steam Generator Replacement Outage*, M.A. do Amaral *et al* (Brazil).

The 2010 and 2012 ISOE International ALARA Symposia will be organised by ETC and NATC respectively.

ISOE Regional ALARA Symposia

NATC, in co-operation with the Electric Power Research Institute (EPRI), organised and conducted the 2009 ISOE North American ALARA Symposium & EPRI Radiation Protection Conference from 12-14 January 2009 in Fort Lauderdale, USA.

ATC organised and conducted the 2009 ISOE Asian ALARA Symposium from 8-9 September 2009 in Aomori, Japan.

Proceedings and conclusions of the various Symposia are available on the ISOE Network.

4.2 The ISOE Network (www.isoe-network.net)

The ISOE Network is a comprehensive information exchange website on dose reduction and ALARA resources for ISOE participants, providing rapid and integrated access to ISOE resources through a simple web browser interface. The network, containing both public and members-only resources, provides participants with access to a broad and growing range of ALARA resources, including ISOE publications, reports and symposia proceedings, web forums for real-time communications amongst participants, members address books, and online access to the ISOE occupational exposure database. In 2009, a major re-organisation of the website was implemented to enhance usability and better meet user needs.

ISOE Occupational Exposure Database

In order to increase user access to the data within ISOE, the ISOE occupational exposure database is accessible to ISOE participants through the ISOE Network. Since 2005, the database statistical analysis module, known as MADRAS, has been available on the Network. Major categories of pre-defined analyses include:

- benchmarking at unit level;
- average annual collective dose per reactor;
- annual total collective dose;
- annual collective dose per TWh;
- contribution of outside personnel and outages to total collective dose;
- trends in the number of reactor units;
- 3-year rolling average for collective dose per reactor; and
- miscellaneous queries.

Outputs from these analyses are presented in graphical and tabular format, and can be printed or saved locally by the user for further use or reference. Modules for on-line data entry for the ISOE 1 questionnaire were completed 2009 and implemented on the ISOE Network.

ALARA Library

The ALARA Library, one of the most used website features, provides ISOE members with a comprehensive catalogue of ISOE and ALARA resources to assist radiation protection professionals in the management of occupational exposures. The ALARA Library includes a broad range of general and technical ISOE publications, reports, presentations and proceedings.

Radiological Protection Forum

In addition to the ALARA Library, registered ISOE users can access the RP Forum to submit a question, comment or other information relating to occupational radiation protection to other users of the Network. In addition to a common user group for all members, the forum contains a dedicated regulators group, common utilities group, and several utilities sub-groups organised by reactor type: PWR, BWR or CANDU. All questions and answers entered in the RP Forum are searchable using the website search engine, increasing the potential audience of any entered information.

4.3 ISOE benchmarking visits

To facilitate the direct exchange of radiation protection practice and experience, the ISOE programme supports voluntary site benchmarking visits amongst the Participating Utilities in the four technical centre regions. These visits are organised at the request of a utility with technical centre assistance and included in the programme of work for the coming year. The intent of such visits is to identify good radiation protection practices at the host plant in order to share such information directly with the visiting plant. While both the request for and hosting of such visits under ISOE are voluntary on the utilities and the technical centres, post-visit reports are made available to the ISOE members (according to their status as utility or authority member) through the ISOE Network website in order to facilitate the broader distribution of this information within ISOE. Highlights of visits conducted during 2009 are summarised below.

Benchmarking visits organised by ETC

In 2009, three benchmarking visits have been organised by ETC for the French utility EDF, using ISOE contacts, but no ISOE/ETC resources. The reports are available on the ISOE website (for utilities only for the Doel and Cook reports and for general public for the Braidwood report).

DOEL NPP (Belgium):

This benchmarking has been organised around 2 visits:

- 19-21 January 2009: meeting with the site RPM, representatives of CEPN and EDF Research & Development/human factor group.
- 21-22 April 2009 during Doel unit 1 outage: observation of practices of RP specialists on the field by representatives of CEPN and EDF Research & Development/human factor group.

Objectives of the visit:

The main objectives were to:

- Analyse the potential evolutions in organisational and practical RP since the 1st benchmarking visit in 2003.
- Discuss about social and organisational analysis on ALARA culture (EDF R&D representatives).

Main Results:

Organisation of RP at the site level:

- There was almost no evolution since 2003 (see CEPN Report No. 279).

Organisation of RP at the corporate level:

- Important modifications and efforts were made to set-up a structured RP at the corporate level. A specific division for safety and radiation protection aspects has been reinforced with about 20 persons (against about 4 in 2003).
- There is a willingness to favour a common policy for Electrabel and to harmonise RP practices and culture on Electrabel (Tihange and Doel NPPs).

RP culture at Doel:

- Radiation protection is a technical specialty, with high stakes and recognized by all the other specialties.
- RP specialists (Electrabel and contractors) are always present in the controlled area. They are in a position of assistance and advisers toward other workers. They are responsible for RP of the jobs (different situation in France). Workers have confidence in them.

BRAIDWOOD NPP (USA):

The visit took place from 20 to 22 October 2009. The French team was composed of two representatives of EDF and two representatives of CEPN.

Objectives of the visit:

Three main topics were discussed:

- General organisation and management of radiation protection in the Braidwood station, especially during outages.
- Radiation protection training of RP specialists and exposed workers.
- RP instrumentation available in the plant.

Key Findings

Radiation protection benefits from an important consideration in the daily running of the plant. In particular, during outages, a strong RP organisation is implemented. Thus, during the preparation period, a detailed "RP Outage Preparation Checklist" is established: it includes more than 275 tasks and allows ensuring that every RP item is taken into account. During the realisation of the outage, the RP Department relies on 12 hour-shifts covering both day and night. Finally, the RP Department ensures a permanent presence in the Outage Control Center: it is represented by a superintendent, which is the hierarchical level just under the radiation protection manager.

The Braidwood RP personnel is very present on the field and assists every worker in respecting radiation protection requirements. This role is all the more important because exposed workers receive a short training on radiation protection and are not responsible for their own protection.

As far as the training is concerned, INPO recently engaged a specific programme to reinforce RP initial training and face ageing of the experienced RP workforce. Exelon and the Braidwood station are strongly involved in this programme. Their initial training sessions appear quite complete and include a significant part of practical works (on-the-job training process). Moreover, continuing training sessions are offered all along the year. It is also worth underlining that a specific 4-week training is mandatory for RP contractors to be authorised to work in the station.

The Braidwood plant is preparing the renewal of its RP staff. Its aim is to compensate every future retirement by hiring a junior technician two years before the departure of the experienced person. In this way, the NPP would be ensured that new comers would be fully competent when they got the job.

Finally, as for instrumentation, it can be noted that the Braidwood station runs with a low quantity of RP equipments compared to EDF plants. Besides that some monitoring domains are not covered in the same way; for instance, the permanent monitoring of gamma dose rates in controlled areas is only performed by fixed instruments and does not rely on specific beacons. Otherwise, the peculiarity of Exelon to work with a central company (Powerlabs) that purchases, provides and ensures maintenance of equipments appears to be very efficient.

<u>COOK NPP (USA):</u>

The visit took place from 23 to 27 October 2009. The French team was composed of two representatives of EDF and two representatives of CEPN.

Objectives of the visit:

Three main topics were discussed (same as Braidwood):

- General organisation and management of radiation protection in the Braidwood station, especially during outages.
- Radiation protection training of RP specialists and exposed workers.

- RP instrumentation available in the plant.

Key Findings:

The Cook plant appears quite ambitious in radiation protection and has implemented a series of arrangements to reach its RP objectives (decrease of the collective dose to 200-250 person·mSv per unit in the next years):

- An important programme dealing with source-term reduction has been established in which 32 million dollars were invested over a 5 year period.
- The plant benefits from an important remote monitoring system (RMS) that allows the RP Department to monitor radworkers in the RCA. The Cook RMS can be operated with up to 50 cameras during refuelling outages. Moreover, the RMS is linked with the use of teledosimetry to follow specific operations: up to 300 teledosimeters can be allocated to workers during outages. Also, telemetry electronic dosimeters are used to measure real time dose rates on the letdown line, RHR pumps and RHR heat exchanges during the PWR shutdown crud burst.

During refueling outages, a specific RP organisation is implemented. RPM outage managers are assigned by the RPM. The RP Department relies on 12 hour-shifts covering both day and night. It can be noted that the RPM outage managers interface with the Outage Control Center (OCC). General supervisors (hierarchical level just under the RPM) represent the RP Department in the OCC.

The Cook station has developed its own competences related to RP training and presents an important Training Department gathering 60 people. As far as radiation protection is concerned, initial training modules for RP technician are very complete. They allow progressively covering every RP job skill that a RP technician needs to be qualified. These training requirements may appear very demanding but they assure that RP technicians assigned RP job coverage in the field are well trained and competent in their “tool box skill sets”. Moreover, it is worth reminding that RP contractors are also required to complete Cook RP training modules conducted by the Training Department. Following several serious safety events in the beginning of 2000s, the Cook station has implemented a major practical training programme on industrial safety. It concerns every worker and supervisor. Making sure work is accomplished safely is a worker responsibility and his supervisor’s responsibility.

As far as the RP instrumentation is concerned, equipments available in Cook appear quite recent compared to the age of the plant. Every “measurement domain” is covered. Most of the current instrumentation comes from ThermoFisher Scientific, but the plant intends to work more and more with Fluke Biomedical/Victoreen for its mobile equipments and with Canberra for its portals. The possibility to perform controls and calibration of instrumentation inside the plant reinforces the autonomy of the station.

Benchmarking visits organised by ATC

The Japan Nuclear Energy Safety Organization (JNES) manages the ISOE-ATC and organised a benchmark visit to the United States on 15-22 February 2009. This was performed as part of a project for exposure reduction entrusted to JNES by the Ministry of Economy, Trade and Industry. The visiting group was composed of people such as JNES staff and university staff related to radiation protection.

The purpose of the visit was to conduct research on the inspection system regarding ALARA and to exchange information about ALARA activities. The group visited Salem NPP (PWR), Hope Creek

NPP (BWR) and US NRC Headquarters. They investigated the actual situation on inspections by Health Physics inspectors and education and training.

Benchmarking visits organised by NATC

EDF and ETC participated in ISOE Benchmarking site visits to Braidwood Nuclear Plant, Units 1 & 2 on October 21 and 22, 2009. Braidwood was in a refuelling outage during the visit which focused on RP instrumental, contamination control and outage dose and RWP management. The plant manager of Goldfish, EDF PWR and EDF corporate RP instrumentation manager participated in the site visits. Goldfish is the first EDF PWR which achieved “street clothes” PWR containment access based on a previous South Texas Project EDF ISOE benchmarking visit in 2004.

The team also visited Cook Cotover 23-25, 2009 and observed the dynamic learning lab for RP worker good practices.

5. ISOE PROGRAMME MANAGEMENT ACTIVITIES DURING 2009

In 2009, the ISOE programme continued to focus on the collection and analysis of occupational exposure data and on the effective exchange of operational radiation protection information and experience, including enhanced inter-regional co-operation and co-ordination. This was facilitated through the ISOE ALARA Symposia, ISOE Network website and ISOE-organised benchmarking visits (see Section 4 for details). These initiatives have continued to position the ISOE programme to better address the operational needs of its end users (radiation protection professionals) in the area of occupational radiation protection and ALARA practices at nuclear power plants.

5.1 Management of the official ISOE databases

Official database release:

ISOE participants provided their 2009 data using the ISOE database software under Microsoft ACCESS, which was integrated into the database by ETC. Data was unable to be submitted through the ISOE Network website due to prolongation of the development and testing schedule for the online data input modules.

ETC continued to manage the official ISOE database, preparing and distributing the CD-ROM /MS-Access version of the database with 2007 data directly to European Participating Utilities in February 2009, and to the other technical centres for distribution to their regional members. The specific databases for each Participating Authority were created and distributed by ETC in March 2009 to all European Participating Authorities and to the other technical centres for distribution to their Participating Authorities. ATC distributed the CD-ROM to its Participating Utilities. The first release of the ISOEDAT database with data of 2008 (partial) was made available in June 2009 through the ISOE Network, followed by regular updates on the Network. The end-of-year release of the database and ISOE Software on CD-ROM was provided to all ISOE participants following the annual ISOE Management Board meeting.

The Development of ISOEDAT online:

The NEA and ETC continued the development of the web-enabled data input modules as part of the ISOEDAT web migration project, Phase 2. In parallel, updates to the on-line MADRAS interface were made to improve the usability and provide better integration with the ISOE 1 data input module. The WGDA undertook extensive testing of the application Dec 2008-Jan 2009, providing extensive comments which were addressed by the development team. Following direction from the WGDA at its May 2009 meeting, the final verification and validation testing of the application was undertaken July-September 2009. New MADRAS queries proposed by ETC, focusing on outage benchmarking, were also recommended by the WGDA.

The ISOE Management Board approved the official implementation and use of the ISOE 1 data input module, and new MADRAS queries, on the ISOE Network at its November 2009 annual meeting. The WGDA held a topical session at its November 2009 meeting to identify any possible gaps in the ISOE data collection/analysis, and proposed recommendations for their resolution. An ISOE 1 online help was developed and integrated in the application.

With respect to modifications addressing data collection/analysis for reactors undergoing decommissioning, a draft modified data questionnaire was prepared by WGDA for distribution to, and feedback from, selected reactors undergoing decommissioning.

Migration of the ISOE 2 questionnaire to the Network was discussed within the WGDA, with agreement to add this as a work item for 2010. Concerning ISOE 3, an updated reporting template in .doc format was developed and posted to the ISOE Network for use by participants.

5.2 Management of the ISOE Network

The ISOE Network continued to serve as the central portal for ISOE-related information and resources, including the ISOE database. ETC finalised the redesign of the new ISOE Network website, which was submitted to the Management Board for testing, and implemented in Oct 2009. All new user accounts requested by ISOE National Co-ordinators or individuals were created and implemented by the NEA Secretariat and ETC. At the end of 2009, about 499 utility and 80 regulatory member accounts had been created.

5.3 ISOE management and programme activities

As part of the overall operations of the ISOE programme, ongoing technical and management meetings were held throughout 2009, including:

ISOE Meetings	**Date**
ISOE Bureau	May 2009; Nov 2009
Working Group on Data Analysis	May 2009; Nov 2009
Ad-hoc Expert Group for the BSS	May 2009
19th ISOE Management Board Meeting	Nov 2009
NEA-ETC Web Working Group	Ad-hoc meetings between NEA and ETC
ETC-NATC Co-ordination Meeting	Feb 2009
Joint NEA/CRPPH-ISOE Activities	
Expert Group on Occupational Exposure	Mar 2009; Oct 2009

ISOE Management Board

The ISOE Management Board continued to focus on the management of the ISOE programme, reviewing the progress of the programme at its annual meeting in 2009 and approving the programme of work for 2010. The 2009 mid-year meeting of the ISOE Bureau focussed on the status of the ISOE activities for 2009, the status of the renewal of the ISOE Terms and Conditions, planning for the 2009 ISOE International ALARA Symposium, and options for co-operation by signing a memorandum of understanding with UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation).

ISOE Working Group on Data Analysis

The Working Group on Data Analysis (WGDA) met in May and November 2009, continuing its focus on the integrity, completeness and timeliness of the ISOE database, finalisation of the on-line data input modules, and options for improving ISOE data collection and analysis, including the implementation of new pre-defined MADRAS queries. New proposed information sheets from the Technical Centres and a revision to the ISOE Network, presented by ETC, were discussed. The WGDA held a topical session at its November 2009 meeting to identify any possible gaps in the ISOE data collection/analysis, and propose recommendations for their resolution. Under the guidance of the WGDA, the NEA and ETC completed the development of the web-enabled ISOE 1 data input modules and MADRAS update, for final testing and implementation on the ISOE Network.

Task Team on Decommissioning: With respect to modifications addressing data collection/analysis for reactors undergoing decommissioning, a draft modified data questionnaire was prepared for distribution to, and feedback from, selected reactors undergoing decommissioning.

Ad-hoc Expert Group on the Revision of the BSS

This ad-hoc expert group was launched by the ISOE Management Board during its annual meeting in 2007, in order to review, with respect to good practice in occupational exposure, drafts of a revised International Basic Safety Standards as they were made available through the ISOE Joint Secretariat (as BSS co-sponsoring organisations). The group met in May 2009 to provide consolidated comments, through the ISOE Secretariat, into the BSS drafting and comment process, including a formal review meeting within the NEA.

Joint NEA/CRPPH-ISOE Activities: Expert Group on Occupational Exposure

The EGOE was created by the NEA's Committee on Radiation Protection and Public Health (CRPPH), with an invitation to ISOE to participate in its activities. The EGOE met twice in 2009, with significant participation by ISOE members, including all Technical Centres. The EGOE has focussed primarily on the development of radiological protection criteria for designing new nuclear power plants, intended for vendors, authorities and utilities. A related report was finalised and approved by the NEA/CRPPH in May 2009. The group also began work addressing implementation aspects of the new ICRP recommendations for occupational exposure.

6. PRINCIPAL EVENTS OF 2009 IN ISOE PARTICIPATING COUNTRIES

As with any summary data, the information presented in Section 2: Occupational Dose Studies, Trends and Feedback, provides only a general overview of average numerical results from the year 2009. Such information serves to identify broad trends and helps to highlight specific areas where further study might reveal relevant experiences or lessons. However, to help to enhance this numerical data, this section provides a short list of important events which took place in ISOE participating countries during 2009 and which may have influenced the occupational exposure trends. These are presented as reported by the individual countries[1]. It is noted that the national reports contained in this section may include dose data arising from a mix of operational and/or official dosimetry systems.

ARMENIA

The Armenian Nuclear Power Plant (ANPP), the only nuclear power plant in the region, consists of two VVER/440/270 units (that is a modified, seismic design VVER/440/230). Unit 1 started its commercial operation in 1976 and Unit 2 in 1980. Both units were shutdown shortly after the 1988 Spitak earthquake. Re-commissioning works were performed from 1993 to 1995 and in November 1995 Unit 2 restarted operation. At this moment, the ANPP Unit N1 is in conservation regime (long-term shut down). Construction of a new unit of ANPP is foreseen and the siting activities have been started.

Summary of National Dosimetric Trends

For the year 2009, the dosimetric trends at the Armenian NPP have slightly decreased for collective and maximum individual dose due to the good planning of repair works. The maximum individual dose was 18.2 mSv. The contractors collective dose was 0.10 man·Sv.

Annual collective doses after restart of Armenian NPP in 1995 [man·Sv]

Year	Collective dose	Year	Collective dose	Year	Collective dose
1995	4.18	2000	0.96	2005	0.82
1996	3.46	2001	0.66	2006	0.85
1997	3.41	2002	0.95	2007	0.78
1998	1.51	2003	0.86	2008	1.05
1999	1.57	2004	1.08	2009	0.54

Events influencing dosimetric trends

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

1. Due to various national reporting approaches, dose units used by each country have not been standardised.

Component or System Replacement

During the outage in 2009, no components or systems were replaced.

Unexpected Events

For the year 2009, unexpected events were not registered.

New plants on line/plants shut down

The new plant construction is on-line, and siting considerations are currently ongoing.

Safety-related issues

Some elements of the radiation control system are obsolete and need replacement. Some safety related issues are expected due to medium activity radioactive waste storage activities.

New/experimental dose-reduction programmes

No new/experimental dose-reduction programmes were applied for in the year of 2009.

Organisational evolutions

The dose planning for the reduction of individual doses of staff is still the main tool.

Technical plans for major work in 2009

Modernisation plan of Radiation Control System, including the individual dose monitoring and contamination spraying monitoring equipment and dose reduction programme for the radioactive waste management was initiated.

Major evolutions

The ALARA principles implementation is going on slowly because of lack of enough ALARA culture.

2009 Issues of Concern

In 2009, radioactive waste drums replacement and conditioning works are expected. Administrative and technical measures must be scheduled by plant and approved by the Armenian Nuclear Regulatory Authority.

Regulatory plans

To review the safety assessment report (SAR) in terms of radiation protection and safety, radioactive waste management due to new unit construction.

BELGIUM

Dose information

Operating reactors		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
Tihange Power Plant (PWR)	3	0.368 man·Sv per reactor Nota Bene: All three Tihange units have a cycle of 18 months. Therefore, there are averagely two outages per year. The total dose for each outage is around 0.550 man·Sv.
Doel Nuclear Power Plant (PWR)	4	0.375 man·Sv per reactor
Total: All types	7	0.372 man·Sv per reactor

Summary of national dosimetric trends

The average of total collective exposure is decreasing.

Events influencing dosimetric trends

Continuous improvement is expected.

Number and duration of outages

In 2009:

- Doel 4 outages (D1 = 6 weeks (+ apart of work for Steam Generator Replacement), D2 = 4 weeks, D3 = 5 weeks, D4 = 6 weeks)
- Tihange 2 outages (Tihange 3 = 7 weeks, Tihange 2 = 8 weeks)

Technical plans for major work in 2010

Doel: Replacement of Steam Generator of Doel 1 end 2009, beginning of 2010.

Regulatory plans for major work in 2010

Doel: OSART Mission in March 2010

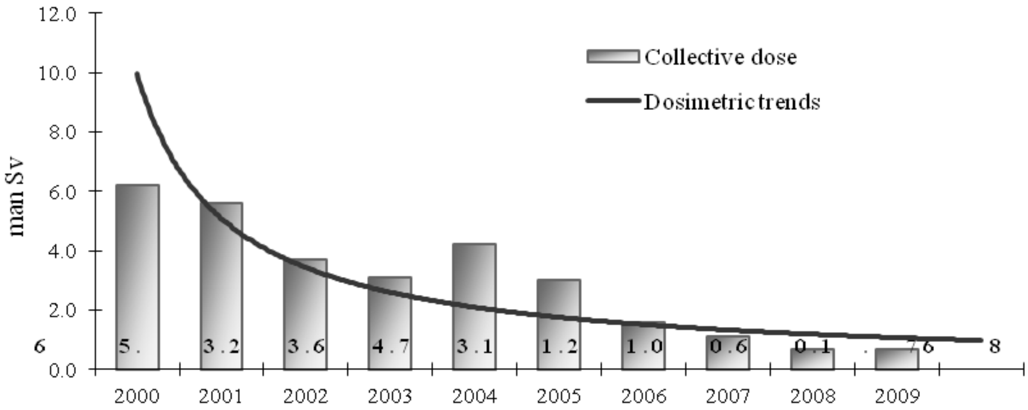
BULGARIA

Dose information

Operating reactors		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
VVER-1000	2	0.279
Reactors in Cold Shutdown or in decommissioning		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
VVER-440	4	0.0294

Summary of national dosimetric trends

Collective dose (CD) at NPP Kozloduy, 2000 – 2009



Number and duration of outages

Unit No.	Outage duration- days	Outage information
Unit 5	42 d	Refuelling and maintenance activities
Unit 6	50 d	Refuelling and maintenance activities

Component or system replacements

Not in the controlled area.

Organisational evolutions

New external organisation for decommissioning of units 1, 2 established.

Issues of concern in 2010

Some decommissioning activities are proposed for units 1 and 2.

Technical plans for major work in 2010

Refuelling and maintenance at unit 5 and 6.

CANADA

Summary of national dosimetric trends

The Canadian collective dose for 2009 for the CANDU fleet of reactors was 26.412 person·Sv for 20 reactors [17 operating units and 3 units in refurbishment] which represents an average of 1.321 person·Sv/reactor. The total collective dose for the 17 operating units was 16.957 p·Sv with an average of 0.99 person·Sv/reactor or 99 person-rem/reactor in operation. Collective dose for units in refurbishment in 2009 (Bruce A Units 1 & 2 and Point Lepreau) was 9.42 p·Sv (average collective dose was 3.14 person·Sv/reactor or 314 person·rem/reactor in refurbishment).

In 2007-2009, the 3-year rolling average annual collective dose per reactor for operating and refurbished of Canadian CANDUs was 1.19 p·Sv/reactor (119 person·rem/reactor), which represents a ~ 5% increase from 2006-2008 three-year rolling average annual collective dose of 1.10 man·Sv/reactor (110 person·rem/reactor). Collective Dose for units in Safe Storage (Pickering-A Units 2&3) was 0.185 person·Sv (average collective dose 0.0925 person·Sv/reactor or 9.25 person·rem/reactor). There was no radiation exposure in excess of regulatory dose limits.

Ontario Power Generation/Darlington Nuclear Generating Station

Darlington Nuclear Generating Station (DNGS) has four operating Units (1 to 4). The station total collective dose for 2009 was 3.193 p·Sv or 0.798 p·Sv/unit. The total collective internal dose was 0.393 p·Sv. The 2009 total collective dose-outages was 2.937 p·Sv, higher than in 2008, due to several forced outages and a vacuum building outage, which required the shutdown of all Units. Darlington continues to strive for improvements in radiation protection through a strategic source term reduction plan scheduled to continue through 2013. Improvements in human performance have resulted in no internal or external unplanned exposures in 2009 - a record for Darlington. Annual collective dose from normal operation was 0.256 p·Sv in 2009.

Ontario Power Generation/Pickering Nuclear Generating Station-A

Pickering Nuclear Generating Station-A (PNGS-A) has two operating Units (1 and 4) and two units in safe storage (2 and 3).

PNGS-A operating Units (1& 4): The total collective dose for these two units was 2.44 p·Sv or 1.22 p·Sv/unit. The External dose was 1.89 p·Sv and internal dose was 0.55 p·Sv. The planned outage P841 was deferred to 2009. The ‘Collective Dose-Outages’ resulted from planned and forced outages in units 1 and 4, was 1.97 p·Sv. Annual dose from routine operations was 0.47 p·Sv. The reduction in routine operations is due to improvements in human performance and reduced on Power time on Unit 4.

PNGS-A Units (2 & 3) in Safe storage: The units (2 & 3) total collective effective dose was 0.185 p·Sv or 0.092 p·Sv/unit (the external dose was equal to 0.097 p·Sv and internal dose was 0.087 p·Sv). The increase in dose on the safe storage compared to 2008 is due to the significant increase in the scope of work in 2009 to bring these two units in a safe storage state.

Ontario Power Generation/Pickering Nuclear Generating Station-B

Pickering B has four operating units (5 to 8): The total collective effective dose was 3.41 p·Sv (0.852 p·Sv/unit). This dose was lower than in 2008, due to decreased outage work. Annual dose for normal operations was 0.573 p·Sv, whereas total collective dose – outages was 2.836 p·Sv. The total collective external dose was 2.877 p·Sv and the total collective internal dose was 0.532 p·Sv. The performance for the internal dose component of 0.133 p·Sv/unit has been the lowest collective internal at Pickering-B to date and can be attributed to several airborne exposure reduction initiatives (e.g. improved drier performance, decreased tritium curie content in moderator and heat transport D2O, and easier access to trends and current tritium levels in the units).

Hydro-Quebec/Gentilly-2 Nuclear Generating station

Hydro-Quebec has one operating unit at Gentilly-2. The total collective effective dose for 2009 was 0.677 p·Sv. The external component was 0.571 p·Sv and the internal component was 0.106 p·Sv. The collective dose-outages was lower than in 2008 due to decreased outage work with a total collective dose – outage of 0.521 p·Sv. Annual dose from normal operation in 2009 was 0.156 p·Sv.

New Brunswick Power/Point Lepreau Generating Station

New Brunswick Power has one operating unit at Point Lepreau. The station was shut down on 28 March 2008 for a planned refurbishment. In 2009, the station remained shutdown as the refurbishment outage continued. Due to the refurbishment work, where many tasks involve high hazards, collective dose to workers is higher than experienced in previous years. The 2009 total collective effective dose was 4.08 p·Sv with an external dose of 3.96 p·Sv and an internal dose of 0.123 p·Sv.

Bruce Power/Bruce Nuclear Generating Station-A

Bruce Nuclear Generating Station-A (Bruce-A) has two operating Units (3 and 4) and two units in refurbishments (1 and 2).

Bruce A operating units (3 & 4): The total collective effective dose was 2.743 p·Sv (or 1.37 p·Sv/unit) with an internal component of 0.244 p·Sv and an external dose of 2.499 p·Sv. In 2009 there were two planned outages. The 'Collective Dose-Outages' was 2.402 p·Sv whereas the annual dose from normal operation in 2009 was 0.341 p·Sv.

Bruce A Units 1 and 2 Restart Project: Units 1 and 2 are shutdown and have been under refurbishment since 2005. A significant portion of dose intensive work was carried out in 2007 and 2008. Units (1&2) total collective dose was 5.110 p·Sv (with an external dose 4.545 p·Sv and an internal dose of 0.565 p·Sv). This internal dose does not include internal dose resulting from alpha event in 2009.

Bruce Power/Bruce Nuclear Generating Station-B

Bruce B has four operating units (5-8): The total collective effective dose was 4.307 p·Sv (1.077 p·Sv/unit) with an external dose of 3.974 p·Sv and an internal dose of 0.333 p·Sv. The total collective dose from the 2009 outages was 3.737 p·Sv. Annual dose from normal operation in 2009 was 0.570 p·Sv.

CHINA

Dose information

Operating Reactors		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
PWR	4	0.562

For Dayabay NPP, the annual collective dose for 2009 is 732.71 man·mSv. For Lingao NPP, the annual collective dose for 2009 is 1 513.86 man·mSv.

Number and duration of outages

Unit	Duration	Collective dose (man·mSv)	Remark
Dayabay unit 1	13th refueling outage, from 2009/04/12 to 2009/05/10, totally 29 days.	545.88	
Dayabay unit 2	No Outage		
Lingao unit 1	7th refueling outage, from 2009/02/25 to 2009/03/26, totally 30 days.	740.29	
Lingao unit 2	6th refueling outage, from 2008/12/09 to 2009/01/11, totally 34 days.	545.52	Collective dose in 2009 is 82.39 man·mSv
Lingao unit 2	7th refueling outage, from 2009/12/13 to 2010/01/04, totally 22 days.	514.109	Collective dose in 2009 is 506.93 man·mSv

CZECH REPUBLIC

<u>Dukovany NPP</u>

Summary of dosimetric trends

There are four units of PWR-440 type 213 in commercial operation since 1985. The collective effective dose (CED) during the year of 2009 was 0.696 man·Sv. CED was 0.068 man·Sv and 0.628 man·Sv for employees of utility and contractors, respectively. The total number of exposed workers was 1,825 (558 utility employees and 1 267 contractors). The average annual collective dose per unit was 0.174 man·Sv.

The maximal individual effective dose 11.14 mSv was reached by a contractor worker carrying out insulation works during outages.

Number and duration of outages

The main contributions to the collective dose were 4 planned outages.

	Outage information	CED [man·Sv]
Unit 1	24 days, standard maintenance outage with refueling	0.092
Unit 2	23 days, standard maintenance outage with refueling	0.060
Unit 3	85 days, standard maintenance outage with refueling Reactor power increased up to 500 MWe	0.326
Unit 4	62 days, standard maintenance outage with refueling	0.165

Major evolutions

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

Unexpected events

There were no unusual or extraordinary radiation events in the year 2009 at Dukovany NPP.

Temelín NPP

Summary of dosimetric trends

There are two units of PWR 1 000 MWe type V320 in commercial operation since 2004. The collective effective dose (CED) during the year 2009 was 0.226 man·Sv. CED was 0.038 man·Sv and 0.188 man·Sv for utility and contractors employees, respectively. The total number of exposed workers was 1 535 (487 utility employees and 1 048 contractors). The average annual collective dose per unit was 0.113 man·Sv. The maximal individual effective dose 3.52 mSv was received by a contractor worker carrying out dismantling and assembly operations on the reactor head during outages.

Number and duration of outages

The main contributions to the values of collective effective dose were 2 planned outages.

	Outage information	CED [man·Sv]
Unit 1	82 days, standard maintenance outage with refueling	0.074
Unit 2	82 days, standard maintenance outage with refueling	0.119

Major evolutions

Very low values of outages and total effective doses represents results of good primary chemistry water regime, well organized radiation protection structure and strictly implementation of ALARA principles during the working activities related to the works with high radiation risk. All CED values are based on electronic personal dosimeters readings.

Unexpected events

There were no unusual or extraordinary radiation events in the year 2009 at Temelín NPP.

FINLAND

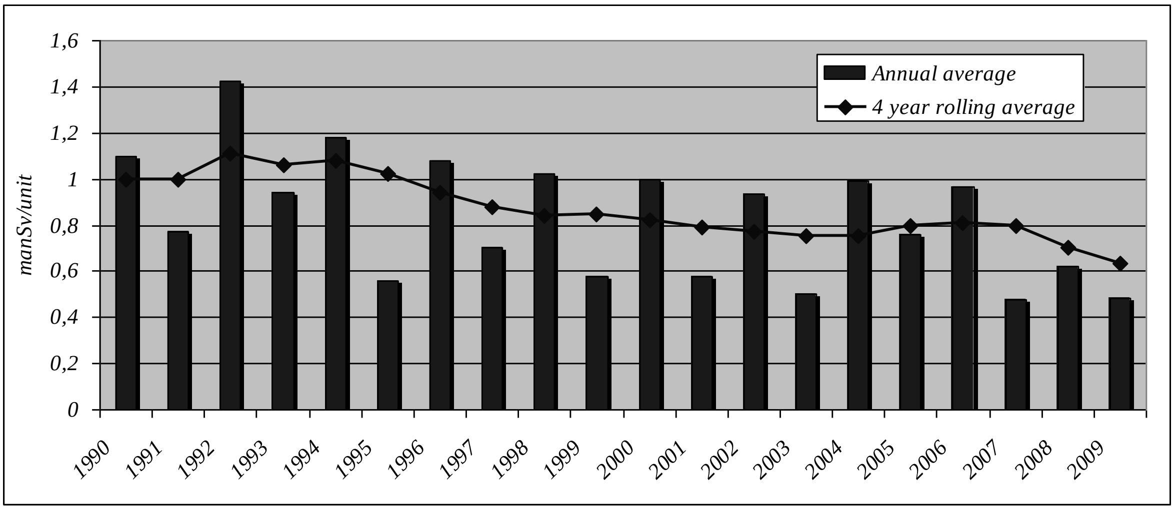
Dose information

Operating Reactors		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
BWR	2	0.593
VVER	2	0.377
Total: All types	4	0.485

Summary of national dosimetric trends

Annual collective dose strongly depends on length and type of annual outages. In 2009 collective dose (1.94 man·Sv) of Finnish NPPs was among the lowest in operating history, mainly due to relatively short outages at all units. Also in the long run the 4-year-rolling average of collective doses shows a slightly decreasing trend since the early 1990s.

Collective dose: Annual and 4-year rolling average in Finnish NPPs



Events influencing dosimetric trends

<u>Olkiluoto NPP</u>

The 2009 annual outage at Olkiluoto 1 unit was a refuelling outage and it took about eight days. In addition to refuelling it included maintenance of one reactor main recirculation pump, some inspections of reactor internals and inspection of a low-pressure turbine. Collective dose of OL1 refuelling outage was 0.265 man·Sv. The maintenance outage at Olkiluoto 2 unit took about 16 days. It included refuelling, replacement of a shutdown cooling system valve, inspections of two low-pressure turbines and scheduled maintenance and tests resulting at a collective dose of 0.725 man·Sv. In Olkiluoto steam dryers of both units have been replaced in 2006 and 2007 and thus dose rates in turbine plants have shown decreasing trend during shutdown.

Loviisa NPP

On both units the 2009 outages were short refuelling outages with durations of some 18 days. On unit 2 a fuel leak was detected during the operating period and the leaking fuel assembly was removed from the reactor during outage. Outage collective doses were among the lowest in plant operating history – 0.38 man·Sv and 0.28 man·Sv. Main contributors to collective dose accumulation were reactor related tasks (disassembly, assembly), cleaning/decontamination and ancillary work as radiation protection, insulation and scaffolding.

Technical plans for major work in 2010

At Olkiluoto 1: an extensive maintenance outage. Planned duration 25 days including several component replacements e.g. low-pressure turbines, inner main steam valves, main sea water pumps and generator cooling system. Olkiluoto 2: a short refuelling outage, planned duration 9 days.

Olkiluoto 3: under construction.

At Loviisa 1: a 23 day short maintenance outage where no major maintenance is planned. At Loviisa 2 an extensive inspection outage of 39 days where all main components will be inspected and some major maintenance and modification work will be conducted, including inspection of all 6 SGs, modification of pressure control system and I&C renewal related piping installations inside containment building.

Regulatory plans for major work in 2010

Work concerning up-dating regulatory guides (also in RP) will continue during 2010. The process will take in account i.e. the experience achieved during the licensing of new NPPs. Target is also to create a new structure for the guides and to minimise the number of guides by combining the existing ones.

STUK continues to review documents concerning OL3. The review-process also includes RP aspects. Three companies, Teollisuuden Voima Oyj (TVO), Fortum Power and Heat Oyj (Fortum) and Fennovoima Oy have submitted to the Ministry of Employment and the Economy (MEE) their applications for a Decision-in-Principle (DIP) of a new NPP unit. Environmental Impact Assessment procedures were conducted for these projects prior to the submission of the applications. STUK gave preliminary safety assessments of the applications for the DIP. Before that STUK issued MEE statements on the EIA programmes and reports.

On 6 May 2010, the Finnish Government made two DIPs in favour of additional construction of nuclear power. TVOs and Fennovoima Oy’s applications were both approved. The Government, however, gave a negative DIP on Fortum’s application. Positive DIPs will still be subject to approval by the Finnish Parliament in July 2010. The result of that voting will have a major impact on the regulatory work on the later half of 2010.

FRANCE

Dose information

Operating reactors		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
PWR	58	0.69
Reactors in cold shutdown or in decommissioning		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
PWR	1	1.93×10^{-3}
CANDU	1	0.02×10^{-3}
GCR	4	1.22×10^{-3}

Annual collective dose

The 2009 average collective dose was 0.69 man·Sv/reactor; the target was 0.65 man·Sv/reactor. The average collective dose for the 3 loop reactors (34 reactors) was 0.79 man·Sv/reactor*;* the average collective dose for the 4 loop reactors (24 reactors) was 0.57 man·Sv/reactor.

In 2009, there were 19 short outages, 26 standard outages, 5 ten yearly outages, 1 forced outage and 7 reactors with no outage. One Steam Generator Replacement and two Reactor Vessel Head Replacements were performed in 2009. The outage collective dose represents 86% of the total annual collective dose. The collective dose from the operating period represents 14% of the annual collective dose. The neutron total collective dose is about 0.27 man·Sv (0.23 man·Sv from the spent fuel transport).

Individual dosesAt the end of 2009, only 2 workers (mechanicals) received a dose higher than 16 mSv on 12 rolling months. This occupational category belongs to the highly exposed specialities (insulation, scaffolding, welding, and mechanics). There were no workers with a 12 month dose over 18 mSv.

77% of the exposed population has a cumulated dose over 12 months less than 1 mSv.

99% of the exposed population has a cumulated dose over 12 months less than 10 mSv.

Principal events

There was a great number of unforeseen events which have had an impact of 0.918 manSv.

The significant events with a dosimetric impact are described hereafter:

- 0.165 man·Sv: Additional works on valves, vessel and modifications at Saint-Laurent B2
- 0.160 man·Sv: Safety Injection System valves + 2nd open/close vessel at Blayais 4
- 0.157 man·Sv: Steam generator tube cracking at Fessenheim 2
- 0.156 man·Sv: Neutron detection chamber unforeseen event during the restart (after steam generator tube plug checking requested by the ASN) at Cattenom 3
- 0.107 man·Sv: Steam generator tube cracking at Bugey 3
- 0.100 man·Sv: Additional works ETV steam generator plugging, nuclear instrumentation system chamber, unforeseen event due to hydrostatic test on residual heat removal system and chemical and volume control system at Saint-Alban 1

- 0.073 man·Sv: Insulation removal of the steam generator loop for the hydrostatic testing of the steam generator secondary side at Penly 2

EDF 3-loop reactors

In 2009, the 3-loop reactors outage programme was composed of 14 short outages, 16 standard outages (with 1 Steam Generator Replacement and 2 Reactor Vessel Head Replacements) and 3 ten yearly outages. The lowest collective doses for the various outage types were:

- Short outage: Chinon 4 with 0.178 man·Sv
- Standard outage: Dampierre 1 with 0.567 man·Sv
- Ten yearly outage: Chinon 3 with 1.667 man·Sv

It can be noted that 1 reactor had no outage and there was no forced outage.

The lowest collective dose for a SGR was Blayais 1 with 0.545 man·Sv.
The lowest collective dose for a RVHR was Chinon 3 with 0.122 man·Sv.

EDF 4-loop reactors

In 2009, the 4-loop reactors outage programme was composed of 5 short outages, 10 standard outages and 3 ten yearly outages. The lowest collective doses for the various outage types were:

- Short outage: Golfech 1 with 0.211 man·Sv
- Standard outage, Chooz 1 with 0.405 man·Sv
- Ten yearly outage, Belleville 2 with 1.152 man·Sv

It can be noted that 6 reactors had no outage and there was 1 forced outage (Cattenom 3) giving a collective dose of 0.182 man·Sv.

RP Events (ESR)

There were 2 ESRs:

- one at Flamanville 2 classified as INES 2 regarding a radiography examination of Pressurizer heaters welding (Intaked dose = 4.75 mSv)
- one at Saint-Alban 1 regarding internal contamination for 5 workers. The cause is probably an atmospheric contamination. (dose < 0.50 mSv)

2010 Goals

The EDF Goal regarding the annual collective dose is 0.65 man·Sv/reactor. For the individual doses, there are two objectives: 1) a decrease by 10% the individual dose of highly exposed workers in 3 years and 2) to keep the good result of “no worker over 18 mSv”.

Future activities in 2010

For the individual dose: Continuation of the current actions.

For the collective dose: ALARA revival to achieve the collective goal which is ambitious compared with the programme of work.

Autorité de Sûreté Nucléaire

In 2009, the French Nuclear Safety Authority, ASN, carried out 19 (1 by plant) on-site radiation protection inspections on pressurised water reactors (PWRs) focusing on the control and containment of contamination in controlled areas, as well as on the management of radioactive sources (especially gamma radiography). ASN and its technical support organisation, the Institute of Radiation Protection and Nuclear Safety, IRSN, continued to analyse and assess radiation monitoring systems in the classified area, as well as the implementation of radiation protection requirements on maintenance activities. They were also interested in the EDF computerised dosimetry management system.

ASN and IRSN led further the assessment process of the preliminary safety report of the EPR, focusing on the activities with high radiological stakes and the "two-room" concept, which enables access during operation for maintenance activities.

In 2009, ASN assessed positively the advances made in the management of source term reduction. However, ASN considered that there are still areas of improvement concerning collective doses, even if improvements concerning individual doses have been observed.

For 2010, ASN and IRSN will remain vigilant to the setting of dose targets and the organisational and technical measures taken to achieve them, especially during reactor outages. They will pay particularly close attention to contamination control. Finally, ASN and IRSN will continue the assessment process of the preliminary safety report of the EPR.

GERMANY

Dose information

Operating Reactors		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
PWR	11	1.05
BWR	6	1.00
Total: All types	17	1.03
Reactors in cold shutdown or in decommissioning		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
PWR	5	0.128
BWR	3	0.138
GCR	2	0.017
VVER	5	0.020

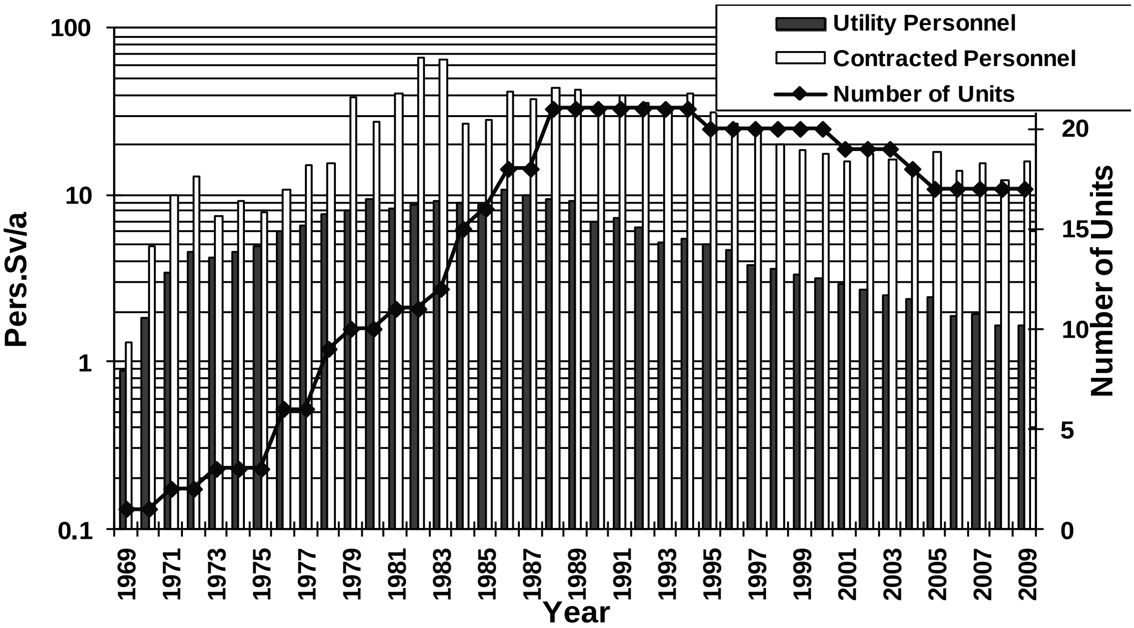
It should be noted that the contribution of each reactor under decommissioning to the annual collective dose strongly depends on the type of reactor and the type of decommissioning work performed in the year. Accordingly it should be noted that among the reactors in cold shut down or in decommissioning some small prototype reactors are considered, which contribute only with small annual doses to the average, and that two reactors in safe enclosure (1 GCR, 1 BWR) are considered again with very small contributions to the related average.

For the 5 reactors participating in ISOE the average numbers in 2008 are 0.194 man·Sv for 3 PWRs, 0.258 man·Sv for one BWR and 0 man·Sv for a GCR in safe enclosure.

Summary of national dosimetric trends

In 2009, 17 nuclear power plants (11 PWR, 6 BWR) were in operation. The trend in the total annual collective dose is presented in the following figure. The total annual collective dose was 17.56 Pers·Sv with 1.64 Pers·Sv for the utility personnel and 15.92 Pers·Sv for the contracted personnel.

Annual collective dose 1969 – 2009 for all units in operation (Utility and Contractor Personnel, Number of Units in Operation)



Events influencing dosimetric trends

In 2008, no outage was performed for two NPPs and the dose contribution from the outage was remarkable low for one NPP. In 2009 for these three NPPs outages, the total annual collective dose was increased partially for several months duration. As such, the data of 2009 are in the range of typical data for the last years.

Number and duration of outages

Outages were performed for each of the 17 NPPs. The total of all planned and unplanned outages was about 1 660 days. For two PWRs, the duration of the outages was 10 months for each of them. For two BWRs, the outages were 11 months and 12 months respectively.

Safety-related issues

During outage of some NPPs the inspection and correction of wall plugs were performed. In some NPPs programmes on investigation and potential corrective action with regard to chloride induced corrosion and cracks were performed.

Unexpected events

99 events were reported to the responsible German authorities of the Länder according to the German Reporting Ordinance (AtSMV). None of these events were classified higher than INES 0. 15 events were directly related to aspects of radiation protection, mainly as they related to small leakages.

New/experimental dose-reduction programmes

In 2009, the first nuclear power plant of the country in operation started with full system decontamination in preparation of the annual outage. The results were promising and other nuclear power plants intend to follow this approach in the next years.

Others in 2009

The VGB Working Group on Radiation Protection was working on a concept for the supervision and avoidance of radioactive intakes in German NPPs. Experience showed that the supervision of Tritium intakes needed some attention. The Working Group will continue considering this item during their future meetings.

As a joint initiative VGB, nuclear service providers and the Swiss Regulatory Body ENSI developed an educational scheme for a new radiation protection professional. The new qualification “Strahlenschutz Techniker (VGB)”, “Strahlenschutz Ingenieur (VGB)” and “Strahlenschutz Meister (IHK)”contribute to a common standard complementing existing qualifications.

Since 1 July 2009 the new technical regulations on nuclear safety and radiation protection in nuclear power plants (“Safety Criteria for Nuclear Power Plants”, http://regelwerk.grs.de) are under a trial application by BMU and Länder authorities. Module 9 of the technical regulations is related to radiation protection. The new technical regulations will be applied in parallel to the existing German regulations. The experiences with the new technical regulations will be incorporated after the end of the trial period, which lasts 15 months.

A new government was formed as a result of the federal election in September 2009. The parties involved were two parties of Christian Democrats (CDU, CSU) and the Liberal Party (FPD). Within their coalition treaty for the next four years the three parties agree on delaying the final shutdown of NPPs in order to achieve affordable prices for energy and less dependency from foreign countries; the treaty does not contain any statements on new nuclear power plants.

HUNGARY

Dose information

Operating Reactors		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
VVER	4	0.587 (with electronic dosimeters) 0.613 (with film badges)

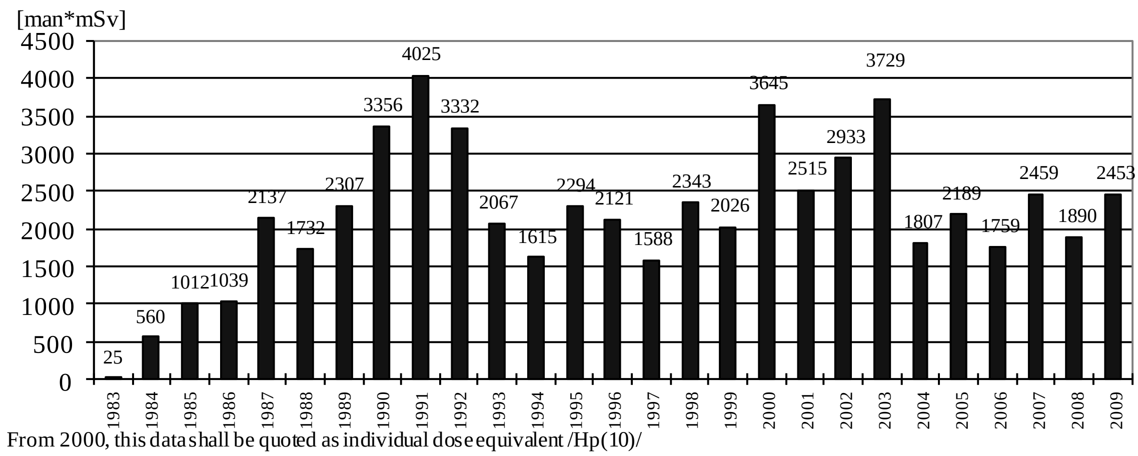
Summary of national dosimetric trends

According to the result of operational dosimetry, the collective radiation exposure was 2 347 man·mSv for 2009 at Paks NPP (1,745 man·mSv with dosimetry work permit 601 man·mSv without dosimetry work permit). The highest individual radiation exposure was 13.5 mSv (measured with electronic dosimeters), which was well below the dose limit of 50 mSv/year, and our dose constraint of 20 mSv/year. The collective dose increased in comparison to the previous year. The higher collective exposures were mainly ascribed to all the outages especially the one "so called" long outages at Unit 3.

Events influencing dosimetric trends

There was one general overhaul (long maintenance outage) in 2009. The collective dose of the outage was 740.5 man·mSv on Unit 3.

Development of the annual collective dose values at Paks Nuclear Power Plant (According to the results of the film badge monitoring by the authorities)



Number and duration of outages

The duration of the outage was 34 days for Unit 1, 28 days for Unit 2, 70 days for Unit 3 and 43 days for Unit 4.

Major evolutions

The four units of the Paks NPP were put into operation between 1982 and 1987. Taking into account the designed lifetime (30 years), they should be shut down between 2012 and 2017. In possession of the country's present technical knowledge it can be considered as a real long-term goal to extend the designed lifetime of the units with at least ten years.

Component/system replacements and safety related issues

The replacement of the installed radiation protection monitoring system in 2009 at Unit 3 and Unit 4 was completed.

ITALY

Dose information

Reactors in cold shutdown or in decommissioning		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
PWR	1	0.002
BWR	2	0.124
GCR	1	0

Events influencing dosimetric trends

In Garigliano (BWR) NPP: removal activity asbestos in reactor building.

In Caorso (BWR) NPP: activities of removal and transport of the spent fuel.

JAPAN

Dose information

Operating Reactors		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
PWR	24	1.61
BWR	32(*1)	1.36
Total: All types	56(*1)	1.47
Reactors in cold shutdown or in decommissioning		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
GCR	1	0.02
LWCHWR	1	0.11

*1 Note: 1. Includes Hamaoka Unit No. 1 & No. 2 in BWRs that have been decommissioning since Nov. 18, 2009.

Summary of national dosimetric trends

Total collective dose in the fiscal year 2009 for all LWRs was 82.06 man・Sv, and this was lower than the fiscal year 2008 value of 84.02 man·Sv. The average annual collective doses per unit for all LWRs, BWRs, and PWRs were 1.47 man·Sv, 1.36 man・Sv and 1.61 man·Sv respectively. The BWR collective dose per unit for 2009 was decreased from the previous year by 0.18. The PWR collective dose per unit for 2009 was increased from the previous year by 0.04 man·Sv. The BWR average collective dose is stable after fiscal year 2004. On the other hand, the PWR average collective dose increased last year and this year.

Events influencing dosimetric trends

The increase in collective dose for PWRs was mainly due to the modification works in a high dose rate area such as the repair of a pressuriser and replacement of equipment and piping during the periodical inspections. Also, improvement works of the seismic safety margin were performed in Japanese BWRs and PWRs.

Number and duration of outages

Periodical inspections were completed at 11 BWRs and 21 PWRs in the fiscal year 2009. The average duration of outage for periodical inspection was 189 days for BWRs and 88 days for PWRs. The average duration for BWRs increased from the previous year by 51 days and PWRs decreased from the previous year by 56 days.

New plants on line/plants shut down

Tomari NPP Unit 3, PWR of Hokkaido Electric Power Company, started commercial operation Dec. 22nd 2009.

Hamaoka unit 1 and unit 2 of Chubu Electric Power Company terminated their operation on January 30th 2009 and have been decommissioning since Nov.18th 2009.

Major evolutions

The new regulatory inspection system was implemented in January 2009. The new inspection system is the one for safety activities based on the maintenance programme, aiming for safety assurance as an important action. In this system the inspection is shifted from an uniform inspection to a fine inspection according to the characteristic of each plant allowing 18 or 24 month operating periods which was limited to 13 months so far.

Component or system replacements

Replacements of a steam generator and a reactor vessel head were carried out at some PWR plants.

REPUBLIC OF KOREA

Dose information

Operating reactors		
Reactor type	**Number of reactors**	**Average annual collective dose per unit [man·Sv]**
PWR	16	0.47
CANDU	4	2.21
Total: All types	**20**	**0.82**

Summary of national dosimetric trends

For the year of 2009, 20 NPPs were in operation including 16 PWR units and 4 CANDU units. The average collective dose per unit for the year 2009 was 0.82 man·Sv. As in previous years, the outages of units in 2009 contributed to the major part of the collective dose, 90.2% of the collective dose was due to works carried out during the outages. There were in total 11 723 people involved in radiation works in 20 operating units and the total collective dose was 16.320 man·Sv.

Events influencing dosimetric trends

Because of tremendous improvement of facilities in Wolsung Unit 1, collective dose in 2009 increased 61% (16.320 man·Sv) in comparison to 10.137 man·Sv in 2008.

Number and duration of outages

Periodic inspection was completed at 11 PWRs and 4 PHWRs. The total duration for periodical inspection was 341 days for PWRs and 345 days for PHWRs.

New plants on line/plants shut down

Shin Kori unit 1(PWR, 1000 MWe) loaded with its first fuel assemblies in May and will begin commercial operation in December 2010.

Component or system replacements

Reactor Pressure Tubes of Wolsung Unit 1(PHWR), which operated for 28 years, are replaced due to the increase of operational life caused sag, elongation, diametral expansion and wall reduction of pressure tubes and calandria tubes. These large tasks will be completed at the end of this year.

Issues of concern in 2010

2010 ISOE Asian Regional ALARA Symposium was organised 30 August-1 September in Gyeong-ju city, Korea.

Technical plans for major work in 2010

A trial application of Zinc injection to reduce the source term is carrying out in Ulchin Unit 1.

Regulatory plans for major work in 2010

The regulatory expert organisation, KINS (Korea Institute of Nuclear Safety), has started the development of the regulatory standards and the regulatory guides since 2007 to reflect the opinions of the stakeholders for more objective and wider regulatory activities. 115 of the regulatory standards and 192 of the regulatory guides in 18 fields have been developed, and deliberated and resolved at the subcommittees, and will be submitted to the main committee and MEST (Ministry of Education, Science and Technology) for approval in 2010.

LITHUANIA

Dose information

Operating reactors		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
LWGR	1	0.7887
Reactors in cold shutdown or in decommissioning		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
LWGR	1	0.1447

Summary of national dosimetric trends

In 2009 the occupational doses at the Ignalina NPP were at a level of 2005-2008 and was 0.9334 man·Sv (0.7887 man·Sv for operating Unit 2 and 0.1447 man·Sv for Unit 1 at cold shutdown). The collective dose for INPP personnel was 0.8639 man·Sv and for outside workers was 0.0695 man·Sv. In 2009, 2153 INPP workers and 1179 outside workers were working under the influence of ionising radiation in the controlled area of the INPP. The average effective individual dose for INPP staff was 0.40 mSv, for INPP staff and outside workers – 0.28 mSv. The highest individual effective dose for INPP staff was 11.59 mSv, and for outside workers – 2.71 mSv.

Events caused the dosimetric trends

In 2009 planned INPP personnel and outside workers occupational factors were made including the possible outage of Unit 2. Planned collective dose during the outage period of Unit 2 for INPP personnel was 0.6 man·Sv, for outside workers – 0.185 man·Sv. Planned annual collective dose for INPP personnel was 1.765 man·Sv, for outside workers – 0.258 man·Sv.

In case of forthcoming decommissioning of Unit 2 it was decided to reduce the amount of repair works and perform only works, which were required for normal operation of Unit 2 till the end of 2009. The main works during the outage were – repair works of reactor control equipment, inspection of the safety system, executing the gamma dose at work places reducing activities.

Therefore the collective dose for INPP personnel was 49% of planned (0.8639 man·Sv), and for outside workers was 27% of planned (0.0695 man·Sv). Overall collective dose for INPP personnel and outside workers was 46% of planned dose (0.933 man·Sv).

The main works that contributed to the collective dose during the outage period of Unit 2 at the INPP are given in the table below:

Main works	Collective dose (man·mSv)
Maintenance, repairing, replacement of the system of the reactor vessel and reactor equipment	84.94
Thermo - insulation works	33.11
Repairing of the main circulation circuit	24.73
Routine inspections	9.50
Repairing of reactor water clean-up system	5.30
Lighting, general electrical equipment	4.81
Radiological monitoring of workplaces	4.69
Preparing for the inspection of the main circulation circuit	1.68
Nuclear ventilation system	1.13
Decontamination of premises	0.09
Other works	7.43

Number and duration of outages

One planned outage at Unit 2 was in 2009 (Unit 1 of INPP was shutdown on 31 December 2004). The duration of outage at Unit 2 was 22 days. The collective dose was distributed as following: normal operation – 71% (0.432 man·Sv) of the Unit 2 annual collective dose, outage – 29% (0.177 man·Sv) of the Unit 2 annual collective dose.

New plants on line/plants shut down

After a Government decision, the Unit 2 of INPP was shutdown on 31 December 2009. The Unit 1 of INPP was shut down on 31 December 2004. Unit 1 was used according to technological regulations in a cooled condition with nuclear fuel in it.

Major evolutions

In 2009 the operation of the new Cement Solidification Facility (CSF) for treatment of liquid radioactive waste and Temporary Storage Building (TSB) was continuing. During 2009 the cementation of ion exchange resins was continued. 275 containers were filled up with waste, each of the containers can contain eight 200 litres drums. During 2009 the 207.4 m3 of pulp was recycled. There are 684 containers in the storage facility.

During 2009 the transportation of spent nuclear fuel from Unit 1 and Unit 2 to the Interim Spent Fuel Storage Facility has been continued. 10 containers of CONSTOR type (4 containers from Unit 1, 6 containers from Unit 2) were transported, in total there are 112 containers in the facility. Interim Spent Fuel Storage Facility will be extended and the loading of spent nuclear fuel will continue in 2010. In total there will be 120 containers in Interim Spent Fuel Storage Facility and it will be fulfilled in March 2010. During 2009 was active preparation for Unit 2 decommissioning.

In 2009, the measures foreseen in the Plan of Implementation of the Decommissioning Programme for the Unit 1 at the INPP were further implemented.

Goals for 2010:

- Continuing the safe decommissioning of Unit 1 and Unit 2;

- Evaluation and upgrading the level of safety culture;
- Extension and support to the effectiveness of the quality improvement system;
- Highest individual dose shall be below 19 mSv;
- The collective dose shall not exceed 1.50 man·Sv;
- Continuous implementation of the ALARA principle.

Component or system replacements

In 2009 the unloading of partially burnt nuclear fuel from Unit 1 and transportation to the Unit 2 were continued and is completed for re-use in the reactor of Unit 2. There were 316 Fuel Assemblies unloaded from Unit 1 since 2006, for 2009 in all 988 Fuel Assemblies are transported. These works allow reducing the nuclear fuel purchases up to 50%. December 14^{th} 2009 an unloading of Fuel Assemblies from the reactor of Unit 1 was completed.

Unexpected events

In 2009, Unit 2 has one unexpected shutdown in June.

Organisational evolutions

In 2009 a new management structure of Ignalina NPP was developed and validated and from January 1^{st} 2010 all departments will be changed according to the new management structure.

Technical plans for major work in 2010

In September 2009, construction was started for a new Spent Fuel Storage Facility according to the B-1 project. In October 2009, construction was also started for a Radioactive Waste Treatment Facility according to the B-3/4 project. In November 2009, the contract on designing of the Radioactive Waste Storage was approved according to the B-5 project. All relevant works of these projects will continue in 2010.

Regulatory work in 2010 and plans in the coming year

In order to protect the public and the environment in the Republic of Lithuania against harmful effects of an ionising radiation, which is related to the activities of the Ignalina Nuclear Power Plant (INPP) the state radiation protection supervision of INPP and outside organisations (contractors) is established and implemented in accordance with the Regulation on state supervision of radiation protection adopted by the Minister of Health.

For 2010 the Radiation Protection centre has set the plan to carry out 4 inspections at INPP and 12 inspections of outside organisations. The main tasks of inspections at INPP in 2010 are these:

- radiation protection of outside workers;
- occupational exposure;
- radiation protection of the all category sources of ionising radiation used at INPP;
- radiation protection of the sources and radioactive waste during transportation and
- radiation protection of the workers during the industry radiography works implemented at INPP.

The review of documents related to INPP decommissioning will continue.

In order to optimise radiation protection and the nuclear safety infrastructure in Lithuania the Government Resolution No. 143 for reorganisation of the Radiation Protection Centre and State Nuclear Power Safety Inspectorate and the establishment of a new single regulatory body the Nuclear and Radiation Protection Regulation Agency was adopted 10th of February 2010. The Nuclear and Radiation Protection Regulation Agency will be established after the preparation of the appropriate legal basis.

MEXICO

Dose information

Operating reactors		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
BWR	2	2.32

Summary of national dosimetric trends

Laguna Verde Nuclear Power Plant (LVNPP or just LV) is composed of two BWR units from GE, and is the only nuclear power plant operating in Mexico. After the collective dose peak in 2008, the plant is getting a better performance, finishing 2009 with a collective dose of about one half of as in 2008. This value is still considered as high and seems not to have a short term solution since it strongly depends on several plant modifications required to reduce the radioactive source term.

Events influencing dosimetric trends

a) **Crud burst** The crud burst, originated by a reactor water chemical instability induced by the application of noble metals and hydrogen to prevent the stress corrosion cracking of reactor internals, is still remarkably influencing dose rates at the plant, and specifically in the drywell during refuelling outages. The BRAC Index (contact dose rates on recirculation pipes) has increased in two cycles from 0.82 to 4 mSv/h in Unit 1, and from 0.58 to 5 mSv/h in Unit 2.
b) **Power Uprate activities**: phase 1 of the Power Uprate activities in Unit 2 consisted of four steam heaters substitution, two main steam reheaters substitution, and main condenser pipes substitution (Cu-Ni to Titanium).
c) **Power Uprate sequels**: steam leaks repairs and other corrective activities in high radiation areas were originated by the Power Uprate Project modifications, new components and new layouts in U1 and U2.

Number and duration of outages

Unit 2 – 10th Refuelling Outage (U2RFO10): 54 days (including Power Uprate Project, first phase)

Major evolutions

Power Uprate Project

The objective of the LV Power Uprate Project is the increase of the nominal power of each unit by 20%. Unit 1 first phase of the project was achieved in Sept-Nov 2008, and Unit 2 in April-May 2009.

Phase I for each unit consisted mainly of:

- Substitution of four steam heaters
- Substitution of the two main steam reheaters (MSRs)
- Substitution of the main condenser pipes (Cu-Ni) to Titanium pipes
- Redesign of Turbine Building HVAC system

The second (and last) phase of the LV Power Uprate Project for both units will take place in 2010, during U1RFO14 (Apr-May 2009) and U2RFO11 (Sept-Oct); it will feature next activities:

- Substitution of turbines
- Substitution of generators
- Redesigned condensate steam ejectors
- Addition to two more steps to the condensate demineraliser system
- Addition of a condensate pump and booster condensate pump
- Reinforcement of Safety Relief Valves (SRVs)

New/experimental dose-reduction programmes

The main topic to be solved regarding a substantial reduction of LV collective dose is the one related to the current high radiation source term. LVNPS is currently working with EPRI looking for the best solution to this concern. Among the main actions included in a draft plan are: feedwater iron concentration reduction, on-line noble metals application, increase of the efficiency of RWCU and condensate demineralisers filters, and chemical decontamination. This seems to be a mid term project and the correct sequence of application will be fundamental for its success.

In the short term, a physical removal (vacuuming) of crud from reactor vessels of both Units is planned for the refuelling outages of both Units in 2010.

Issues of concern in 2010

Collective dose reduction/source term reduction.

Technical plans for major work in 2010

Power Uprate project, second phase (see *Major Evolutions*): during Unit 1 Refuelling Outage 14 (Apr-May 2010), and Unit 2 Refuelling Outage 11 (Set-Oct 2010).

THE NETHERLANDS

Dose information

Operating reactors		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
PWR	1	0.242
Reactors in cold shutdown or in decommissioning		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
BWR	1	0.00058

The Netherlands has two nuclear power plants: Dodewaard and Borssele.

The Dodewaard BWR (57 MWe), operated by GKN, was shut down in March 1997 for political and economical reasons. The modification works for transferring the plant into a 'safe enclosure' (for 40 years) have been completed per July 1st in 2005. In the past years a number of buildings have been demolished and several decommissioning activities have been carried out. New systems were built for ventilation, water treatment and monitoring of emissions. For the next years every year some surveillance and maintenance activities will continue to be carried out. The collective annual dose (only for own staff) in 2009 was 0.58 man·mSv, mainly due to some extra inspections.

The Borssele plant (515 MWe), operated by NV EPZ, is a baseload unit. Up to this year it has enjoyed 34 years of commercial operation. Major backfittings were completed in the plant in 1997 and 2006. The plant's electrical output has been raised in 2006 to 515 MWe. The annual outage in April lasted 28 days. It was a short outage with some maintenance and inspection works. The collective dose in the outage was 0.182 man·Sv. The annual collective dose amounted to 0.242 man·Sv. In 2009 the average individual dose was 0.26 mSv for plant and 0.43 mSv for contractor personnel. The highest annual individual dose was 3.31 mSv for plant personnel and 3.53 mSv for contractor personnel.

Related to the future of the plant: programmes and plans for enabling Long Term Operation (LTO) until 2034 are being developed in the organisation.

PAKISTAN

Dose information

Operating reactors		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
PHWR (KANUPP)	1	1.858
PWR (CNPP-1)	1	0.232

ROMANIA

Dose information

Operating reactors		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
CANDU	2	0.243

Summary of national dosimetric trends

Occupational exposure at Cernavoda NPP (2000-Oct 2009)

	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	209.3	479.34	688.6
2009	67.6	417.7	485.3

Events influencing dosimetric trends

Normal operation of the plant (U1 & U2)

During normal operation intervals of both units there were not radiological events that could have an impact on individual or collective doses. At the end of 2009:

- there were 13 employees 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 since the beginning of the year is 7.18 mSv;
- The contribution of internal dose due to tritium intake was 13.9%.

Planned Outage

A 23 days planned outage was done at Unit 2 between May 9th and June 1st 2009. Activities with major contribution to the collective dose were as follows:

- 13 Fuel channel inspections;
- feeders inspection/measuring;
- preventive maintenance of fueling machine bridge components;
- mandatory tests programme during planned outage;
- mandatory inspection programme

The total collective dose at the end of the planned outage was 133 man·mSv (122 man·mSv external dose and 11 man·mSv internal dose due to tritium intakes).

Finally this planned outage had a 27% contribution to the collective dose of 2009.

Planned Outages dose history

Year	Unit	Interval	Collective dose received (man·mSv)		
			External	Internal (^{3}H intakes)	Total
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

Radiation protection-related issues

During 2009, modernisation of the "Tritium in Air Monitoring" system in Unit 1 continued with installing four loops; in order to improve the system efficiency, one supplementary Local Monitoring Unit will be implemented, so the system will contain five Local Monitoring Units.

The contract for installing the fifth loop was signed and this action will be finished at the end of July 2010.

The extension and improvement of the Area Alarming Gamma Monitors (AAGM) system is in progress.

During the Unit 2 planned outage in 2009 four loops were improved and one loop was improved in running.

During the Unit 1 planned outage in 2010, the last three loops will be improved.

For the long term a heavy water de-tritiation facility project is in progress. A pilot-plant is under commissioning to test the technology to be applied to reduce tritium concentration in our CANDU reactor moderator and primary heat transport systems.

Issues of concern in 2009

The main concerns for 2009 were important works, with high radiological impact, performed during the planned outage of Unit 2.

Issues of concern in 2010

The main concerns for 2010 are activities with high radiological impact, to be performed during the planned outage of Unit 1 (e.g. End Fitting Positioning Assembly Reconfiguration; Steam Generator's ECT inspection).

RUSSIAN FEDERATION

Dose information

Operating reactors		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
PWR (VVER)	15	0.805
Reactors in cold shutdown or in decommissioning		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
PWR (VVER)	2	0.084

Summary of national dosimetric trends

With respect to 6 operating VVER-440 MWe and 9 operating VVER-1000 MWe type reactors, the total (utilities employees and contractors) effective annual collective dose in 2009 was 12.070 man·Sv. This result represents a 23% or 2.415 man·Sv increase from the year 2008 total collective dose of 10.408 man·Sv.

Comparative analysis shows a considerable difference between average annual collective doses per VVER-440 and VVER-1000 reactors. In 2009, these values were:

- 1.254 man·Sv/reactor for VVER-440 MWe.
- 0.496 man·Sv/reactor for VVER-1000 MWe.

The maximum individual dose at all Russian plants with VVER was 18.46 mSv. This dose was gradually received over 2009 by a maintenance worker at Novovoronezh NPP.

Events influencing dosimetric trends

The principal cause of the total collective dose increase in the year 2009 came out from the essential growth of annual outages durations at some reactors as well as an increase in repairing and maintenance works. In 2009, the total length of the planned outages for all Russian VVERs was 753 days. In 2008, this value was 659 days.

The maximum increase of the annual collective dose was at Novovoronezh 3 (VVER-440 MWe). In 2009, a major maintenance outage with refueling was performed, a 100% cladding failure detection and location of fuel assembly and repair of leaks between the primary and secondary side of the steam generators were done. As a result of this repairing activity, the annual collective dose at Novovoronezh 3 reached 3.661 man·Sv, at 2.291 man·Sv more than the previous year. Moreover, this result was the maximum for Novovoronezh 3 starting from 2002 – the first year of participation in the ISOE.

Planned outages duration and collective doses

Reactor	Duration [days]	Collective dose [man·Sv]
Balakovo 1	no outage	--
Balakovo 2	40	0.313
Balakovo 3	62	1.049
Balakovo 4	44	0.337
Kalinin 1	45	0.566

Kalinin 2	69	0.743
Kalinin 3	40	0.128
Kola 1	60	0.797
Kola 2	72	0.874
Kola 3	60	0.475
Kola 4	37	0.273
Novovoronezh 3(*)	71	2.492
Novovoronezh 4	50	1.264
Novovoronezh 5	69	0.615
Volgodonsk 1	34	0.043

(*) At Novovoronezh 3, there were two unplanned repairing outages: from 24 March to 05 April and from 16 April to 12 June. The total collective dose for these outages was 0.881 man·Sv.

New plants on line

In December 2009, Unit 2 of Rostov NPP (also known as Volgodonsk) with VVER-1000 MWe type reactor achieved a first criticality. The preliminary date for commercial operation is planned in October 2010.

New dose-reduction programmes

A new conceptual programme "Optimization of Occupational Exposures at Russian NPPs" was developed by Concern Rosenergoatom (Russian operating utility) in 2009. Realisation of the programme is scheduled for the 2010-2014 period. Next targets were determined in the programme to the end of this period:

- 0.6 man·Sv/reactor for average annual collective dose of all VVER type reactors.
- nobody with an annual individual dose more than 18 mSv and nobody with an individual dose more than 75 mSv per 2010-2014 period and less than 30 percent of the personnel with an annual individual dose more than 1 mSv.

Issues of concern in 2010

- Determination and validation of the values of the annual individual control dose level based on the analysis of occupational exposures at Russian NPPs.
- Continuation of the preparatory activities aimed at implementation of 18 months fuel cycle for VVER-1000 MWe type reactors.
- Development of uniform guidelines for radiological posting and labeling.
- Organisation and conducting the final stage of the professional contest of health physics workers.
- Delivery arrangements of new types of electronic personnel dosimeters (EPD).
- Development of recommendations on self assessment in occupational radiation protection.
- Development of guidelines on radiation passbook for outside workers.

SLOVAK REPUBLIC

Dose information

Operating reactors		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
VVER	4	0.190
Reactors in cold shutdown or in decommissioning		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
VVER	2	0.106

Summary of national dosimetric trends

Bohunice NPP (2 units – Bohunice 3 and 4): The total annual effective dose in Bohunice NPP in 2009 calculated from legal film dosimeters was 266.515 man·mSv (employees 138.973 man·mSv, outside workers 127.542 man·mSv). The maximum individual dose was 4.553 mSv (NPPs employee).

JAVYS NPP (2 units – Bohunice 1 and 2): The total annual effective dose in JAVYS NPP in 2009 calculated from legal film dosimeters was 211.96 man·mSv (employees 11.97 man·mSv, outside workers 199.99 man·mSv). The maximum individual dose was 5.273 mSv (outside worker).

Mochovce NPP (2 units): The total annual effective dose in Mochovce NPP in 2009 evaluated from legal film dosimeters and E_{50} was 493.304 man·mSv (employees 174.192 man·mSv, outside workers 319.112 man·mSv). The maximum individual dose was 5.770 mSv (NPPs employee).

Events influencing dosimetric trends

Bohunice NPP: Standard operation and short outages influenced low results of dosimetry data

JAVYS NPP: Unit 1 has not been in the operation and has been prepared to decommissioning. During the year all nuclear fuel from this unit was carried away to the spent fuel store. Unit 2 has not been in operation since 01.01.2009 due to a planned shut down.

Number and duration of outages

Bohunice NPP:
- Unit 3: 24.4 days standard maintenance outage. The collective exposure was 99.59 man·mSv
- Unit 4: 25.2 days standard maintenance outage. The collective exposure was 95.537 man·mSv

JAVYS NPP:
- Unit 1: out of operation since 01.01.2007
- Unit 2: out of operation since 01.01.2009

Mochovce NPP:
- Unit 1: 51.5 days major maintenance outage. The collective exposure was 375.705 man·mSv
- Unit 2: 27 days standard maintenance outage. The collective exposure was 89.438 man·mSv

Note: all data in this paragraph came from electronic operational dosimetry.

New plants on line/plants shut down

New NPP: Completion of the Mochovce units 3 and 4. In the year 2009 contracts were signed with the main suppliers. Preparatory work for completion started.

Shut down of second unit of JAVYS NPP: Unit 2 was shut down on 31 Dec 2008. Both units (1 and 2) have an operation license till 2011 (Unit 1 – June 2011; Unit 2 – Oct 2011). Both units have been prepared for the decommissioning.

Major evolutions

JAVYS NPP: Preparation for the decommissioning of Unit 1 and 2 (preparation of the new license for decommissioning).

Component or system replacements

Bohunice NPP:

- replacement of major electronic parts of stationary NPP radiation protection system
- replacement of old portal personal contamination monitors at the main NPP gate
- works with the transformation of existing radiation protection information and work management software into the new software environment – common for both Bohunice and Mochovce NPP
- replacement of old liquid effluents monitors
- installation of additional (14) detectors on site in emergency shelters, security offices, control rooms, …
- enhancement of operational dosimetry terminals including EPDs into specific places as NDT offices, emergency shelters, fire brigade offices

*JAVYS NPP: R*eplacement of old portable instruments

*Mochovce NPP: R*eplacement of major electronic parts of stationary NPP radiation protection system

Safety-related issues

JAVYS NPP: Preparation of the new license for the decommissioning

New/experimental dose-reduction programmes

*JAVYS NPP: R*emote and underwater cleaning of equipments in the spent fuel pool

Technical plans for major work in 2010

*Bohunice NPP: E*xchange of old portal personal contamination monitors at the entry to the hot change rooms

*JAVYS NPP: C*ompletion of the radiological characterisation of the site and database for decommissioning

Mochovce NPP: From 1.1.2010 SAP implementation in work management, RWP management, radioactive sources management, RP laboratory results management, implementation of personal dose management system SEOD

Regulatory plans for major work in 2010

- Decommissioning of JAVYS NPP (Bohunice V1), licensing process
- Construction of unit 3 and 4 of Mochovce NPP, inspection

SLOVENIA

Dose information

Operating Reactors		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
PWR	1	0.653

Summary of national dosimetric trends

Collective dose trend after the SG replacement in 2000 shows a decrease during the last decade. The three years' collective dose average decreased from previous 0.63 man·Sv to 0.55 man·Sv for the period 2007-2009. The fuel cycle is 18 months.

The maximum individual annual dose was 6.84 mSv, average dose per person was 0.56 mSv.

Events influencing dosimetric trends

The outage collective dose was 0.53 man·Sv. It was a refuelling outage with the steam generator and reactor vessel head in service inspections (ISI).

Number and duration of outages

One planned outage of 31 days.

Major evolutions and dose-reduction programme

A dose reduction programme has been established by a special plant management manual. This programme is regularly reviewed at ALARA committee meetings. The actions to support the dose reduction programme in the next three years are:

- Technology has been developed for ISI of reactor vessel head weld inspection with qualified robotic polishing of J-weld when required. Robotic polishing of J-weld (as-built) material surplus was first implemented in 2009.
- A replacement project of the reactor vessel head is scheduled for 2012 and it will include new permanent gamma shield and removable neutron shields as well as some other improvements to simplify installation and transport procedures.

- Optimised procedure for reactor vessel head studs tensioning
- Rise of reactor coolant pH from 7.1 to 7.2.
- Equipment for cleaning of reactor cavity sumps and for water filtration.

Technical plans for major work in 2010

- Ten years ISI programme of reactor vessel
- Pressuriser weld overlays
- Replacement of stator of turbine generator
- Operating license extension for twenty years after 2023.

Regulatory plans for major work in 2010

Slovenian Nuclear Safety Administration (SNSA) and Slovenian Radiation Protection Administration (SRPA) will be performing regulatory control and inspection surveillance of Krško NPP operation.

REPUBLIC OF SOUTH AFRICA

Dose information

Operating reactors		
Reactor type	**Number**	**Average annual collective dose per unit [man·Sv/unit]**
PWR	2	0.744

Summary of national dosimetric trends

During the year of 2009 Koeberg Nuclear Power Station had a normal maintenance shutdown on both unit 1 and unit 2. The overall collective dose average for 2009 (0.744 man·Sv) was marginally lower than for 2008 (0.749 man·Sv). However, 2 outages were performed in 2009 as compared to only 1 normal maintenance outage in 2008.

Events influencing dosimetric trends

Maintenance shutdowns were performed on both units 1 and 2 as well as safety related modifications during these outage periods. 12 Modifications accounted for 155.4 mSv on unit 1 and 11 modifications accounted for 67.2 mSv on unit 2.

Number and duration of outages

Two scheduled maintenance outages were held during 2009. Approximately 80.3% of the total dose accrued during 2009 for Koeberg was due to the two outages. The duration of the outage on unit 1 was 70 days and on unit 2 was 58 days.

Component or system replacements

A new radiation worker dose access system was implemented during 2009.

Issues of concern in 2010

Dose reduction initiatives will continue to be a priority focus for Koeberg Nuclear Power Station.

SPAIN

Summary of national dosimetric trends

In 2009, the average dose per refuelling outage was 0.842 person·Sv for PWRs (5 units). The average dose per outage for BWRs was 1.88 person·Sv (2 units). Per plant, the annual collective doses and the outage collective doses are as follows:

NPP	Type	Outage Coll. Doses (person·Sv)	No. Days	Annual Coll. Doses (person·Sv)	Comments
Almaraz I	PWR	0.730	71	0.764	
Almaraz II	PWR	0.696	52	0.747	
Ascó I	PWR	0.854	55	0.826	(*)
Ascó II	PWR	----	----	0.023	No outage
Vandellos II	PWR	1.122	137	1.211	
Trillo	PWR	0.808	53	0.777	(*)
S.M Garoña	BWR	1.340	35	1.726	
Cofrentes	BWR	2.421	46	2.896	

(*)The reason of the discrepancy observed between outage and annual collective doses is that the outage doses are operational doses, recorded with ED (recording level 0.001 mSv) and the annual doses are official doses recorded with TLD (recording level 0.100 mSv).

Regarding the annual collective dose in PWRs, the PWR average for this year was 0.72 person·Sv while the three-year rolling average was 0.51 person·Sv. Concerning the annual collective dose in BWRs, the average total collective dose was 2.31 person·Sv. The three-year rolling average is 2.32 person·Sv, still affected by the dosimetric results obtained in 2007. A significant decrease is expected for the next year.

	PWR			BWR		
Year	Outages	Collective doses (person·Sv)	3 year rolling average	Outages	Collective doses (person·Sv)	3 year rolling average
2004	4	0.31	0.41	0	0.46	1.38
2005	5	0.38	0.37	2	2.32	1.65
2006	5	0.38	0.36	0	0.41	1.06
2007	5	0.51	0.42	2	4.15	2.29
2008	3	0.29	0.39	0	0.50	1.69
2009	5	0.72	0.51	2	2.31	2.32

In S. M. Garoña NPP, two unscheduled outages for valve repairing in areas with high radiation involvement, have led to a greater extent in ALARA activities and an increase in the expected annual collective dose. An inadvertent entry of three workers into a temporarily reclassified "Regulated Permanency Controlled Area" has led to the decision of sealing the access to these areas. "No Trespassing" on the access doors was unnoticed by the workers. Fortunately the doses received have been negligible.

Vandellós II NPP has had a large refueling outage of 137 days, due to the modernization of the Emergency Cooling System to refrigerate the spent fuel pool and residual heat removal systems. The task with major radiological significance has been the weld overlay of the pressuriser nozzles. On the other hand, there has been a reduction of 30% in dose rates in Steam Generator zones as a result of zinc injection in the primary circuit. This plant is currently implementing a plan for organisational strengthening and generational change.

Refueling outage doses at Almaraz I & II NPP have been higher than expected (in fact, the objectives of annual and refueling doses had to be slightly re-estimated) due to defects found after NDT inspection in a Steam Generator of Unit II. This has forced the inspection of the rest of the Steam Generators, and the installation of 158 pluggings and 78 stiffeners. This has also made the planned inspection longer at Unit I Steam Generators, revealing no need for tube plugging. Excellent dosimetric results have been obtained in the pressuriser weld overlay with 0.88 person·Sv, and 0.90 person·Sv in Units I and II respectively.

Access to the Controlled Area at Ascó I NPP has been modified, as Ascó II NPP will be in 2010. These changes together with a design change at the exit of the Containment Building in Unit II, will minimise the spread of the contamination. Contamination traces detected in the Control Building drain well, have lead to the launching of radiological controls in wells and sumps at non-radiological buildings and to the development of a special surveillance programme inside the buildings, structures not subject to radiation monitoring and outdoor areas. A programme to expand human resources at the RP department has been launched and staff has been strengthened with four new workers. Additional staff will be incorporated throughout the first half of 2010, after their training programmes.

Relating the Jose Cabrera NPP, currently in definitive cold shutdown, the total collective dose has been 0.244 person·Sv. Removal of the spent fuel to dry storage casks from January to September 2009 has been the most relevant task having an impact on the collective dose. In 2009, RP staff has been reduced from six to three people due to the lower work load associated with the new circumstances.

The Spanish Regulatory Body (CSN) has assessed the decommissioning request of Jose Cabrera NPP, and the responsibility has been transferred to ENRESA in order to carry out decommissioning activities. The dismantling process will start in 2010.

Another important issue evaluated by CSN has been the S.M. Garoña NPP request to extend the operating license for 10 years. The regulatory body reported its conformity to the Minister of Industry who, on the 3rd of July 2009, issued his decision that the final shutdown will be on the 6th of July 2013.

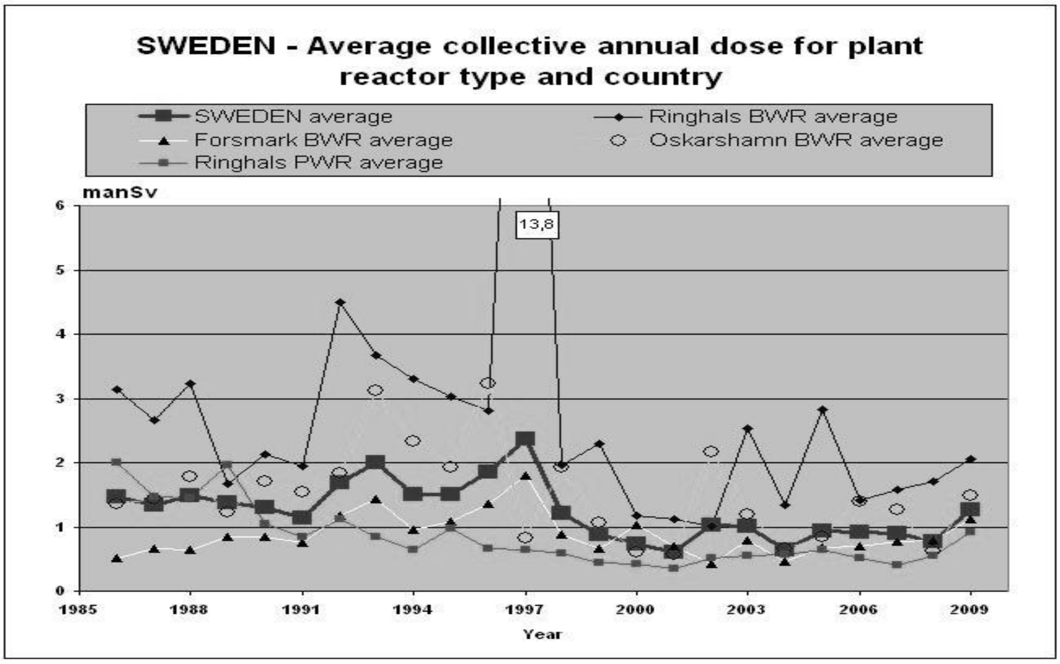
SWEDEN

Dose information

Operating reactors		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
PWR	3	0.92
BWR	7	1.40
Total: All types	10	1.26
Reactors in cold shutdown or in decommissioning		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
BWR	2	0.028

Summary of national dosimetric trends

Since 2005, the collective and individual doses at the Swedish nuclear power plants show a fluctuating trend. During 2009, more than 6400 persons at the NPPs were registered as receiving at least 0.1 mSv (TLD-dose) during at least one month (dosimeter read-out period) of the year. This resulted in a total collective dose in Sweden of 12.6 man·Sv, a country average individual dose of 1.95 mSv and a highest country annual individual dose of 22.8 mSv (highest plant individual dose 19.6 mSv). Note that the values presented here include the doses received at the two closed reactor units at Barsebäck NPP (82 persons with dose > 0.1 mSv, collective dose: 0.055 man·Sv, average dose: 0.1 mSv and max. dose: 4.21 mSv).



Events influencing dosimetric trends

There are several projects in progress for modernisation, plant life extension, safety related measures (regulatory demands) and power upgrades. The increase in the number and extent of these projects has required an increasing amount of installation work to be done during operation and outage, which influences the dosimetric trends.

At Forsmark 2, the total collective dose for the outage was approximately 2 250 man·mSv. Nearly 1 500 man·mSv was received from work on the turbine side, including change of intermediate heat exchangers/super heaters (799 man·mSv), change of HP turbine and valves (430 man·mSv).

At Ringhals 2, refurbishing of the containment floor and wall coating (paint) resulted in a collective dose of approximately 800 man·mSv (prediction 300 man·mSv). TWICE (Ringhals TWo Instrumentation and Control room Exchange) project (complete control room exchange) ended at 408 man·mSv.

At Oskarshamn 3, modernisation included the exchange of a LP turbine, intermediate heat exchangers, moderator tank lid, reactor vessel moist separator, main steam and feed water isolation valves, main circulation pump impeller etc.

Number and duration of outages 2009

Plant	**Type of Reactor**	**Length of Outage** (Days)	**Collective Dose** (man·Sv)	**Comments**
Forsmark 1	BWR	22	507	Extended 1 day
Forsmark 2	BWR	108	2251	Extended 62 days due to major work in the turbine plant with new HP turbines and intermediate heat exchangers/super heaters.
Forsmark 3	BWR	47	235	Extended 19 days due to control rod shaft inspection and repair.
Oskarshamn 1	BWR	31	830	Extended 7 days due to MTL testing.
Oskarshamn 2	BWR	55	1050	Extended 15 days due to LP turbine exchange
Oskarshamn 3	BWR	287	2530	Extended 195 days due to technical issues in the modernisation project
Ringhals 1	BWR	260	1924	Planned 63 days but extended to 260 days during 2009, plant in operation 2010-03-09, in total 359 days. Technical difficulties in projects and additional work due to valve material concerns.
Ringhals 2	PWR	220	1912	Planned 145 days but extended to 220 days during 2009, plant in operation 2010-02-28, in total 281 days. Mainly due to delay in the modernisation project TWICE.
Ringhals 3	PWR	22	195	As scheduled
Ringhals 4	PWR	26	462	As scheduled

(Outage collective dose is registered with EPD dose)

Component or system replacements

As a result of ongoing projects for modernisation, plant life extension, safety related measures (regulatory demands) and power upgrades at the Swedish NPPs, there are many components and system modifications/replacements, which results in a significant dose outcome. Modernisation of

RPS (Reactor Protection System) and installation of a diversified/redundant Residual Heat Removal and Cooling Water systems (BWR), exchange of HP/LP turbines and RV internals are other examples of major work that have influence on dosimetric trends.

Forsmark 3 and Oskarshamn 3, exchange of 104 respectively 169 shafts to control rods with a new shaft design which is not crack sensitive.

Safety-related issues

Forsmark 3 and Oskarshamn 3 **–** To implement permanent measures in order to ensure that cracks in the control rod shafts cannot occur.

Unexpected events

Oskarshamn 1 – High dose rates were detected on the CRDM mechanism positioned at the core border (650 mSv/h).

Organisational evolutions

Since the termination of the operation of Barsebäck NPP (BKAB) in 2005, BKAB has opened the site for training courses, tests and research for national and international organisations and companies. The present scheduled training courses aims at training on work methods, safety regulations and safety culture, ALARA and a good professional performance in all. A full system decontamination was performed 2007/2008 with good results on both units, which resulted in low dose rates and an increased availability to the plant. For more information contact: bengt.sikland@barsebackkraft.se.

An European course on ALARA from theory to practice in nuclear installations will be held at Barsebäck in February 2011, http://www.eu-alara.net/.

Issues of concern in 2010

OSART inspections are completed at the Swedish NPPs, Forsmark 2008, Oskarshamn 2009 and Ringhals 2010. Follow-up with major additional work are resulting in optimisation towards best praxis in radiation protection at Nuclear Power Plants. Joint proceeding at the Swedish NPP and methods in the radiation protection area are an example of the outcomes from the OSART mission.

Technical plans for major work in 2010

Examples for the Swedish NPP are – Forsmark, exchange of internals and this will hopefully lower the dose rates in the turbine system due to lowered moist content in the steam, change of preparations prior to major remodelling work in the turbine plant before power uprate. Measures were introduced to solve the problems with vibrations in the HP turbine valves.

Ringhals 1, installation of pre stressed clamps on the main circulation valves (12), exchanges of feed water valves (Stellite).

Regulatory plans for major work in 2010

Periodic safety reviews of the Ringhals NPP, Oskarshamn NPP and the Forsmark NPP will be carried out during 2010. Radiation protection issues are specifically addressed and hence efforts will be put into this area.

In addition to basic regulatory oversight SSM will focus its supervision in the occupational exposure area to the following:

- Inspection of the whole body counting systems in Sweden. During 2010, the whole body counting systems will be reviewed for new approvals.
- Inspection of the radiography work at NPPs. The collaboration between the NPP and the contractor in radiation protection issues will be particularly addressed.

SWITZERLAND

Dose information

Operating reactors		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·mSv]**
PWR	3	359
BWR	2	1038

Summary of national dosimetric trends

The 5 year average collective dose in Swiss NPP remains stable since around 10 years. With exception of an unexpected event (see below) the highest individual dose in 2009 was 8.9 mSv/y. It is the first year since starting up nuclear power production in Switzerland that the individual doses of all persons in all NPP stayed well below the operational annual dose constrain (target from NPP) of 10 mSv/y.

Events influencing dosimetric trends

As a general trend the source term reduction by developed water chemistry leads to a slow decrease in dose rates at primary cooling loops, although the NPP Gösgen had several small leakages in the fuel cladding in 2008 and 2009.

Number and duration of outages

Each NPP had one planned outage in 2009 with an average duration of 27.2 days (minimum 12 days, maximum 47 days). No unexpected outage took place.

New plants on line

For three new NPP the general licenses were applied 2008. In 2009 the authority body ENSI (Swiss Federal Nuclear Safety Inspectorate) was preparing experts opinions. It is foreseen that expertises will be published mid of 2010. A public referendum may be performed 2014. The license for construction will probably be issued around 2018.

Component or system replacements

In NPP Beznau the exchange of baffle bolts started and was finished during the outage 2010.

Unexpected event

On the 3rd of August 2009 two workers in NPP Beznau (KKB) were irradiated exceeding the statutory annual limits of 20 mSv: a maintenance worker received a dose of 37.8 mSv and a radiation protection worker (RP-controller) 25.4 mSv. The incident shows the failure of various safety measures. The incident was rated as INES Level 2: "Overexposure of a worker". Only by a lucky chance the doses did not reach any level with deterministic harmful effects.

Pre-event situation/background:

During the outage it was scheduled to perform a 10-yearly pressure test of the primary circuit. As a preparation work floodlight and camera rails had to temporarily be installed in the room located under the reactor pressure vessel (reactor cavity room). Additional to this task the inner-tubes of the highly activated in-core instrumentation system had to be withdrawn from the core and sealed pressured-tight. In the original planning these activities (work under vessel and withdrawing of in-core tubes) were separated with a controlling step (shielding and lock of reactor cavity room) in between.

Direct cause:

Because of a planning error, the time scheduled for the pressure-tight sealing of the in-core tubes at the seal table was too short. To fix this problem, the beginning of the in-core tube withdrawing was brought forward in the time schedule without recognising the conflict with the work in the reactor cavity room.

Incident history and evolution:

Before starting the job in the reactor cavity room the dose rate (about 1.5 mSv/h) was monitored by the RP-controller. The RP-controller admitted the maintenance worker to enter the cavity room to start the installation of the light. Whilst the two employees were working in resp. just outside the room under the reactor pressure vessel, the inner tubing was withdrawn from the reactor pressure vessel. The withdrawing of the in-core thimbles causes a rapid increase of the dose rate in the reactor cavity room. The test shows 2.8 Sv/h with two tubes withdrawn.

Only by chance this situation was recognised by the radiation protection co-ordinator on duty who had no knowledge of the changes in the schedule. The RP co-ordinator alarmed the person inside the reactor cavity room who left the scene as quickly as possible (resulting dose 37.8 mSv). Soon afterwards the RP co-ordinator commanded the RP controller to monitor the dose rate in the reactor cavity room. The RP controller used the dose rate meter in an inadequate manner and was therefore too close to the source for around 20 sec (resulting dose 25.4 mSv)

The findings from incident analysis (root causes and additional factors):

- The safety checks offered by the computer based planning tool, especially the interlocking of tasks with conflict potential, were not used.
- The declaration of task chronology in the outage schedule was misleading: preceding tasks have been marked as a successor with negative time interlacing; therefore the conflict with predecessor was not recognized by manual checking.
- The outage schedule was not updated with the planning tool at the actual change, resulting in a different outage schedule compared to the actual task chronology.
- The concerned departments were not involved in the safety check when changing the outage schedule; in particular the radiation protection department was not consulted.
- The information on the schedule change was badly documented and distributed.

- The radiation protection worker (RP-controller) had not enough on-the-job experience; he finished a training course some months before he worked for the first time at the NPP KKB.
- Responsibilities in the area of radiation protection were determined in an inadequate manner (function splitting); Different persons are responsible for co-ordination and clearance of tasks, resulting in a loss of overview in case of communication errors.
- The electronic personal dosimeter was programmed inadequately; the alarm level (normal setting 1 mSv/h) was not adjusted to actual dose rate in the reactor cavity room (around 1.5 mSv/h). As a result the dosimeter alerts from the beginning of the work, already when entering the room. Because of that the person in the reactor cavity room did not react on the alarm signal and could not know that the dose rate at the work place had drastically increased.
- Technical measures were missing on-site to avoid withdrawing the inner tubing whilst the reactor cavity room was open and accessible for persons.
- A permanent (or temporary) local dose rate meter with optical and acoustical signalisation of a sudden increase in high dose rate was not installed.
- The handheld dose rate monitor was used incorrectly to verify the radiological situation. The RP controller entered the high dose radiation area with a handheld dose rate monitor instead of using a telescopic dose meter. This reaction maybe results from a wrong human reaction under a stress condition.

The lessons learned are used in education and training e.g. of RP-personnel. ENSI obliged KKB to undertake several measures to correct and improve the findings. All other nuclear facilities in Switzerland are asked to be prepared on such events with unexpectedly high dose rates.

Organisational evolutions

The authority body ENSI moved from the Paul Scherrer Institute site to Brugg, a town located between NPP Beznau and NPP Gösgen. New address: ENSI (Swiss Federal Nuclear Safety Inspectorate), Industriestrasse 19, CH 5200 Brugg, Tel: +41 56 460 8631 (ISOE National Co-ordinator, S.G. Jahn)

UNITED KINGDOM

Dose information

Operating reactors		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
PWR	1	0.337
GCR (AGR)	14	0.1
GCR (Magnox)	4	0.072
Reactors in cold shutdown or in decommissioning		
Reactor type	**Number of reactors**	**Average annual collective dose per unit and reactor type [man·Sv]**
GCR (Magnox)	16	0.042

Summary of national dosimetric trends

With the exception of Sizewell B all of UKs nuclear power plants are gas-cooled. Doses were higher than the previous year on the Advanced Gas Cooled Reactors (AGRs) at Hinkley Point and Hunterston because of extensive in-vessel inspection and repairs. However the doses from these two reactor sites still represented around 90% of the collective dose for the AGRs. The Collective Radiation Exposure for the British Energy Advanced Gas Cooled Reactor fleet was approximately 1.4 man·Sv. At the end of 2009 the rolling three year collective dose trend for the PWR at Sizewell is 0.22 man·Sv.

Events influencing dosimetric trends

The average annual collective dose at the AGR sites was again dominated by doses received during in-vessel work at the AGRs at Hinkley Point and Hunterston. Previous inspections of these power plants had detected defects in the boiler pipework, requiring additional inspections and repairs. This work continued in 2009 necessitating prolonged work inside the reactor vessels, in areas of higher dose rate. A number of dose management initiatives were successfully used including teledosimetry for in-vessel entrants and training on Mock-ups.

Number and duration of outages

The gas-cooled reactors operate to a two-yearly outage frequency so each site typically has one reactor outage per annum. Refuelling of the gas-cooled reactors is carried out on-load. The highest outage doses on the gas-cooled reactors were received at Hinkley Point B and Hunterston B plants with outage doses of approximately 0.63 man·Sv and 0.48 man·Sv respectively. The majority of the doses at Hinkley Point B and Hunterston were associated with in-vessel inspections and repair rather than routine outage tasks.

The annual dose at Sizewell B was dominated by the tenth Refuelling Outage which contributed 84% of the annual total. The standard outage lasted thirty five days and recorded a collective dose of 0.283 man·Sv.

Decommissioning Sites: Major evolutions

All Magnox sites are owned by the Nuclear Decommissioning Authority, a government owned management unit, with sites operated or being decommissioned under contract by a number of consortia. Of the original Magnox reactor fleet two sites remain in power operation, Oldbury and Wylfa. The reactors at Oldbury NPP have had their operating lives extended, after appropriate regulatory approval. A similar extension to the planned 2010 final shutdown date for Wylfa NPP is also expected subject to satisfactory regulatory approval. Of the permanently shutdown sites some are completely defuelled and are at various stages of decommissioning. Other sites are shutdown with the reactors still fuelled and with air cooling. Defuelling of these sites continue to be rate limited by the capacity of the Sellafield reprocessing plant to receive and process fuel.

UK New Nuclear Build

In late 2009 the UK government announced that a number of sites had been considered suitable for nuclear new build, all sites being on or near to existing nuclear facilities. EDF Energy who now own British Energy intend to build two twin EPRs at Hinkley Point and Sizewell. EON & RWE have expressed an interest in building further nuclear power plants. The regulators are continuing to carry out generic licensing assessments of the proposed reactor designs.

UNITED STATES

Occupational Dose Trends

An increase in annual average collective dose at US light water reactors (LWR) was recorded in 2009 at the 104 operating reactor units. The US average collective dose in 2009 for the light water reactors was 96.4 person·cSv (person·rem) per reactor. The total collective dose was 10,024.804 person·cSv (person·rem) and is 9% higher than the 2008 total collective dose of 9,195.940 person·cSv (person·rem).

The 2009 US annual collective dose shows that the US dose trend over the past 5 years has been essentially flat. It is a dramatic improvement over the 1980 US LWR average dose of 790 person·cSv (person·rem) per reactor (or about one tenth of the 1980 value). The current dose trend is a reminder to the US industry that a continuing commitment to the lowering of occupational doses can be achieved by fostering a strong ALARA culture on-site, reducing source term, implementing effective exposure reduction station enhancements and maintaining high equipment reliability.

In 2009, the total collective dose for US PWRs was 4,741.935 person·cSv (person·rem) for 69 reactors. The resulting average collective dose per reactor for PWRs in 2009 was 68.7 person·cSv (person·rem) per reactor. This average represents a 1% increase from the 2008 value of 68 person·cSv (person·rem) per reactor. (In 2004 and 2007, 71 and 69 person·cSv (person·rem) was recorded, respectively.) This is the eleventh year the US average annual PWR dose has been less than 100 person·cSv (person·rem) per reactor.

The total collective dose for US BWRs in 2009 was 5,282.869 person·cSv (person·rem) for 35 reactors. The resulting average collective dose for BWRs in 2009 was 150.94 person·cSv (person·rem). This average represents a 17% increase from the 2008 value of 129.212 person·cSv (person·rem) per reactor. In 2008, this was the lowest BWR average collective dose ever recorded.

US utilities are implementing new and innovative ALARA initiatives to reverse the upward trend in annual collective doses. The US plants are developing new Five Year ALARA Plans to meet the new 2015 INPO BWR and PWR dose goals. On-site initiatives include dynamic learning laboratories to reinforce good radworker practices, ALARA work plans, effective ALARA pre-job briefs, source term reduction programmes, efficient outages, enhanced reactor coolant chemistry control, benchmarking low dose plants, use of shielded vests for some workers, and strong senior management support of each Station ALARA programme.

One of the noted differences between the collective doses recorded in 2006, 2007, 2008 and 2009 was the number of units having collective doses equal to or less than 100 person·cSv (person·rem) for the year. In 2006, five LWRs had collective doses equal to or less than 100 person·cSv (person·rem) for the year; in 2007, nine LWRs had annual collective doses in this range; in 2008 only two LWRs had annual collective doses equal or less than 100 person·cSv (person·rem); and in 2009, three LWRs had annual collective doses in this range.

The US NRC, since 2000, has used the three-year-rolling average collective dose as an indicator of a plant's ALARA performance. In the Significance Determination Process for the Occupational Radiation Safety Cornerstone, each licensee's three-year-rolling average is compared against criteria established earlier (1995-1997) of 135 person·cSv (person·rem)/unit for PWRs and 240 person·cSv (person·rem)/unit for BWRs to aid in determining the level of ALARA inspections for the next year. For 2007-2009, three (of 69) US PWRs exceeded the PWR criterion: Waterford 3, Crystal River 3, and Palisades. For US BWRs during the same period, Perry was the only BWR site (of 35) that exceeded the criterion.

Davis Besse achieved the lowest US PWR annual collective dose of 3.621 person·cSv (person·rem). Grand Gulf achieved the lowest US BWR annual collective dose of 30.721 person·cSv (person·rem).

US Nuclear Generation Overview & Results

In 2009, the 104 US units achieved a capacity factor of 91%. Thirty-five BWR units operate in the US; 14 one unit sites, 9 two unit sites and 1 on a three unit site (Browns Ferry 1, 2, 3). Sixty-nine PWR units operated in the US in 2009; 15 one unit sites, 24 two unit sites and 2 three unit sites (Palo Verde 1, 2, 3 and Oconee 1, 2, 3). Palo Verde Units 1, 2, 3 (Arizona) is the largest US site with 1 311, 1 314, and 1 312 MWe, respectively. The total generation at Palo Verde is 3 937 MWe. The smallest site in the US is Ft. Calhoun (Nebraska) at 482 MWe. The oldest US unit is Oyster Creek (New Jersey) which started commercial operation in April 1969.

Thirty-two companies are licensed to operate nuclear reactors in the US in thirty-one states. Of these 31 states, Vermont has the highest nuclear generation of 73.7%, followed by South Carolina, New Jersey, Connecticut, and Illinois having 51.2%, 50.7%, 48.9%, and 47.8% nuclear generation, respectively.

US Nuclear Regulatory Commission Update

The US Nuclear Regulatory Commission has implemented a new Radiation Protection (RP) Inspection Manual which included two additional inspection modules and an introductory document. The previous RP inspection manual had six inspection topics including one for ALARA inspections. The two new modules deal with hazardous material and radiological aspects of emergency planning inspections. One of the objectives of the new inspection manual is to focus on-site inspections on field observations as compared to reviewing files of historic radiological event reports. Another goal is to assist new health physics inspectors to conduct effective risk-based inspections.

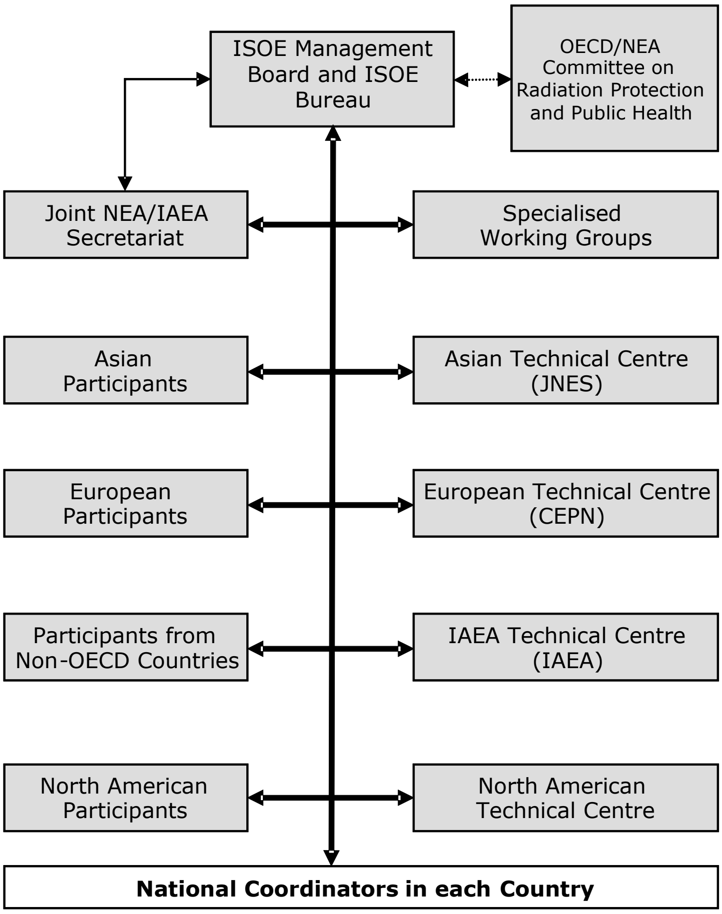
Annex 1

ISOE ORGANISATIONAL STRUCTURE AND PROPOSED PROGRAMME OF WORK FOR 2010

A.1 ISOE Organisational Structure

ISOE operates in a decentralised manner. A Management Board composed of utility and regulatory authority representatives from all participating countries, supported by the joint NEA and IAEA Secretariat, provides overall direction. The ISOE Management Board reports to the Steering Committee of the Nuclear Energy Agency through the NEA Committee on Radiation Protection and Public Health. More information on the organisational structure can be found on the NEA website (www.oecd-nea.org).

Four ISOE Technical Centres (Europe, North America, Asia and IAEA) manage the programme's day-to-day technical operations, serving as contact point for the transfer of information from and to participants. A national co-ordinator in each country provides a link between the ISOE participants and the ISOE programme. A list of National Co-ordinators is given in Annex 6.



ISOE PARTICIPATION

The current ISOE Terms and Conditions for the period 2008-2011 came into force on 1 January 2008, for which Participants under the previous Terms were invited to confirm their ongoing acceptance. Based on feedback received as of December 2010, the ISOE programme included:

- 66 Participating Utilities[1] in 26 countries, covering 320 operating units; 40 shutdown units),
- Regulatory authorities of 24 countries (3 countries participate with 2 authorities).

Objective: During 2010, the ISOE Technical Centres and ISOE Joint Secretariat continued to pursue the formal renewal of previous participants under the current ISOE Terms and Conditions (Utilities: Lithuania, Pakistan, Ukraine, USA; Authorities: China, South Africa), and seek the involvement of new participants.

Objective: During 2010, a proposal developed for Management Board and utility feedback on removing Participating Authority restrictions on data access, for decision by the ISOE Bureau. However, it was not accepted by the Management Board.

ISOE PROGRAMME ACTIVITIES

1) ISOE Database Management

Data collection and management

Objective: Collection of ISOE 1, ISOE 2, ISOE 3 data: ISOE participants will provide their 2009 ISOE 1 data through the new ISOE Network website data input modules and/or using the ISOE Software under Microsoft ACCESS. The ISOE 2 data will be provided using the ISOE Software under Microsoft ACCESS. The ISOE Network website will be used to exchange and record new ISOE 3-type information (i.e., radiation protection-related information for specific operations or tasks). All new ISOE 3 reports will be posted to the ISOE Network website RP Library using a standard template available on the website.

Management of the ISOE Databases

Objective: Official Database – On-line Update and CD-ROM Release: Data submitted directly by participants through the ISOE Network will be available as soon as the data is validated. Data submitted to ETC via electronic form (Access database) will be made available through the Network at regular intervals through the year. The annual CD-ROM of the whole database, including 2009 data, will be released at the end of the 2010.

Continued development of ISOEDAT on-line

Objective: Phase 3 of the ISOEDAT web migration will focus on the following elements:
- ISOE 1: Incorporation of a CANDU job/task list;
- ISOE 1: Incorporation of changes based on WGDA proposals for decommissioning (end of year);
- ISOE 2: Elaboration of proposals for development of ISOE 2 data entry modules;
- MADRAS: Implementation of new analyses;

1. Represents the number of lead utilities; in some cases, a plant may be owned/operated by multiple enterprises.

- Initial development of new data export system.

2) ISOE Management and Programme Activities

Objective: Maintain an efficient schedule of official meetings of the relevant ISOE groups (ISOE Management Board, Bureau and WGDA) and other ad-hoc groups according to the Management Board direction.

ISOE Management Board and ISOE Bureau

Objective: The ISOE Management Board, supported by the ISOE Bureau, will continue to focus on the ISOE programme management by reviewing and directing the progress of the programme at its annual meeting, developing and approving the programme of work for the coming year, identifying areas for specific activities, promoting the ISOE programme, and providing direction to its sub-groups.

ISOE Working Group on Data Analysis

Objective: The Working Group on Data Analysis (WGDA)/Technical Centres will:

- Continue to review the completeness and quality of ISOE data collection;
- Undertake and disseminate identified technical analyses (including standard routine analyses) of use to the ISOE membership, and contribute to the development of the ISOE Annual Report;
- Validate the online help/user's guide for the ISOEDAT web-enabled data entry module;
- Elaborate technical proposals and implement approved modifications to ISOEDAT to enhance data collection and analysis from nuclear power plants which are in shut-down or some stage of decommissioning;
- Elaborate technical proposals and implement approved enhancements to the ISOEDAT data analysis functions through implementation of a new data export system;
- Perform other technical analysis as directed by the Management Board, based on end-user feedback and in support of the ISOE Annual Reports.
- Consider development of a survey on the use of zinc injection to reduce source terms.

Ad-hoc Expert Group on the Revision of the BSS

Objective: The Ad-hoc Expert Group on the Revision of the BSS will meet, *if appropriate*, to review drafts of the revised International Basic Safety Standards from the perspective of good practice in occupational radiation protection, according to availability of drafts (as provided by the ISOE Joint Secretariat) and opportunities to provide any comments into the revision process through the established NEA/CRPPH review process (as one of the BSS co-sponsoring organisations).

Joint NEA/CRPPH-ISOE Activities: Expert Group on Occupational Exposure (EGOE)

Objective: ISOE members will continue to participate in the activities of the EGOE, organised by the NEA's Committee on Radiation Protection and Public Health (CRPPH), according to the meeting schedule established by the EGOE.

ISOE Publications and Reports

Objective: Develop and distribute relevant ISOE publications. The following ISOE publications and reports will be produced and published in 2010. Products will be made available through the ISOE Network as appropriate.

- **ISOE Annual Reports**
  - Publish the 19^{th} ISOE Annual Report (2009)
- **ISOE News:** Continue to electronically issue current ISOE information through the ISOE News, according to the ISOE Management Board decision on publication frequency (generally 2x per year).
- **ISOE Symposia Proceedings:** ETC will update the ISOE Network with available symposia proceedings and presentations, as provided to the ETC by each centre.
- **Benchmark Visit Reports:** Reports of benchmarking visits organised under ISOE will be made available to the ISOE membership through the ISOE Network. Additionally, ETC will, for its benchmarking visits organised outside of ISOE resources, do its best to make the reports available to ISOE Participants after agreement of the plant visited.

3) ISOE ALARA Symposium (International and Regional)

Objective: Organise to hold the following international and regional ISOE Symposium *(note: international symposia are considered a mandatory task for the technical centres; regional symposia are considered an optional task).*

International Symposia:

- 2010 ISOE International ALARA Symposium and RPM/Regulatory Body meetings, Cambridge, United Kingdom (16-19 Nov 2010), organised by ETC
- 2012 ISOE International ALARA Symposium, Fort Lauderdale, USA (8-11 January 2012), organised by NATC

Regional Symposia:

- 2010 ISOE North American ALARA Symposium, Ft. Lauderdale, USA (11-13 Jan 2010), organised by NATC
- 2010 ISOE Asian Regional Symposium, Republic of Korea (30-31 Aug), organised by ATC

4) ISOE Network Website Management and Technical Centre Input

Network Website Management

Objective: ETC will continue the website management. Development and implementation of the ISOE Network website enhancements will continue to be subject to Management Board guidance.

Technical Centre Input for the ISOE Network

Objective: Technical Centres will continue to make their information available for posting on the ISOE Network. The ETC will continue to post all information and products from all regions as it is made available. The ETC will continue to produce synthesis documents of requests posted on the website Forum and those received by e-mail. These documents will also be posted on the website Forum and attached to the request.

5) Reports and Documents, Information Sheets, and Information Exchange

Objective: Effectively support information exchange activities between ISOE participants

New Reports and Documents:

Objective: The following new documents and reports will be prepared:

- Reports on ISOE Database Completeness (ETC)

Technical Centre Information Sheets planned for 2010:

Objective: The following technical centre information sheets will be prepared:

Technical Centre Information Sheets planned for 2010				
Yearly analyses	**ATC**	**ETC**	**IAEATC**	**NATC**
ATC: Japanese dosimetric results: FY 2009 data and trends	X			
ATC: Korea (Republic of): summary of national dosimetric trends	X			
ETC: European dosimetric results for 2008		X		
Special analyses				
Analysis of annual collective dose by reactor age		X		
Analysis of outage collective dose for PWRs, BWRs by sister unit group		X		
Alpha values around the world		X		
Industrial radiography – recommendations from a French Working Group		X		
In-field telemetry (ED location, crudburst results)				X

Information Exchange Activities:

Objective: The Technical Centres will continue to respond to special requests from users for technical feedback, and share this information with all participants globally, according to the access privileges as utility or authority member.

Objective: A template for exchanging lessons learned from operating experience in radiological protection will be developed, for approval by the ISOE Bureau.

6) ISOE-organised Benchmarking Visits

None planned

7) Other topics

ISOE/UNSCEAR co-operation

Objective: The NEA and UNSCEAR secretariats will elaborate terms and a related process for the routine provision of agreed ISOE data to UNSCEAR, as a contribution to the UNSCEAR reports on “Sources and Effects of Ionising Radiation”.

Promotion of ISOE Use

Objective:

- A mechanism for gathering feedback from users and providing information to users will be implemented through the ISOE Network and other means as appropriate.
- Further information on ISOE will be distributed to non-OECD country participants through IAEA Technical Cooperation Projects to IAEA Member States (non-OECD countries)
- Other opportunities for ISOE promotion, such as through relevant conferences and workshops, will be sought (e.g., IRPA Europe 2010).

OVERALL SCHEDULE OF ISOE MEETINGS FOR 2010

ISOE Meetings for 2010	**Jan**	**May**	**Sept**	**Nov**
Technical Centre Coordination meeting				
ISOE Bureau/Technical Centres		X		X
Working Group on Data Analysis			X	
20th ISOE Management Board Meeting				X
ISOE International ALARA Symposium				X
ISOE North American ALARA Symposium	X			
ISOE Asian ALARA Symposium			X	

**Ad-hoc meetings not included.*

Annex 2

LIST OF ISOE PUBLICATIONS

Reports

1. *L'organisation du travail pour optimiser la radioprotection professionnelle dans les centrales nucléaires*, OCDE, 2010.
2. *Occupational Exposures at Nuclear Power Plants: Eighteenth Annual Report of the ISOE Programme, 2008,* OECD, 2010.
3. *Work Management to Optimise Occupational Radiological Protection at Nuclear Power Plants,* OECD, 2009.
4. *Occupational Exposures at Nuclear Power Plants: Seventeenth Annual Report of the ISOE Programme, 2007*, OECD, 2009.
5. *Occupational Exposures at Nuclear Power Plants: Sixteenth Annual Report of the ISOE Programme, 2006*, OECD, 2008.
6. *Occupational Exposures at Nuclear Power Plants: Fifteenth Annual Report of the ISOE Programme, 2005*, OECD, 2007.
7. *Occupational Exposures at Nuclear Power Plants: Fourteenth Annual Report of the ISOE Programme, 2004*, OECD, 2006.
8. *Occupational Exposures at Nuclear Power Plants: Thirteenth Annual Report of the ISOE Programme, 2003*, OECD, 2005.
9. *Optimisation in Operational Radiation Protection*, OECD, 2005.
10. *Occupational Exposures at Nuclear Power Plants: Twelfth Annual Report of the ISOE Programme, 2002*, OECD, 2004.
11. *Occupational Exposure Management at Nuclear Power Plants: Third ISOE European Workshop, Portoroz, Slovenia, 17-19 April 2002,* OECD 2003.
12. *ISOE – Information Leaflet,* OECD 2003.
13. *Occupational Exposures at Nuclear Power Plants: Eleventh Annual Report of the ISOE Programme, 2001,* OECD, 2002.
14. *ISOE – Information System on Occupational Exposure, Ten Years of Experience*, OECD, 2002.
15. *Occupational Exposures at Nuclear Power Plants: Tenth Annual Report of the ISOE Programme, 2000*, OECD, 2001.
16. *Occupational Exposures at Nuclear Power Plants: Ninth Annual Report of the ISOE Programme, 1999*, OECD, 2000.
17. *Occupational Exposures at Nuclear Power Plants: Eighth Annual Report of the ISOE Programme, 1998*, OECD, 1999.
18. *Occupational Exposures at Nuclear Power Plants: Seventh Annual Report of the ISOE Programme, 1997*, OECD, 1999.
19. *Work Management in the Nuclear Power Industry*, OECD, 1997 (also available in Chinese, German, Russian and Spanish).
20. *ISOE – Sixth Annual Report: Occupational Exposures at Nuclear Power Plants: 1969-1996,* OECD, 1998.
21. *ISOE – Fifth Annual Report: Occupational Exposures at Nuclear Power Plants: 1969-1995,* OECD, 1997.

22. *ISOE – Fourth Annual Report: Occupational Exposures at Nuclear Power Plants: 1969-1994,* OECD, 1996.
23. *ISOE – Third Annual Report: Occupational Exposures at Nuclear Power Plants: 1969-1993,* OECD, 1995.
24. *ISOE – Nuclear Power Plant Occupational Exposures in OECD Countries: 1969-1992,* OECD, 1994.
25. *ISOE – Nuclear Power Plant Occupational Exposures in OECD Countries: 1969-1991,* OECD, 1993.

ISOE News

2009	No. 13 (January), No. 14 (July)
2008	No. 12 (October)
2007	No. 10 (July); No. 11 (December)
2006	No. 9 (March)
2005	No. 5 (April); No. 6 (June); No. 7 (October); No. 8 (December)
2004	No. 2 (March); No. 3 (July); No. 4 (December)
2003	No. 1 (December)

ISOE Information Sheets

Asian Technical Centre

No. 32: Jan. 2009	Japanese Dosimetric Results: FY 2007 data and trends
No. 31: Nov. 2007	Korea, Republic of; summary of national dosimetric trends
No. 30: Oct. 2007	Japanese dosimetric results: FY 2006 data and trends
No. 29: Nov. 2006	Japanese Dosimetric Results : FY 2005 Data and Trends
No. 28: Nov. 2005	Japanese Dosimetric Results : FY 2004 Data and Trends
No. 27: Nov. 2004	Achievements and Issues in Radiation Protection in the Republic of Korea
No. 26: Nov. 2004	Japanese occupational exposure during periodic inspection at PWRs and BWRs ended in FY 2003
No. 25: Nov. 2004	Japanese dosimetric results: FY2003 data and trends
No. 24: Oct. 2003	Japanese Occupational Exposure of Shroud Replacements
No. 23: Oct. 2003	Japanese Occupational Exposure of Steam Generator Replacements
No. 22: Oct. 2003	Korea, Republic of; Summary of national dosimetric trends
No. 21: Oct. 2003	Japanese occupational exposure during periodic inspection at PWRs and BWRs ended in FY 2002
No. 20: Oct. 2003	Japanese dosimetric results: FY2002 data and trends
No. 19: Oct. 2002	Korea, Republic of; Summary of national dosimetric trends
No. 18: Oct. 2002	Japanese occupational exposure during periodic inspection at PWRs and BWRs ended in FY 2001
No. 17: Oct. 2002	Japanese dosimetric results: FY2001 data and trends
No. 16: Oct. 2001	Japanese occupational exposure during periodical inspection at PWRs and BWRs ended in FY 2000
No. 15: Oct. 2001	Japanese Dosimetric results: FY 2000 data and trends

No. 14: Sept. 2000	Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1999
No. 13: Sept. 2000	Japanese Dosimetric Results: FY 1999 Data and Trends
No. 12: Oct. 1999	Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1998
No. 11: Oct. 1999	Japanese Dosimetric Results: FY 1998 Data and Trends
No. 10: Nov. 1999	Experience of 1^{st} Annual Inspection Outage in an ABWR
No. 9: Oct. 1999	Replacement of Reactor Internals and Full System Decontamination at a Japanese BWR
No. 8: Oct. 1998	Japanese Occupational Exposure During Periodical Inspection at LWRs Ended in FY 1997
No. 7: Oct. 1998	Japanese Dosimetric Results: FY 1997 data
No. 6: Sept. 1997	Japanese Occupational Exposure during Periodical Inspection at LWRs ended in FY 1996
No. 5: Sept. 1997	Japanese Dosimetric Results: FY 1996 data
No. 4: July 1996	Japanese Occupational Exposure during Periodical Inspection at LWRs ended in FY 1995
No. 3: July 1996	Japanese Dosimetric Results: FY 1995 data
No. 2: Oct. 1995	Japanese Occupational Exposure during Periodical Inspection at LWRs ended in FY 1994
No. 1: Oct. 1995	Japanese Dosimetric Results: FY 1994 data

European Technical Centre

No. 51: Dec.2009	European dosimetric results for 2008
No. 50: Sep.2009	Outage duration and outage collective dose between 1996 – 2006 for VVERs
No. 49: Sep.2009	Outage duration and outage collective dose between 1996 – 2006 for BWRs
No. 48: Sep.2009	Outage duration and outage collective dose between 1996 – 2006 for PWRs
No. 47: Feb.2009	European dosimetric results for 2007
No. 46: Oct. 2007	European dosimetric results for 2006
No. 44: July 2006	Preliminary European dosimetric results for 2005
No. 43: May 2006	Conclusions and recommendations from the Essen Symposium
No. 42: Nov. 2005	Self-employed Workers in Europe
No. 41: Oct. 2005	Update of the annual outage duration and doses in European reactors (1994-2004)
No. 40: Aug. 2005	Workers internal contamination practices survey
No. 39: July 2005	Preliminary European dosimetric results for 2004
No. 38: Nov. 2004	Update of the annual outage duration and doses in European reactors (1993-2003)
No. 37: July 2004	Conclusions and recommendations from the 4th European ISOE workshop on occupational exposure management at NPPs
No. 36: Oct. 2003	Update of the annual outage duration and doses in European reactors (1993-2002)
No. 35: July 2003	Preliminary European dosimetric results for 2002
No. 34: July 2003	Man-Sievert monetary value survey (2002 update)

No. 33: March 2003	Update of the annual outage duration and doses in European reactors (1993-2001)
No. 32: Nov. 2002	Conclusions and Recommendations from the 3rd European ISOE Workshop on Occupational Exposure Management at Nuclear Power Plants
No. 31: July 2002	Preliminary European Dosimetric Results for the year 2001
No. 30: April 2002	Occupational exposure and steam generator replacements - update
No. 29: April 2002	Implementation of Basic Safety Standards in the regulations of European countries
No. 28: Dec. 2001	Trends in collective doses per job from 1995 to 2000
No. 27: Oct. 2001	Annual outage duration and doses in European reactors
No. 26: July 2001	Preliminary European Dosimetric Results for the year 2000
No. 25: June 2000	Conclusions and recommendations from the 2nd EC/ISOE workshop on occupational exposure management at nuclear power plants
No. 24: June 2000	List of BWR and CANDU sister unit groups
No. 23: June 2000	Preliminary European Dosimetric Results 1999
No. 22: May 2000	Analysis of the evolution of collective dose related to insulation jobs in some European PWRs
No. 21: May 2000	Investigation on access and dosimetric follow-up rules in NPPs for foreign workers
No. 20: April 1999	Preliminary European Dosimetric Results 1998
No. 19: Oct. 1998	ISOE 3 data base – New ISOE 3 Questionnaires received (since Sept 1998)
No. 18: Sept. 1998	The Use of the man-Sievert monetary value in 1997
No. 17: Dec. 1998	Occupational Exposure and Steam Generator Replacements, update
No. 16: July 1998	Preliminary European Dosimetric Results for 1997
No. 15: Sept. 1998	PWR collective dose per job 1994-1995-1996 data
No. 14: July 1998	PWR collective dose per job 1994-1995-1996 data
No. 12: Sept. 1997	Occupational exposure and reactor vessel annealing
No. 11: Sept. 1997	Annual individual doses distributions: data available and statistical biases
No. 10: June 1997	Preliminary European Dosimetric Results for 1996
No. 9: Dec. 1996	Reactor Vessel Closure Head Replacement
No. 7: June 1996	Preliminary European Dosimetric Results for 1995
No. 6: April 1996	Overview of the first three Full System Decontamination
No. 4: June 1995	Preliminary European Dosimetric Results for 1994
No. 3: June 1994	First European Dosimetric Results: 1993 data
No. 2: May 1994	The influence of reactor age and installed power on collective dose: 1992 data
No. 1: April 1994	Occupational Exposure and Steam Generator Replacement

IAEA Technical Centre

No. 9: Aug. 2003	Preliminary dosimetric results for 2002
No.8: Nov. 2002	Conclusions and Recommendations from the 3rd European ISOE Workshop on Occupational Exposure Management at Nuclear Power Plants
No. 7: Oct. 2002	Information on exposure data collected for the year 2001

No. 6: June 2001	Preliminary dosimetric results for 2000
No. 5: Sept. 2000	Preliminary dosimetric results for 1999
No. 4: April 1999	IAEA Workshop on implementation and management of the ALARA principle in nuclear power plant operations, Vienna 22-23 April 1998
No. 3: April 1999	IAEA technical co-operation projects on improving occupational radiation protection in nuclear power plants
No. 2: April 1999	IAEA Publications on occupational radiation protection
No. 1: Oct. 1995	ISOE Expert meeting

North American Technical Centre

NATC-No. 05-6	3-year rolling average annual dose comparisons Canadian CANDU (2002-2004)
NATC-No. 05-5	3-year rolling average annual dose comparisons US BWR (2002-2004)
NATC-No. 05-2	US BWR refuelling outage duration and dose trends for 2004
NATC-No. 05-1	US PWR refuelling outage duration and dose trends for 2004
NATC-No. 04-4	3-year rolling average annual dose comparisons US PWR (2002-2004)
No. 02-6: 2002	Monetary value of person-rem avoided
No. 02-5: July 2002	US BWR 2001 Occupational Dose Benchmarking Chart
No. 02-4: July 2002	US PWR 2001 Occupational Dose Benchmarking Chart
No. 02-2: July 2002	3-year rolling average annual dose comparisons US BWR (1999-2001)
No.02-1:Nov. 2002	3-year rolling average annual dose comparisons US PWR (1999-2001)
No. 8: 2001	Monetary Value of person-REM Avoided: 2000
No. 7: 2001	U.S. BWR 2000 Occupational Dose Benchmarking Charts
No. 6: 2001	U.S. PWR 2000 Occupational Dose Benchmarking Charts
No. 5: 2001	3-year rolling average annual dose comparisons CANDU, 1998 – 2000
No. 4: 2001	3-year rolling average annual dose comparisons US BWR, 1998 – 2000
No. 3: 2001	3-year rolling average annual dose comparisons US PWR, 1998 – 2000
No. 2: 1998	Monetary Value of person-REM Avoided 1997
No. 1: July 1996	Swedish Approaches to Radiation Protection at Nuclear Power Plants: NATC site visit report by Peter Knapp

ISOE International and Regional Symposia

Asian Technical Centre

Sep. 2009 (Aomori, Japan)	2009 ISOE Asian ALARA Symposium
Nov. 2008 (Tsuruga, Japan)	2008 ISOE International ALARA Symposium
Sept. 2007 (Seoul, Korea)	2007 ISOE Asian Regional ALARA Symposium
Oct. 2006 (Yuzawa, Japan)	2006 ISOE Asian Regional ALARA Symposium
Nov. 2005 (Hamaoka, Japan)	First Asian ALARA Symposium

European Technical Centre

June 2008 (Turku, Finland)	2008 ISOE European Regional ALARA Symposium
March 2006 (Essen, Germany)	2006 ISOE International ALARA Symposium
March 2004 (Lyon, France)	Fourth ISOE European Workshop on Occupational Exposure Management at Nuclear Power Plants
April 2002 (Portoroz, Slovenia)	Third ISOE European Workshop on Occupational Exposure Management at Nuclear Power Plants
April 2000 (Tarragona, Spain)	Second EC/ISOE Workshop on Occupational Exposure Management at Nuclear Power Plants
Sept. 1998 (Malmö, Sweden)	First EC/ISOE Workshop on Occupational Exposure Management at Nuclear Power Plants

IAEA Technical Centre

Oct. 2009 (Vienna, Austria)	2009 ISOE International ALARA Symposium

North American Technical Centre

Jan. 2009 (Ft. Lauderdale, FL, USA)	2009 ISOE North American ALARA Symposium
Jan. 2008 (Ft. Lauderdale, FL, USA)	2008 ISOE North American ALARA Symposium
Jan. 2007 (Ft. Lauderdale, FL, USA)	2007 ISOE International ALARA Symposium
Jan. 2006 (Ft. Lauderdale, FL, USA)	2006 ISOE North American ALARA Symposium
Jan. 2005 (Ft. Lauderdale, FL, USA)	2005 ISOE International ALARA Symposium
Jan. 2004 (Ft. Lauderdale, FL, USA)	2004 North American ALARA Symposium
Jan. 2003 (Orlando, FL, USA)	2003 International ALARA Symposium
Feb. 2002 (Orlando, FL, USA)	North-American National ALARA Symposium
Feb. 2001 (Orlando, FL, USA)	2001 International ALARA Symposium
Jan. 2000 (Orlando, FL, USA)	North-American National ALARA Symposium
Jan. 1999 (Orlando, FL, USA)	Second International ALARA Symposium
March 1997 (Orlando, FL, USA)	First International ALARA Symposium

Annex 3

STATUS OF ISOE PARTICIPATION UNDER THE RENEWED ISOE TERMS AND CONDITIONS (2008-2011)

Note: This annex provides the status of ISOE official participation as of time of publication of this report (December 2010)

Officially Participating Utilities: Operating reactors

Country	Utility[1]	Plant name	
Armenia	Armenian (Medzamor) NPP	Medzamor 2	
Belgium	Electrabel	Doel 1, 2, 3, 4	Tihange 1, 2, 3
Brazil	Eletronuclear A/S	Angra 1, 2	
Bulgaria	Nuclear Power Plant Kozloduy	Kozloduy 5, 6	
Canada	Bruce Power	Bruce A1, A2, A3, A4	Bruce B5, B6, B7, B8
	Hydro Quebec	Gentilly 2	
	New Brunswick Power	Pt. Lepreau	
	Ontario Power Generation	Darlington 1, 2, 3, 4	Pickering A1, A2, A3, A4 Pickering B5, B6, B7, B8
China	Guangdong Nuclear Power Joint Venture Co., Ltd	Daya Bay 1, 2	
	Ling Ao Nuclear Power Co. Ltd	Ling Ao 1, 2	
	Qinshan Nuclear Power Co., Ltd.	Qinshan 1	
Czech Republic	CEZ	Dukovany 1, 2, 3, 4 Temelin 1, 2	
Finland	Fortum Power and Heat Oy	Loviisa 1, 2	
	Teollisuuden Voima Oyj	Olkiluoto 1, 2	
France	Électricité de France (EDF)	Belleville 1, 2 Blayais 1, 2, 3, 4 Bugey 2, 3, 4, 5 Cattenom 1, 2, 3, 4 Chinon B1, B2, B3, B4 Chooz B1, B2 Civaux 1, 2 Cruas 1, 2, 3, 4 Dampierre 1, 2, 3, 4 Fessenheim 1, 2	Flamanville 1, 2 Golfech 1, 2 Gravelines 1, 2, 3, 4, 5, 6 Nogent 1, 2 Paluel 1, 2, 3, 4 Penly 1, 2 Saint-Alban 1, 2 Saint Laurent B1, B2 Tricastin 1, 2, 3, 4

1. Where multiple owners and/or operators are involved, only Leading Undertakings are listed.

Germany	E.ON Kernkraft GmbH	Brokdorf Grafenrheinfeld Grohnde	Isar 1, 2 Unterweser
	EnBW Kernkraft AG	Philippsburg 1, 2	Gemeinschaftskraftwerk-Neckar 1, 2
	RWE Power AG	Biblis A, B Emsland	Gundremmingen B, C
	Vattenfall Europe Nuclear Energy GmbH	Brunsbüttel	Krümmel
Hungary	Magyar Villamos Muvek Zrt	Paks 1, 2, 3, 4	
Japan	Chubu Electric Power Co.	Hamaoka 1, 2, 3, 4, 5	
	Chugoku Electric Power Co.	Shimane 1, 2	
	Hokkaido Electric Power Co.	Tomari 1, 2, 3	
	Hokuriku Electric Power Co.	Shika 1,2	
	Japan Atomic Power Co.	Tokai 2	Tsuruga 1, 2
	Kansai Electric Power Co.	Mihama 1, 2, 3 Ohi 1, 2, 3, 4	Takahama 1, 2, 3, 4
	Kyushu Electric Power Co.	Genkai 1, 2, 3, 4	Sendai 1, 2
	Shikoku Electric Power Co.	Ikata 1, 2, 3	
	Tohoku Electric Power Co.	Onagawa 1, 2, 3	Higashidori 1
	Tokyo Electric Power Co.	Fukushima Daiichi 1, 2, 3, 4, 5, 6 Fukushima Daini 1, 2, 3, 4	Kashiwazaki Kariwa 1, 2, 3, 4, 5, 6, 7
Korea	Korean Hydro and Nuclear Power	Kori 1, 2, 3, 4 Ulchin 1, 2, 3, 4, 5, 6	Wolsong 1, 2, 3, 4 Yonggwang 1, 2, 3, 4, 5, 6
Mexico	Comisiòn Federal de Electricidad	Laguna Verde 1, 2	
Romania	Societatea Nationala Nuclearelectrica	Cernavoda 1, 2	
Russian Federation	Energoatom Concern OJSC	Balakovo 1, 2, 3, 4 Kalinin 1, 2, 3 Kola 1, 2, 3, 4	Novovoronezh 3, 4, 5 Volgodonsk 1
Slovak Republic	JAVYS	JAVYS 1, 2	
	Slovenské Electrárne	Bohunice 3, 4	Mochovce 1, 2
Slovenia	Nuklearna Elektrarna Krško	Krško 1	
South Africa	ESKOM	Koeberg 1, 2	
Spain	UNESA	Almaraz 1, 2 Asco 1, 2 Cofrentes	Santa Maria de Garona Trillo Vandellos 2
Sweden	Forsmarks Kraftgrupp AB (FKA)	Forsmark 1, 2, 3	
	OKG Aktiebolag (OKG)	Oskarshamn 1, 2, 3	
	Ringhals AB (RAB)	Ringhals 1, 2, 3, 4	
Switzerland	Forces Motrices Bernoises (FMB)	Mühleberg	
	Kernkraftwerk Gösgen-Däniken (KGD)	Gösgen	
	Kernkraftwerk Leibstadt AG (KKL)	Leibstadt	
	Axpo AG	Beznau 1, 2	
The Netherlands	N.V. EPZ	Borssele	
Ukraine	Ministry of Fuel and Energy of Ukraine	Khmelnitski 1, 2 Rovno 1, 2, 3, 4	South Ukraine 1, 2, 3 Zaporozhe 1, 2, 3, 4, 5, 6
United Kingdom	British Energy Generation Ltd.	Sizewell B	

United States	American Electric Power Co.	D.C. Cook 1, 2	
	Constellation Energy Group	Calvert Cliffs 1, 2 Ginna	Nine Mile Point 1, 2
	Exelon Corporation	Braidwood 1, 2 Byron 1, 2 Clinton 1 Dresden 2, 3 LaSalle County 1, 2	Limerick 1, 2 Oyster Creek 1 Peach Bottom 2, 3 Quad Cities 1, 2 TMI 1
	First Energy Corporation	Beaver Valley 1, 2 Davis Besse 1	Perry 1
	Florida Power and Light	Duane Arnold 1 Point Beach 1, 2 Seabrook	St. Lucie 1, 2 Turkey Point 3, 4
	PPL Susquehanna, LLC	Susquehanna 1, 2	
	South Carolina Electric Co.	Virgil C. Summer 1	
	Southern Nuclear Operating Co.	Vogtle 1, 2	
	Tennessee Valley Authority (TVA)	Browns Ferry 1, 2, 3 Sequoyah 1, 2	Watts Bar 1
	XCel Energy	Monticello	

Officially Participating Utilities: Definitively shutdown reactors

Country	**Utility**	**Plant name**	
Bulgaria	Nuclear Power Plant Kozloduy	Kozloduy 1, 2, 3, 4	
Canada	Hydro Quebec	Gentilly 1	
	Ontario Power Generation	NPD	
France	Électricité de France (EDF)	Bugey 1 Chinon A1, A2, A3	Chooz A St. Laurent A1, A2
Germany	E.ON Kernfraft GmbH	Würgassen	Stade
	EnBW Kernkraft AG	Obrigheim	
	Energiewerke Nord GmbH	AVR Jülich	
	RWE Power AG	Mülheim-Kärlich	
Italy	SOGIN	Caorso Garigliano	Latina Trino
Japan	Japan Atomic Energy Agency	Fugen (LWCHWR)	
	Japan Atomic Power Co.	Tokai 1	
Lithuania	Ignalina Nuclear Power Plant	Ignalina 1, 2 (Ignalina 2 shutdown 2009/12/31)	
Russian Federation	Energoatom Concern OJSC	Novovoronezh 1, 2	
Spain	UNESA	Jose Cabrera	Vandellos 1
Sweden	Barsebäck Kraft AB (BKAB)	Barsebäck 1, 2	
The Netherlands	BV GKN	Dodewaard	
Ukraine	Ministry of Ukraine of Emergencies and Affairs of Population Protection from the Consequences of Chornobyl Catastrophe	Chernobyl 1, 2, 3	
United States	Exelon Corporation	Dresden 1 Peach Bottom 1	Zion 1, 2

Participating Regulatory Authorities

Country	Authority
Armenia	Armenian Nuclear Regulatory Authority (ANRA)
Belgium	Federal Agency for Nuclear Control
Brazil	Comissão Nacional de Energia Nuclear
Bulgaria	Bulgarian Nuclear Regulatory Agency
Canada	Canadian Nuclear Safety Commission (CNSC)
China	Nuclear and Radiation Safety Centre (NSC)
Czech Republic	State Office for Nuclear Safety
Finland	Säteilyturvakeskus (STUK)
France	Autorité de Sûreté Nucléaire (ASN); Direction Générale du Travail (DGT) du Ministère de l'emploi, de la cohésion sociale et du logement, represented by l'Institut de Radioprotection et de Sûreté Nucléaire (IRSN)
Germany	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, represented by GRS
Japan	Ministry of Economy, Trade and Industry (METI)
Korea	Ministry of Education, Science and Technology (MEST); Korea Institute of Nuclear Safety (KINS)
Lithuania	Radiation Protection Centre
Mexico	Commision Nacional de Seguridad Nuclear y Salvaguardias
The Netherlands	Ministerie van Sociale Zaken en Werkgelegenheld
Pakistan	Pakistan Nuclear Regulatory Authority
Romania	National Commission for Nuclear Activities Control (CNCAN)
Slovak Republic	Public Health Authority of the Slovak Republic
Slovenia	Slovenian Nuclear Safety Administration (SNSA); Slovenian Radiation Protection Administration (SRPA)
Spain	Consejo de Seguridad Nuclear
Sweden	Swedish Radiation Safety Authority
Switzerland	Swiss Federal Nuclear Safety Inspectorate (ENSI)
Ukraine	State Nuclear Regulatory Committee of Ukraine
United States	U.S. Nuclear Regulatory Commission (US NRC)

Country – Technical Centre affiliations

Country	Technical Centre*	Country	Technical Centre
Armenia	IAEATC	Mexico	NATC
Belgium	ETC	The Netherlands	ETC
Brazil	IAEATC	Pakistan	IAEATC
Bulgaria	IAEATC	Romania	IAEATC
Canada	NATC	Russian Federation	IAEATC
China	IAEATC	Slovak Republic	ETC
Czech Republic	ETC	Slovenia	IAEATC
Finland	ETC	South Africa, Rep. of	IAEATC
France	ETC	Spain	ETC
Germany	ETC	Sweden	ETC
Hungary	ETC	Switzerland	ETC
Italy	ETC	Ukraine	IAEATC
Japan	ATC	United Kingdom	ETC
Korea, Republic of	ATC	United States	NATC
Lithuania	IAEATC		

* Note: ATC: Asian Technical Centre, IAEATC: IAEA Technical Centre
ETC: European Technical Centre, NATC: North American Technical Centre

ISOE Network and Technical Centre information

ISOE Network web portal	
ISOE Network	www.isoe-network.net
ISOE Technical Centres	
European Region (ETC)	Centre d'étude sur l'évaluation de la protection dans le domaine nucléaire (CEPN), Fontenay-aux-Roses, France
	www.isoe-network.net
Asian Region (ATC)	Japan Nuclear Energy Safety Organisation(JNES), Tokyo, Japan
	www.jnes.go.jp/isoe/english/index.html
IAEA Region (IAEATC)	International Atomic Energy Agency (IAEA), Vienna, Austria Agence Internationale de l'Energie Atomique (AIEA), Vienne, Autriche
	www-ns.iaea.org/tech-areas/rw-ppss/isoe-iaea-tech-centre.asp
North American Region (NATC)	University of Illinois, Urbana-Champaign, Illinois, U.S.A.
	http://hps.ne.uiuc.edu/natcisoe/
Joint Secretariat	
OECD/NEA (Paris)	www.oecd-nea.org/jointproj/isoe.html
IAEA (Vienna)	www-ns.iaea.org/tech-areas/rw-ppss/isoe-iaea-tech-centre.asp

International co-operation

- European Commission (EC)
- United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)

Annex 4

ISOE BUREAU, SECRETARIAT AND TECHNICAL CENTRES

Bureau of the ISOE Management Board

	2007 2008	2009 2010	2011 2012
Chairperson (Utilities)	MIZUMACHI, Wataru Japan Nuclear Energy Safety Organisation JAPAN	SIMIONOV, Vasile Cernavoda NPP ROMANIA	ABELA, Gonzague EDF FRANCE
Chairperson Elect (Utilities)	SIMIONOV, Vasile Cernavoda NPP ROMANIA	ABELA, Gonzague EDF FRANCE	HARRIS, Willie EXELON UNITED STATES
Vice-Chairperson (Authorities)	RIIHILUOMA, Veli Finnish Centre for Radiation and Nuclear Safety (STUK) FINLAND	HOLAHAN, Vincent US Nuclear Regulatory Commission UNITED STATES	DJEFFAL, Salah Canadian Nuclear Safety Commission CANADA BROCK, Terry US Nuclear Regulatory Commission UNITED STATES
Past Chairperson (Utilities)	GAGNON, Jean-Yves Centrale Nucleaire Gentilly-2, CANADA	MIZUMACHI, Wataru Japan Nuclear Energy Safety Organisation JAPAN	SIMIONOV, Vasile Cernavoda NPP ROMANIA

ISOE Joint Secretariat

OECD Nuclear Energy Agency (OECD/NEA)

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OKYAR, Halil Burçin *(after September 2010)*
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Annex 5

ISOE WORKING GROUPS (2009, 2010)

Working Group on Data Analysis (WGDA)

Chair: HENNIGOR, Staffan (Sweden); Vice-Chair: STRUB, Erik (Germany)

CANADA	
DJEFFAL, Salah	Canadian Nuclear Safety Commission
McQUEEN Maureen	Bruce Power
CZECH REPUBLIC	
FARNIKOVA, Monika	Temelin NPP
FRANCE	
BADAJOZ, Caroline	CEPN (ETC)
D'ASCENZO, Lucie	CEPN (ETC)
SCHIEBER, Caroline	CEPN (ETC)
COUASNON, Olivier	ASN
ROCHER, Alain	EDF
GERMANY	
KAULARD, Jorg	Gesellschaft für Anlagen-und Reaktorsicherheit mbH
STRUB, Erik	Gesellschaft für Anlagen-und Reaktorsicherheit mbH
JENTJENS, Lena	VGB-PowerTech
BASCHNAGEL, Michael	Biblis NPP
JAPAN	
HAYASHIDA, Yoshihisa	Japan Nuclear Energy Safety Organization (ATC)
MIZUMACHI, Wataru	Japan Nuclear Energy Safety Organization (ATC)
SUZUKI, Akiko	Japan Nuclear Energy Safety Organization (ATC)
KOREA (REPUBLIC OF)	
CHOI, Won-Chul	Korea Institute of Nuclear Safety (KINS)
JUNG, Kyu-Hwan	Korea Institute of Nuclear Safety (KINS)
ROH, Hyun-Suk	Korea Institute of Nuclear Safety (KINS)
MEXICO	
ZORRILLA, Sergio H.	Central Laguna Verde
ROMANIA	
SIMIONOV, Vasile	Cernovoda NPP
RUSSIAN FEDERATION	
GLASUNOV, Vadim	Russian Research Institute for Nuclear Power Plant Operation (VNIIAES)
SLOVENIA	
BREZNIK, Borut	Krsko NPP
SPAIN	
Miguel Angel de la Rubia Rodiz	CSN
SWEDEN	
HENNIGOR, Staffan	Forsmarks Kraftgrupp AB
SOLSTRAND, Christer	OKG AB
SVEDBERG, Torgny	Ringhals AB
UNITED STATES OF AMERICA	
HAGEMEYER, Derek	Oak Ridge Associated Universities (ORAU)
LEWIS, Doris	US Nuclear Regulatory Commission
MILLER, David .W.	D.C. Cook Plant (NATC)
HARRIS, Willie	Exelon

WGDA Expert Group on Work Management

Chair: MIZUMACHI, Wataru (Japan)

FRANCE	
ABELA, Gonzague	EDF
BERTIN, Hélène	EDF
DROUET, François	CEPN (ETC)
SCHIEBER, Caroline	CEPN (ETC)
GERMANY	
STEINEL, Dieter	Philippsburg NPP
JAPAN	
HAYASHIDA, Yoshihisa	Japan Nuclear Energy Safety Organization (ATC)
MIZUMACHI, Wataru	Japan Nuclear Energy Safety Organization (ATC)
SUGAYA, Junko	Japan NUS Co., Ltd
KOREA (REPUBLIC OF)	
CHOI, Won-Chul	Korea Institute of Nuclear Safety (KINS)
MEXICO	
ZORRILLA, Sergio H.	Central Laguna Verde
ROMANIA	
SIMIONOV, Vasile	Cernovoda NPP
RUSSIAN FEDERATION	
GLASUNOV, Vadim	Russian Research Institute for Nuclear Power Plant Operation (VNIIAES)
SLOVENIA	
BREZNIK, Borut	Krsko NPP
SPAIN	
GARROTE PEREZ, Fernando	TECNATOM
SWEDEN	
HENNIGOR, Staffan	Forsmarks Kraftgrupp AB
UNITED KINGDOM	
LUNN, Matthew	Sizewell B NPP
RENN, Guy	Sizewell B NPP
UNITED STATES OF AMERICA	
DOTY, Rick	PPL Susquehanna LLC
HUNSICKER, John	VC Summer NGS
MILLER, David .W.	D.C. Cook Plant (NATC)
OHR, Ken	Quad Cities NGS

WGDA Task Team on Decommissioning

Chair: KAULARD, Jorg (Germany)

ARMENIA	
AVETISYAN, Aida	Armenian Nuclear Regulatory Authority (ANRA)
FRANCE	
CROUAIL, Pascal	CEPN (ETC)
GERMANY	
JURETZKA, Peter	Stade NPP
KAULARD, Jorg	Gesellschaft für Anlagen-und Reaktorsicherheit mbH
JAPAN	
HAYASHIDA, Yoshihisa	Japan Nuclear Energy Safety Organization (ATC)
MIZUMACHI, Wataru	Japan Nuclear Energy Safety Organization (ATC)
MEXICO	
ZORRILLA, Sergio H.	Central Laguna Verde
ROMANIA	
SIMIONOV, Vasile	Cernovoda NPP
SPAIN	
ORTIZ RAMIS, Maria Teresa	ENRESA
SWEDEN	
LINDVALL, Carl Göran	Barsebäck Kraft AB
LORENTZ, Hakan	Barsebäck Kraft AB
UNITED STATES OF AMERICA	
MILLER, David W.	D.C. Cook Plant (NATC)

Annex 6

ISOE MANAGEMENT BOARD AND NATIONAL CO-ORDINATORS

Note: ISOE National Co-ordinators identified in **bold**.

ARMENIA	
ATOYAN, Vovik	Armenian Nuclear Power Plant Company
AVETISYAN, Aida	Armenian Nuclear Regulatory Authority
BELGIUM	
NGUYEN Thanh Trung	Electrabel (Tihange NPP)
SCHRAYEN, Virginie	FANC-Federal Agency for Nuclear Control
BRAZIL	
do AMARAL, Marcos Antônio	Angra NPP
BULGARIA	
NIKOLOV, Atanas	Kozloduy NPP
KATZARSKA, Lidia	Bulgarian Nuclear Regulatory Agency
CANADA	
McQUEEN, Maureen	Bruce Power
DJEFFAL, Salah	Canadian Nuclear Safety Commission
GAGNON, Jean-Yves	Centrale Nucleaire Gentilly-2
VILLEMAIRE, Mike	Pickering NPP
ALLEN, Scott	Bruce Power
CHINA	
LI, Ruirong	Daya Bay NPS
ZHANG, Jintao	China National Nuclear Corporation
CZECH REPUBLIC	
KOC, Josef	Temelin NPP
FARNIKOVA, Monika	Temelin NPP
URBANCIK, Libor	State Office for Nuclear Safety (SUJB)
KULICH, Vladimir	Dukovany NPP
FINLAND	
KONTIO, Timo	Fortum, Loviisa NPP
RIIHILUOMA, Veli	Centre for Radiation and Nuclear Safety, STUK
KUKKONEN, Kari	TVO, Olkiluoto NPP
VILKAMO, Olli	Centre for Radiation and Nuclear Safety, STUK
FRANCE	
ABELA, Gonzague	EDF
CORDIER, Gerard COUASNON, Olivier	EDF
CHEVALIER, Sophie	ASN
GUZMAN LOPEZ-OCON, Olvido	ASN
GERMANY	
JENTJENS, Lena	VGB PowerTech e.V.
BASCHNAGEL, Michael	RWE Power AG, Kraftwerk Biblis
FRASCH, Gerhard	Bundesamt für Strahlenschutz
KAULARD, Jörg	Gesellschaft für Anlagen-und Reaktorsicherheit mbH (GRS)
STRUB, Erik	Gesellschaft füer Anlagen-und Reaktorsicherheit mbH (GRS)
HUNGARY	
BUJTAS, Tibor	PAKS NPP
ITALY	
MANCINI, Francesco	SOGIN Spa

JAPAN	
HAYASHIDA, Yoshihisa	Japan Nuclear Energy Safety Organization (ATC)
KOBAYASHI, Masahide	Japan Nuclear Energy Safety Organization (ATC)
MIZUMACHI, Wataru	Japan Nuclear Energy Safety Organization (ATC)
SUZUKI, Akira	Tokyo Electric Power Company
TSUJI, Masatoshi	Nuclear and Industrial Safety Agency (NISA)
YONEMARU, Kenichi	Kyushu Electric Power Company
KANEOKA, Tadashi	The Chugoku Electric Power Co., Inc.
KOREA (REPUBLIC OF)	
CHOI, Won-Chul	Korea Institute of Nuclear Safety (KINS)
AN, Yong Min	Korea Hydro and Nuclear Power. Co. Ltd
LEE, Hee-hwan	Korea Hydro and Nuclear Power. Co. Ltd
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LITHUANIA	
PLETNIOV, Victor	Ignalina NPP
BALCYTIS, Gintautas	Radiation Protection Centre
MEXICO	
ZORRILLA, Sergio H.	Central Laguna Verde
MEDRANO, Marco	National Nuclear Research Institute
THE NETHERLANDS	
MEIJER, Hans	Borssele NPP
BREAS, Gerard	Ministry For Environment
PAKISTAN	
NASIM, Bushra	Pakistan Nuclear Regulatory Authority
MUBBASHER, Makshoof	Chashma NPP (Unit1)
ROMANIA	
SIMIONOV, Vasile	Cernavoda NPP
RODNA, Alexandru	National Commission for Nuclear Activities Control
VELICU, Oana	National Commission for Nuclear Activities Control
RUSSIAN FEDERATION	
BEZRUKOV, Boris	Energoatom Concern OJSC
GLASUNOV, Vadim	Russian Research Institute for Nuclear Power Plant Operation (VNIIAES)
SLOVAK REPUBLIC	
DOBIS, Lubomir	Bohunice NPP
VIKTORY, Dusan	Public Health Institute of the Slovak Republic
SLOVENIA	
BREZNIK, Borut	Krsko NPP
JANZEKOVIC, Helena	Slovenian Nuclear Safety Administration
JUG, Nina	Slovenian Radiation Protection Administration
CERNILOGAR RADEZ, Milena	Slovenian Nuclear Safety Administration
SOUTH AFRICA (REPUBLIC OF)	
MAREE, Marc	Koeberg NPS
SPAIN	
HERRERA Borja Rosell	Almaraz NPP
LABARTA, Teresa	Consejo de Seguridad Nuclear
ROSALES CALVO, Maria Luisa	Consejo de Seguridad Nuclear
DE LA RUBIA, Miguel Angel	Consejo de Seguridad Nuclear
SWEDEN	
SVEDBERG, Torgny	Ringhals NPP
FRITIOFF, Karin	Swedish Radiation Safety Authority
LINDVALL, Carl Göran	Barsebäck NPP
SOLSTRAND, Christer	Oskarsham NPP
HENNIGOR, Staffan	Forsmark NPP
SWITZERLAND	
JAHN, Swen-Gunnar	ENSI
UKRAINE	
LISOVA, Tetyana	Ministry of Fuel and Energy of Ukraine
RYAZANTSEV, Viktor	SNRCU
UNITED KINGDOM	
RENN, Guy	Sizewell B Power Station
ZODIATES, Anastasios	British Energy

UNITED STATES OF AMERICA

MILLER, David	D.C. Cook Plant (NATC)
GREEN, Bill	Clinton Power Station
LEWIS, Doris	U.S. Nuclear Regulatory Commission
BROCK, Terry	U.S. Nuclear Regulatory Commission
HARRIS, Willie	Exelon – Corporate
DALY, Patrick	Exelon - Braidwood
JONES, Patricia	Constellation Energy - Calvert Cliffs
OHR, Kenneth	Exelon - Quad Cities Station
HUNSICKER, John	South Carolina Electric - V.C Summer