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Ionising radiation metrology infrastructure in Europe

A survey in European counties' regulations about IR metrology regulations and calibration requirements in radiation protection legislation.

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Key words:
Infrastructure, ionizing radiation, dosimetry, activity, metrology, survey, national standards, legal regulation, traceability.

Abstract:
The status of ionising radiation metrology infrastructure in European countries is compiled. It is documented how traceability of activity and dosimetry quantities are disseminated and which organisations have been given this task in the European countries. This report summarise work in the EURAMET project no. 1284.

Referanse:
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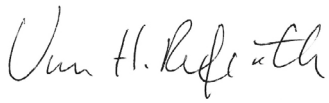
Emneord:
Infrastruktur, ioniserende stråling, dosimetri, aktivitet, metrologi, spørreundersøkelse, nationale standarder, lovregulering, sporbarhet.

Resymé:
Status for ioniserende strålings infrastruktur i europeiske land er samlet. Det er dokumentert hvordan sporbarhet av aktivitet og dosimetriske størrelser formidles og hvilke organisasjoner som har fått denne oppgaven i de europeiske landene. Denne rapporten oppsummerer arbeidet i EURAMET prosjekt nr. 1284.

Head of project: Hans Bjerke
Approved:



Unn Hilde Refset, director, Department of Monitoring and Research

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Ionising radiation metrology infrastructure in Europe

A survey in European counties' regulations about IR metrology regulations and calibration requirements in radiation protection legislation.

Report from EURAMET project no. 1284

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Statens strålevern

Norwegian Radiation Protection Authority
Østerås, 2017

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[8] National Physical Laboratories (NPL)

Contents

1 List of acronyms

ALARA	As Low As Reasonably Achievable
BEV	Bundesamt für Eich- und Vermessungswesen, Austria
BIM	Bulgarian Institute for Metrology, Bulgaria
BIPM	Bureau International des Poids et Mesures
BSS	Basic Safety Standard
CCRI	Consultative Committee for Ionizing Radiation
CIPM	The General Conference on Weights and Measures
CIEMAT	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, Spain
CMC	Calibration and Measurement Capability
CMI	Czech Metrology Institute/Ceský metrologický institut, Czech Republic
DI	Designated Institute
DTU	Technical University of Denmark, Denmark
EC	European Commission
ENEA-INMRI	Istituto Nazionale di Metrologia delle Radiazioni Ionizzanti, Italy
EU	European Union
EURAMET	European Association of National Metrological Institutes
EURATOM	European Atomic Energy Community
FTMC	Center for Physical Sciences and Technology, Lithuania
GR	Geislavarna ríkisins, Icelandic Radiation Safety Authority, Iceland
GUM	Central Office of Measures, Poland
HERCA	Heads of European Radiological protection Competent Authorities
HMI/IRB-SSDL	Secondary Standard Dosimetry Laboratory of the Ruđer Bošković Institute, Croatia
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IFIN-HH	National Institute of Research and Development for Physics and Nuclear Engineering, Romania
IPH	Institute of Public Health, Republic of Mecedonia
IR	Ionising Radiation
IRA	Institut Universitaire de Radiophysique Appliquée, Switzerland
IRCL/GAEC-EIM	Ionizing Radiation Calibration Laboratory/Greek Atomic Energy Commission - Hellenic Institute of Metrology, Greece
IRMM	Institute for Reference Materials and Measurements, European Commission (former JRC in Geel)
IST/ITN	Instituto Tecnológico e Nuclear, Instituto Superior Técnico, Portugal
IJS	Jožef Stefan Institute, Slovenia
JRC in Geel	Joint Research Centre at Geel, European Commission
LATMB	LNMC Metrology Bureau, Latvia
LMRI	Laboratório de Metrologia das Radiações Ionizantes, Portugal
LNE-LNHB	Laboratoire National de Métrologie et d'Essais - Laboratoire National Henri Becquerel, France
LNMC	Latvian National Metrology Centre, now LNMC Metrology Bureau (LATMB)
LNS/SAR	Laboratoire National de la Santé, Service d'Analyses Radiologiques, Luxemburg
MCCAA	Malta Competition and Consumer Affairs Authority, Malta

METAS	Federal Institute of Metrology, Switzerland
Metrosert	Central Office of Metrology, Estonia
MKEH	Hungarian Trade Licensing Office, Hungary
mSv	milli sievert
NCRRP	National Centre of Radiobiology and Radiation Protection - SSDL, Bulgaria
NEA	OECD Nuclear Energy Agency
NMI	National Metrological Institute
NPL	National Physical Laboratory, UK
NRPA	Norwegian Radiation Protection Authority, Norway
NS	Neytendastofa, Island
NTI	Institute of Nuclear Sciences, Vinča, Serbia
OECD	Organisation for Economic Co-operation and Development
POLATOM	National Centre for Nuclear Research, Poland
PSI	Paul Scherrer Institute, Switzerland
PTB	Physikalisch-Technische Bundesanstalt, Germany
RPII	Radiological Protection Institute of Ireland, Ireland
SI	The International System of Units
SMU	Slovak Institute of Metrology/Slovenský Metrologický Ústav, Slovakia
SSM	Swedish Radiation Safety Authority, Sweden
STUK	Radiation and Nuclear Safety Authority, Finland
TAEK	Turkish Atomic Energy Authority, Turkey
TC-IR	Technical Committee of Ionising Radiation
TWh	Tera watt hour
VINS	Vinča Institute of Nuclear Sciences, Serbia
VMC	Vilnius Metrology Center, Metrology Laboratory of Radiation Safety, Dosimetry and Radiometry, Lithuania
VSL	Dutch Metrology Institute, Netherlands

2 Summary

The information in this report covers compiled information on legal regulations and practices in ionising radiation calibrations in thirty-six European countries, being members of the European Association of National Metrology Institutes – EURAMET (EURAMET has 37 members from 2016). In the introduction the general facts about ionising radiation metrology and its connection to the International System of Units are presented. This report comprises the information collected within the EURAMET Project 1284 "Survey of European countries' legal regulations and practices in ionising radiation calibrations", conducted among EURAMET members from 2013 to 2016. The presented countries' data from the respondents represents the results in this report. It was not possible to get complete data from a couple of countries.

This survey revealed that 72 % of EURAMET member countries have regulations of the radiation units Gy, Sv and Bq covered by legislation. 75 % of the countries have a National Metrology Institute (NMI) or Designated Institute (DI) responsible for maintaining and disseminating the ionising radiation units. However, there are eight countries, where this is not the case.

Medical use of radiation is an important area for ionising radiation metrology. 83 % of the countries had regulations for traceable dosimetry in radiotherapy and 86 % for x-ray diagnostic and intervention. The availability of national calibration dosimetry standards in radiotherapy was only 61 %, and 53 % for x-ray diagnostic and intervention. The traceability of activity for nuclear medicine is covered through their own national standards in only fourteen European countries. This finding shows a remarkable low service rate for activity calibration (Bq) in nuclear medicine.

The 14 countries having electricity production from nuclear energy were divided into two groups: medium and major. The major group, 7 countries, had more than 35 % of nuclear energy, the medium less than 35 %. All countries in the medium group reported regulations on traceability for the measurement of dose and activity, while some of the countries in the major group don't have these regulations. Not all of these 14 countries reported to have national standards for individual monitoring of gamma and neutron dose to the workers, early warning networks, environmental activity and activity measurements of waste.

Only 15 countries have national standards for environmental activity measurements, and 26 of the 36 countries in the survey reported regulation on environmental activity measurements.

Indoor radon calibrations facilities were reported in 9 countries, and only one of these maintained a national standard in activity per unit volume for Rn-222 in the unit Bq m^{-3}. The reported metrology infrastructure for indoor radon measurements was very sparse.

The evaluation of medical use of ionising radiation shows needs for improvements to ensure safety and efficacy of healthcare in member countries of EURAMET. The strategic EURAMET goals indicate possible improvement when tested against the findings in the survey for IR measurements in handling of indoor radon and in the measurements in the nuclear energy industry. During time of report writing (three years) we noticed that countries in South-East Europe improved their regulations on traceability and developed national standards. This report gives some input to understand the true needs of the member states and may provide input to the development of relevant policies as planned in the EURAMET 2020 strategy.

3 Foreword

A complex and extensive European and national legislation is existing for ionising radiation. A lot of scientific and metrology activities in Europe are given or initiated by legal requirements. The basis for fulfilling the legal tasks on a high level of quality is a reliable and quality assured metrology. The situation in the European countries is diverse and a comprehensive overview has been not available. Therefore NRPA has conducted a EURAMET project, its findings presented in this report gives such very valuable overview for the first time and provides a lot of helpful information.

The new European regulation in ionising radiation laying down in the COUNCIL DIRECTIVE 2013/59/EURATOM of 5th December 2013 has to be transferred in national legislation by the European countries. A follow-up project with the focus on the transfer of this Directive to national legislation and the consequences and applications could be helpful and could arise synergies.

By Ulrike Ankerhold, PTB. TC Chair of the Technical Committee for Ionising Radiation.

4 Introduction

In this report, the status of existing national legislation in the EURAMET member countries is compiled. Beside this it is documented how traceability of activity and dosimetry quantities are disseminated and to which organisations this task are appointed. Collected facts on infrastructure for each country support the evaluation of the results. The information in this report are based on the answers given by the respondents.

The background for this survey was that the ionising radiation (IR) metrology in Europe is complex and that the European IR laboratories share a large part of the calibration and measurement capabilities and metrology research resources in the world. Specialities for these national metrological laboratories are needs related to the following facts:

- safety, health, energy and fundamental scientific metrology are focused in society, and requested from international organisations such as the EU, the IAEA and the OECD/NEA
- many laboratories are designated institutes (DIs) in the field of IR metrology,
- all three IR quantities are derived SI units and have rather large uncertainties, and
- there has been high focus on security and risks related to IR.

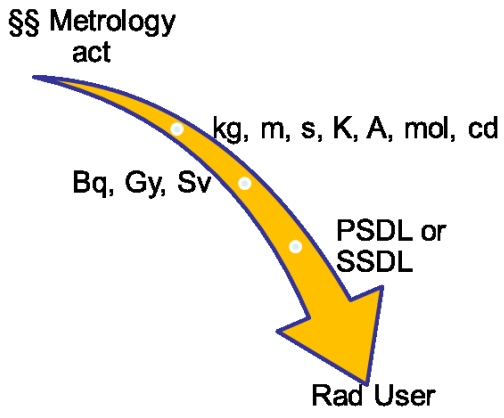

Figure 1 Metrology act regulates the seven SI units, the three IR units, and their dissemination.

An illustration of the dissemination of the units, becquerel (Bq), gray (Gy) and sievert (Sv) to the radiation user is presented on Figure 1. The aim of the project was to gather all relevant information related to legal regulations and dissemination of ionising radiation measurements and calibrations in European countries. A questionnaire was prepared and circulated to all European NMIs /DIs and some other contacts in the field of ionising radiation. All EURAMET delegates and IR contact persons got an e-mail with a link to the questionnaire. The respondents were asked to answer the questionnaire on

behalf of their country. The questionnaire had two main parts: 1) questions related to radiation calibration legislation, dissemination and responsibility (responsible institution), and 2) questions on how ionising radiation measurements have legal regulations on traceability. In addition, the respondents were asked about their opinion on legal requirements on ionising radiation measurements.

Information on the country's regulations concerning IR metrology, the responsible NMI or DI, and on the calibration services was also requested. The second part of the survey seeks for the stakeholders' views which mean the radiation user point of view; the survey asks if the national radiation protection regulations have requirements on the traceability of radiation measurements (dosimetry), measurements of activity and neutrons. On Figure 2 these two parts of the survey are presented.

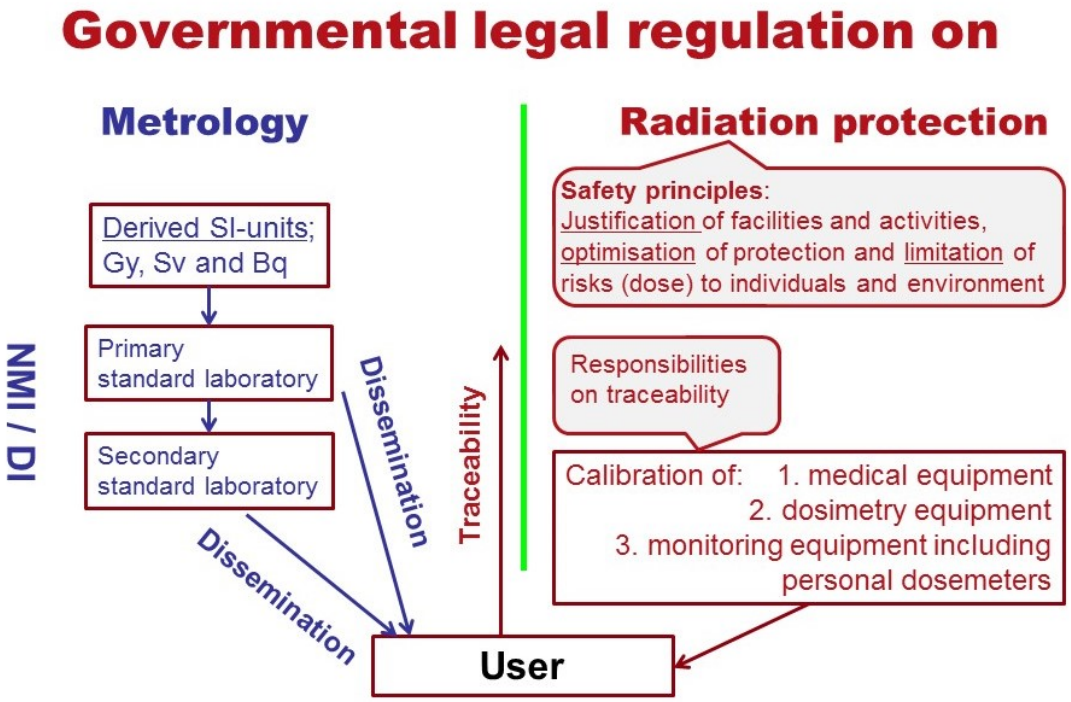

*Figure 2 Governmental regulations: on one side the **metrology** and dissemination of units and on the other side the regulations about the **use of radiation** by the radiation protection legislation.*

The project will meet the CCRI Strategy [1] action plan for 2013-2015 (table 4):

- ID c; Increase meaningful dialogue between NMIs and DIs

The EURAMET in 2011 issued a strategic plan towards 2020 [2] saying that reliable and traceable measurement underpins the welfare of a modern society, and that developed measurement infrastructure gives confidence in our daily life by:

EURAMET 2020 Strategy

Goals from the strategic objectives of EURAMET 2020 Strategy are to:

- Develop key partnerships
- Understand stakeholder needs
- Increase impact of EURAMET work
- Anticipate market and needs trends based on foresight analysis.
- Provide inputs to the development of relevant policies where measurement considerations are important.
- Understand the true needs and visions of members and have an inclusive approach to all member needs

- Enabling the development and manufacturing of reliable high quality and innovative products
- Supporting industry to be competitive and sustainable in its production
- Removing technical barriers to trade and supporting fair trade
- Ensuring safety and efficacy of healthcare
- Meeting the grand challenges of energy and environment.

This survey intention was to map the situation in European countries for legal responsibility in IR metrology; dissemination of ionising radiation calibrations, and the traceability of measurements of ionising radiation – kerma, dose, dose rate and activity, as well as measurement of neutrons.

The consequence for the nonexistence or weak regulations of the IR metrology makes the NMI unable or confused in supporting or designating an IR laboratory. Users of ionising radiation will have difficulties in finding calibration services to support their quality systems when having a weak or no regulations on measurement or calibration traceability. These users are nuclear power industry, other industrial facilities using ionising radiation, medical ionising radiation users, and physical and biological radiation research institutions. The same situation concerns the environmental measurement of natural and anthropogenic radionuclides.

In the field of ionising radiation, European ALARA Network has performed surveys:

- On radon exposure management [3],
- On Rules and practices regarding delineation of and access to regulated areas for radiation protection [4],
- The implementation of the 'justification', 'optimisation' and 'limitation of doses' radiological protection principles in national regulations in Europe and request on radiation protection of aircraft crew [5].

These surveys refer to ionising radiation quantities, as it was mass in kg or length in m with very low uncertainties. However, for ionising radiation quantities in units of gray (Gy), sievert (Sv) or becquerel (Bq), the situation is different. The units you can find in BIPM SI brochure Table 3 [6] are not easily available in every country, and when asking for service at a national calibration laboratory you will find a much higher uncertainty in IR than in the other metrology fields. In this survey, we want to assess the legal regulations of ionising radiation units.

5 Method of the survey and method for the evaluation

The questions were prepared in a web based survey program Easyresearch, a QuestBack platform. This program has four main features:

1. the questions and its system
2. e-mail list of respondents
3. invitation mail and follow-up mails and
4. reporting

The survey program could produce histograms and presentations from the collected answers, but it turned out to be difficult to produce reports directly from the survey program.

5.1 Part I of the survey, legal regulations of the units Bq, Gy and Sv.

The first topic was to get information about the legal metrology regulations on the derived SI-units becquerel (Bq), gray (Gy) and sievert (Sv). The respondent was asked if the country has regulations on Bq, Gy, and Sv. Moreover, questions were posed about the type of regulations and whether it was possible to have these regulations in English.

In addition, contact details of the laboratory responsible for keeping and maintaining national standards for ionising radiation units as well as disseminating the units of ionising radiation were asked.

The details about calibration services are published in the Calibration and Measurement Capabilities (CMCs) on the BIPM Key Comparison Database and BIPM (KCDB) web page [7], and the questionnaire gave the CMC-information to the respondent for the respective country as background for his/her answer.

5.2 Part II of the survey, legal regulations of traceable IR measurements

The second part of the survey was about the legal requirements on traceability (calibration and/or verification of measurements) in radiation protection, radiation use and nuclear activities. The respondents were asked to mark relevant areas of legal regulations. The areas given were:

1. Measurements involved in determining patient dose and dose distribution in radiotherapy
2. Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention
3. Activity measurements for nuclear medicine
4. Radiation measurements involved in individual monitoring of workers
5. Radiation measurements involved in monitoring of members of the public
6. Measurements of radon concentration in air
7. Radiation dosimetry for early warning networks
8. Environmental activity measurements
9. Activity measurements of waste
10. Neutron measurements involved in individual monitoring of workers
11. Dosimetry in type testing of equipment
12. Activity measurements in type testing of equipment and radiopharmaceuticals.

After choosing the relevant areas the respondents were asked to give references to legal regulations.

The next step in the survey dealt with national standards. The same twelve areas of measurements listed before were used for this area as well. Just before this list, the respondent was prompted to a link with

the country's CMCs in the BIPM Appendix C in order to see the country's calibration and measurements capability in IR metrology. For respondents from countries without CMCs this possibility was not available.

The last list of information asked for the respondents' opinion about legal requirements on traceable measurements in the country. Here "Yes" and "No" options were used to give only an idea of the status among the different countries. The list consisted of the following areas:

1. Dosimetry in radiotherapy
2. Dosimetry in X-ray diagnostic and intervention
3. Activity measurements in nuclear medicine
4. Dosimetry and measurements of activity and neutrons in nuclear energy
5. Personal dosimetry
6. Environmental dosimetry
7. Measurements of activity in environmental samples
8. Radon in air
9. Early warning networks

All the details of the questionnaire are reproduced in the appendix 13.2

5.3 The mailing lists

The mailing lists were produced from the EURAMET web page of the delegate list and the TC-IR contact persons. A third list was set up in order to get information from countries not covered by the two first lists.

The regulations asked for in the second part of the survey were most often found in the radiation protection legislations. Therefore, it was considered to have supplementary answers from a European radiation protection organisation. Such an organisation is the Heads of European Radiological protection Competent Authorities (HERCA) [8], and the chairperson of HERCA was asked a possible use of the e-mail list of the HERCA of participants to answer the questionnaire. It turned out that the chairpersons and directors of the radiation protection authorities considered themselves not being the right persons to answer the survey.

5.4 The collection of information

The survey started with the first mail sent on 11th November 2013; reminders were sent one and two weeks later to the recipients who did not respond. The last reminder was sent to 45 of the 77 total of recipients on 10th January 2014. In June 2014, 4 countries were contacted for completing their answers.

A preliminary presentation was at the EURAMET TC-IR Contact Person meeting in October 2014, and unfortunately, in 2015 there was no further progress in the reporting. Writing started up again in 2016, and existing information was organised in nine country groups. The draft version of the report together with Excel sheets ware e-mailed to nine persons representing the county groups. They were asked to check the information, supply new information and give an updated version of their countries. Drafts of the report were circulated among the persons for control of information and valuable review of the text.

5.5 The evaluation of the results.

The results of the survey itself may be of some interest, but the main aim was to see the regulations related to the use of ionising radiation in the various countries. Four areas of information were included in the result table of the grouped countries. These information were:

1. the country population, in 1000 inhabitants
2. the electricity generation
    a. the total electricity generation, in TWh/year
    b. the share nuclear in electricity production, in per cent

3. the radiotherapy
    a. the number of teletherapy radiotherapy units per million inhabitants
    b. the present access to radiotherapy for cancer patients, per cent of full access
4. the medical x-ray diagnostic and intervention
    a. the mean effective doses from x-ray procedures, in mSv/year
    b. the number of medical x-ray CT procedures per 1000 inhabitants and year

These information were available from five sources:

Population: About the EU. Living in EU [9], and Worldometers. Elaboration of data by United Nations, Department of Economic and Social Affairs, Population Division [10].
Energy generation: International Energy Agency. IEA Energy Atlas [11].
Radiotherapy: N.R. Datta, M. Samiei, S. Bodis. Radiotherapy infrastructure and human resources in Europe — Present status and its implications for 2020 [12].
Medical exposure: EC. Medical Radiation Exposure of the European Population [13].

6 SI Units for ionising radiation and the realisation of the units

The current internationally quantities and units for ionising radiation were defined 40 years ago by the general conference of weight and measures (CGPM). The BIPM publishes the International System (SI) units in the Units SI brochure [6]. In the brochure's Table 3 you find the IR units with special names and symbols. The three special units for ionising radiation are:

1. special name for the SI unit of **activity**, **becquerel**, symbol **Bq**, equal to one reciprocal second, resolution 8 of the CGPM (1975)
2. special name for the SI unit of **absorbed dose**, **gray**, symbol **Gy**, equal to one joule per kilogram, resolution 9 of the CGPM (1975). In the field of ionizing radiation the gray may also be used with other physical quantities also expressed in joules per kilogram.
3. special name for the SI unit of **dose equivalent**, **sievert**, symbol **Sv**, equal to the joule per kilogram, resolution 5 of the CGPM (1979). The sievert is the SI unit of dose equivalent in the field of radioprotection.

6.1 Realisation of the IR units

The realisation of the units depends on the physical constants and the work performed in the primary standard laboratories. In the field of ionising radiation (IR), this work started at Sorbonne university in Paris in 1896 [14]. Marie Skłodowska Curie, Pierre Curie, Henri Becquerel and J. Perrin worked together and developed the ionisation chamber for measurements of activity of Radium and roentgen radiation. In the early 1920s the characterisation and definition of quantities and units were still under international debate. Special contributions came from Sievert in 1926 [15] describing depth doses in water and Taylor in 1929 [16], defining the principles of the free air chamber for radiation measurements in air.

As in other fields of metrology, the development and needs for national standards for ionising radiation have not followed a strict plan and therefore all countries don't have national IR standards for all their fields of ionising radiation use.

6.2 The world key standards in IR metrology

The BIPM maintain the world key standards in IR metrology, and those countries maintaining primary standards repeat their key comparisons with the BIPM standards at least once every 10 years [17]. The secondary IR standards at NMI or DI of other countries are traceable to (are calibrated against) the BIPM IR standards or to the other primary IR standards.

6.3 Database of the metrology infrastructure

The BIPM maintain a database of all national calibration and measurement capabilities worldwide. The Calibration and Measurement Capabilities (CMCs) are open accessed at the BIPM web in the BIPM Key Comparison Database and BIPM (KCDB) [7]. The number of CMCs published by the European countries you find tabulated in Appendix 13.3.

7 International recommendations/requirements — Basic Safety Standards

7.1 International standards for legal regulations of ionising radiation metrology

A survey on legal regulations and practices in ionising radiation calibration should be tested against an international standard. The most relevant references are:

- the definition of the units gray (Gy), sievert (Sv) and becquerel (Bq) [6],
- the International Atomic Energy Agency (IAEA) Basic Safety Standard (IAEA BSS) [18] and
- the European Union (EU) council directive laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation (EU BSS) [19].

The discussion on the units is not a topic in this document. Relevant paragraphs from the basic safety standards (BSS from IAEA and EU) are, however, reproduced for recommendations on legal regulations regarding IR metrology.

7.2 The International Atomic Energy Agency's Basic Safety Standards

The IAEA BSS [18] is the basic reference on International Basic Safety Standards, where IAEA publishes the safety requirements for Member States that shall be met to ensure the protection of people and environment, both now and in the future. The standard was revised and published in 2014. The IAEA BSS [19] is intended for use by governmental authorities including regulatory bodies responsible for the licensing of facilities and activities using ionising radiation.

For this report relevant recommendations of the IAEA BSS are:

A. **Requirement 2: Establishment of a legal and regulatory framework,** paragraph 2.23. *The government shall ensure that arrangements are in place for the provision of technical services relating to protection and safety, such as services for personal dosimetry, environmental monitoring and the calibration of monitoring and measuring equipment.*

B. **Requirement 20: Requirements for monitoring and recording of occupational exposure**, paragraph 3.73. *The regulatory body shall be responsible, as appropriate, for: (c) Authorization or approval of service providers for individual monitoring and calibration services.*

C. **Requirement 21: Responsibilities of employers, registrants and licensees for the protection of workers**, paragraph 3.76. *Employers, registrants and licensees shall ensure, for all workers engaged in activities in which they are or could be subject to occupational exposure, that: (g) Appropriate monitoring equipment and personal protective equipment are provided and arrangements are made for its proper use, calibration, testing and maintenance.*

D. **Requirement 36: Responsibilities of registrants and licensees specific to medical exposure**, paragraph 3.154. *Registrants and licensees shall ensure that:*

d. For therapeutic radiological procedures, the requirements of these Standards for calibration, dosimetry and quality assurance, including the acceptance and commissioning of medical radiological equipment, as specified in paras 3.167, 3.168(c), 3.170 and 3.171, are fulfilled by or under the supervision of a medical physicist.

e. For diagnostic radiological procedures and image guided interventional procedures, the requirements of these Standards for medical imaging, calibration, dosimetry and quality assurance, including the acceptance and commissioning of medical radiological equipment, as specified in paras 3.167, 3.168(a) and (b), 3.170 and 3.171, are fulfilled by

or under the supervision of a medical physicist, whose degree of involvement is determined by the complexity of the radiological procedures and the associated radiation risks.

E. **Requirement 38: Optimization of protection and safety. Calibration**, paragraph: 3.167. *In accordance with paragraph. 3.154(d) and (e), the medical physicist shall ensure that:*

a. *All sources giving rise to medical exposure are calibrated in terms of appropriate quantities using internationally accepted or nationally accepted protocols*
b. *Calibrations are carried out at the time of commissioning a unit prior to clinical use, after any maintenance procedure that could affect the dosimetry and at intervals approved by the regulatory body*
c. *Calibrations of radiotherapy units are subject to independent verification prior to clinical use*
d. *Calibration of all dosimeters used for dosimetry of patients and for the calibration of sources is traceable to a standards dosimetry laboratory.*

Standards dosimetry laboratory is in the list of definitions defined as: *A laboratory, designated by the relevant national authority that possesses certification or accreditation necessary for the purpose of developing, maintaining or improving primary or secondary standards for radiation dosimetry.*

7.3 The European Union's Basic Safety Standards

The council of the European Union has adopted the directive 2013/59/EURATOM [19] (EU BSS) laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation.

The EU BSS establishes uniform basic safety standards for the protection of the health of individuals subject to occupational, medical and public exposures against the dangers arising from ionising radiation.

For this report are relevant these recommendations of the EU BSS:

A. Article 4, **Definitions**

a. *(24) "dosimetry service" means a body or an individual competent to calibrate, read or interpret individual monitoring devices, or to measure radioactivity in the human body or in biological samples, or to assess doses, whose capacity to act in this respect is recognised by the competent authority;*
b. *(32) "environmental monitoring" means the measurement of external dose rates due to radioactive substances in the environment or of concentrations of radionuclides in environmental media;*
c. *(64) "practical aspects of medical radiological procedures" means the physical conduct of a medical exposure and any supporting aspects, including handling and use of medical radiological equipment, the assessment of technical and physical parameters (including radiation doses), calibration and maintenance of equipment, preparation and administration of radio-pharmaceuticals, and image processing;*

B. Article 14, **General responsibilities for the education, training and provision of information**

a. *2. Member States shall ensure that arrangements are made for the establishment of education, training and retraining to allow the recognition of radiation protection experts and medical physics experts, as well as occupational health services and dosimetry services, in relation to the type of practice.*

C. Article 34, **Consultations with a radiation protection expert**
Member States shall require undertakings to seek advice from a radiation protection expert within their areas of competence as outlined in Article 82, on the issues below that are relevant to the practice:

- *a. the examination and testing of protective devices and measuring instruments*
- *b. prior critical review of plans for installations from the point of view of radiation protection*
- *c. the acceptance into service of new or modified radiation sources from the point of view of radiation protection*
- *d. regular checking of the effectiveness of protective devices and techniques*
- *e. regular calibration of measuring instruments and regular checking that they are serviceable and correctly used.*

D. Article 41, **Individual monitoring**

a. 1. Member States shall ensure that category A workers are systematically monitored based on individual measurements performed by a dosimetry service.

E. Article 68, **Tasks for the undertaking**
Member States shall require the undertaking to carry out the following tasks:

- *a. achieve and maintain an optimal level of protection of members of the public*
- *b. accept into service adequate equipment and procedures for measuring and assessing exposure of members of the public and radioactive contamination of the environment*
- *c. check the effectiveness and maintenance of equipment as referred to in point (b) and ensure the regular calibration of measuring instruments*
- *d. seek advice from a radiation protection expert in the performance of the tasks referred to in points (a), (b) and (c).*

F. Article 79, **Recognition of services and experts**
1. Member States shall ensure that arrangements are in place for the recognition of:

- *a. occupational health services*
- b. *dosimetry services*

G. Article 81, **Dosimetry services**
Member State shall ensure that dosimetry services determine internal or external doses to exposed workers subject to individual monitoring, in order to record the dose in cooperation with the undertaking and in the case of outside workers, the employer, and where relevant the occupational health service.

These international standards recommendations and requirements for regulations will not be tested against each country's response to the questionnaire, but are recording in this document and used as a background information for the reading of the results of the survey.

8 Results from the questionnaire

The first survey was sent in 2013 to, at that time, 35 EURAMET delegates; only 10 of them responded and two of them gave incomplete answers. Twenty-seven contact persons in the technical committee for ionising radiation got the survey as well and we got response from 26 of them. Three out of the 26 answers were not complete. Denis Glavič-Cindro, Slovenia helped me setting up a supplementary list and together with other information, this additional list contained 15 contact persons, from which we got 9 complete answers. Out of the expected 37 European countries, we got in touch with 36 of them, leaving Cyprus outside the survey because we didn't get any contact persons to ask for these information. Additionally we didn't get any information from Kosovo (not member of EURAMET). Therefore, in the survey we received 45 answers in total. In addition, we were able to supply information by asking colleagues in the report-writing period. Appendix Table 6 contains list of all the respondents and informers.

8.1 The survey results and discussion — Grouped answers by country

The results of the survey are organised in tables. The presentation of the answers created challenges in making the results understandable for readers. The survey revealed missing information from the respondents, and for the improvement of quality of the results, a new round of e-mailing questions to selected partners was performed. In order to facilitate the review, the results of up to five neighbouring countries were grouped in two tables. In the first table the country's legislation on ionising radiation metrology and the use of radiation is presented. The references to acts, regulations and web pages given in the survey were hyperlinked as footnotes on the same page.

In the second table the survey results on question no 11, regulations on the twelve radiation areas, question no 14 on the twelve calibration areas where the country has national standards and country facts, data on infrastructure and use of radiation are shown. The relevant information were made available for each country:

- Population. Information gathered from European Union. About the EU. Living in EU. Size and population [9,10].
- Total electricity generation and Share nuclear in electricity production found in Worldometers. Elaboration of data by United Nations, Department of Economic and Social Affairs, Population Division [11].
- Teletherapy radiotherapy units and present access to radiotherapy collected from Radiotherapy infrastructure and human resources in Europe [12]. Reported data was from 2012.
- Mean effective doses from X-ray procedures (Table 5.16) and Number of CT procedures (Table 5.4) reported in 2015 by European Commission in Medical Radiation Exposure of the European Population, Radiation Protection No 180 [13].

In the country facts, the numbers come from the references even if other information was available. The nine country groups contain the following countries:

1. Central Europe – North: Austria, Czech, Germany, Poland, Switzerland
2. The North: Denmark, Finland, Iceland, Norway, Sweden
3. Europe South – West: Italy, Malta, Portugal, Spain
4. Europe Central – West: Belgium, France, Luxembourg, Netherlands
5. Central Europe South – East: Bosnia and Herzegovina, Croatia, Serbia, Slovenia, Montenegro
6. Europe South – East: Albania, Greece, FYR Macedonia, Turkey
7. Central Europe – East: Bulgaria, Hungary, Romania, Slovakia
8. The Baltic: Estonia, Latvia, Lithuania
9. The Europe North – West: United kingdom, Ireland

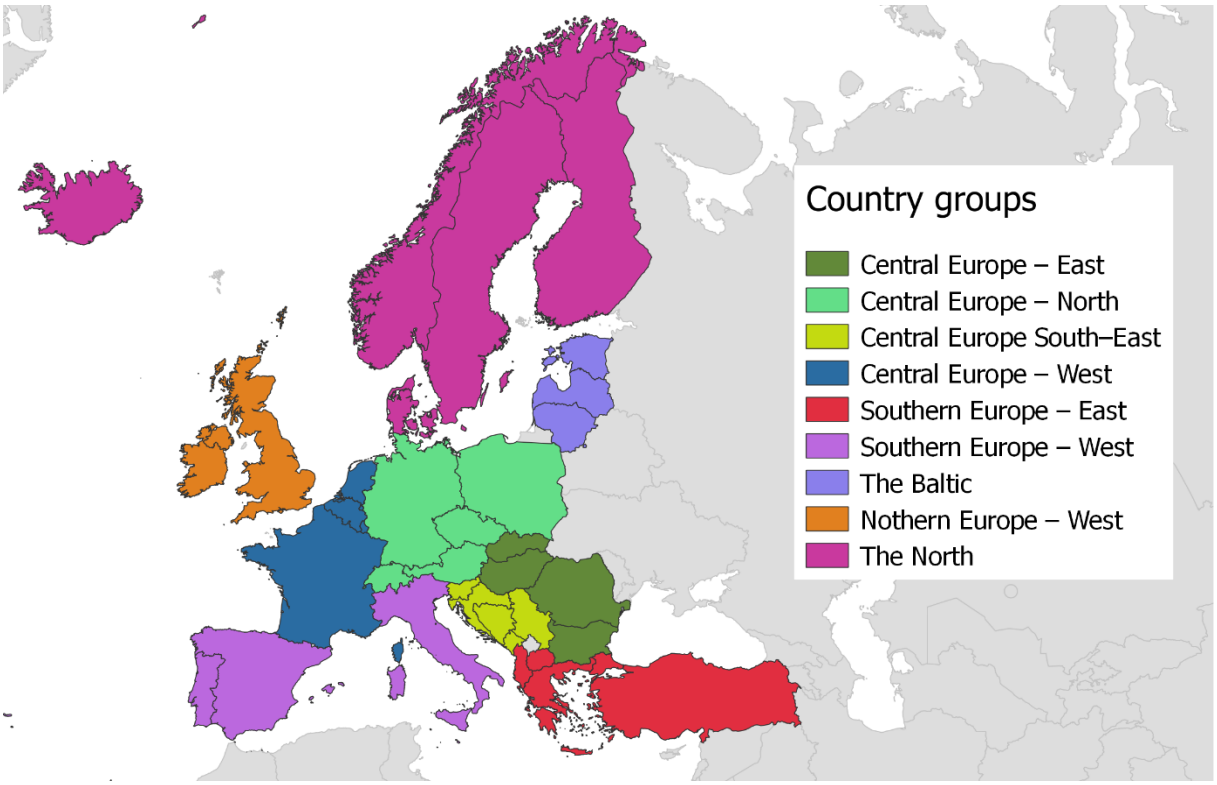

Figure 3 The European Country groups

Country Group 1 Central Europe - North

Country	Austria	Czech	Germany	Poland	Switzerland
Part I					
3 Does your country have legal regulations of the derived SI-units gray (Gy), sievert (Sv) and becquerel (Bq)?	Yes	Yes Gy, Bq	Yes	Yes	Yes
5 Text of the regulations in English?	No[1]	Yes[2]	Yes[3]	No[4]	Yes[5]
6 Does your org. have a laboratory responsible for keeping and maintaining national standards for ionising radiation units in your country?	Yes BEV	Yes CMI	Yes PTB	Yes GUM	Yes METAS (Gy)
7 If there is other responsible laboratory in your country, please specify.	No	No	No	Yes POL-ATOM	Yes Bq: IRA, CHUV, Sv: PSI, ETHZ
8 Responsible to disseminate the units in ionising radiation of your country?	Yes	Yes	Yes	Yes	Yes Gy
Part II					
9 Does your country have legal requirements on traceability (calibration and/or verification of measurements) in your legislation about radiation protection, radiation use and nuclear activities?	Ref[6]	Ref[7]	Ref[8]	Ref[9]	Ref[10]

[1] Metrology act and related ordinances Mass- und Eichgesetz BGBl. I Nr. 148/2015 Eichzulassungsverordnung BGBl. II Nr. 31/2016

[2] Act on metrology 505/1990 Coll. issued 1990 (as amended) decree 264/2000 Coll. issued 2000 (as amended)

[3] Gesetz über die Einheiten im Messwesen und die Zeitbestimmung Law on Units and Time 31.08.2015 Atomgesetz Atomic Energy Act 20.11.2015 only informative english version

[4] Prawo o miarach/Law on Measures 1069 25/05/2016 w sprawie legalnych jednostek miar 1638 30/11/2006

[5] Strahlenschutzgesetz SR 814.50 22. März 1991. Strahlenschutzverordnung No. SR 814.501 22. Juni 1994 . Messmittelverordnung SR 941.210 15. Februar 2006. Verordnung des EJPD über Messmittel für ionisierende Strahlung SR 941.210.5 7. Dezember 2012(English version only informative).

[6] Strahlenschutz-EU-Anpassungsgesetz 2004 BGBl. I Nr. 137/2004

[7] Decree 345/2002 Coll. issued 2002 (as amended)

[8] Strahlenschutzvorsorgegesetz Precautionary Radiation Protection Act 31.08.2015 Strahlenschutzverordnung Radiation Protection Ordinance 27.04.2016 Röntgenverordnung X-ray Ordinance 11.12.2014 Gesetz über das Inverkehrbringen und die Bereitstellung von Messgeräten auf dem Markt, ihre Verwendung und Eichung sowie über Fertigpackungen (Mess- und Eichgesetz - MessEG) Weights and Measures Act 11.04.2016 Verordnung über das Inverkehrbringen und die Bereitstellung von Messgeräten auf dem Markt sowie über ihre Verwendung und Eichung (Mess- und Eichverordnung - MessEV) Measures and Verification Ordinance 11.12.2014

[9] REGULATION BY THE MINISTER OF HEALTH Dz. U. nr 51 poz. 265, 18 February 2011. On the terms for safety application of the ionizing radiation for all kind of medical exposure ACT OF PARLIAMENT Dz. U. poz. 264 13 March 2012. on the Atomic Law REGULATION OF THE COUNCIL OF MINISTERS Dz. U. nr 20, poz. 168, 18 January 2005 Prawo atomowe/The Atomic Law Act 42/276 (number/item) 29/11/2000.

[10] Radiological Protection Ordinance SR 814.501 22 June 1994.

Country cont.	Austria	Czech	Germany	Poland	Switzerland
11 *Please mark relevant radiation areas that have legal regulations*					
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X	X	X	X	X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X	X	X	X	X
c) Activity measurements for nuclear medicine	X	X	X	X	X
d) Radiation measurements involved in individual monitoring of workers	X	X	X	X	X
e) Radiation measurements involved in monitoring of members of the public	X		X	X	X
f) Measurements of radon concentration in air	X	X	X	X	X
g) Radiation dosimetry for early warning networks	X		X	X	X
h) Environmental activity measurements	X		X	X	X
i) Activity measurements of waste	X	X	X	X	X
j) Neutron measurements involved in individual monitoring of workers		X	X	X	X
k) Dosimetry in type testing of equipment	X	X	X	X	X
l) Activity measurements in type testing of equipment and radiopharmaceuticals.	X	X	X	X	X
14 *Mark the calibration areas where your country has national standards*					
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X	X	X	X	X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X	X	X	X	X
c) Activity measurements for nuclear medicine	X	X	X	X	X
d) Radiation measurements involved in individual monitoring of workers	X	X	X	X	X
e) Radiation measurements involved in monitoring of members of the public	X	X	X	X	X
f) Measurements of radon concentration in air	X	X	X	X	X
g) Radiation dosimetry for early warning networks	X	X	X	X	X
h) Environmental activity measurements	X	X	X	X	X
i) Activity measurements of waste	X	X	X	X	X
j) Neutron measurements involved in individual monitoring of workers		X	X	X	X
k) Dosimetry for type testing of equipment	X	X	X	X	X
l) *Activity measurements for type testing of equipment*	X	X	X	X	X
Country facts, data on infrastructure and use of radiation from EU, Worldometers, IEA, EC and KSA-KSB					
Population, 1000 inhabitants	8585	10538	81174	38006	7996
Total electricity generation, TWh/y	64.54	86.16	627.37	164	68.81
Share nuclear in electricity production, per cent	0	36	16	0	38
Teletherapy radiotherapy units, TRT per mill. inhabitants	5.59	5.5	6.41	2.93	8.43
Access to radiotherapy in 2012, per cent	82	72	78	53	113
Mean effective doses from x-ray procedures, mSv/y	0.85	0.99	1.67	0.93	1.18
Number of CT procedures per 1000 inhabitants	63	87	105	44	89

Country Group 2 The North

Country	Denmark	Finland	Iceland	Norway	Sweden
Part I					
3 Does your country have legal regulations of the derived SI-units gray (Gy), sievert (Sv) and becquerel (Bq)?	No	Yes Sv, Gy, Bq	Yes	Yes Sv, Gy, Bq	Yes Sv, Gy, Bq
5 Text of the regulations in English?	No data	Yes[1]	No data	Yes[2]	partly
6 Does your org. have a laboratory responsible for keeping and maintaining national standards for ionising radiation units in your country?	No	Yes	Yes	Yes	Yes (Sv, Gy) SSM
7 If there is other responsible laboratory in your country, please specify.	DTU, SIS	STUK	GR	NRPA	No
8 Responsible to disseminate the units in ionising radiation of your country?	Yes	Yes	No	Yes	Yes
Part II					
9 Does your country have legal requirements on traceability (calibration and/or verification of measurements) in your legislation about radiation protection, radiation use and nuclear activities?	Ref[3]	Ref[4]		Ref[5]	Ref[6]

[1] Act on measurement units and system for standards 496/2006 2.06. 2006 Decree on change on degree for measurement units 130/2010 25.02.2010 http://www.finlex.fi http://www.stuk.fi/julkaisut_maaraykset/viranomaisohjeet/en_GB/stohjeet/

[2] Act on measurement units, measurements and standard time.

[3] Lov om brugen af røntgenstråler m.v., jf. lovbekendtgørelse nr 1170 af 29/11/2011. Lov om brug m.v. af radioaktive stoffer, nr 94 af 31/03/1953. Bekendtgørelse om røntgenterapiapparater til patientbehandling, nr 765 af 06/10/1999. Bekendtgørelse om elektronacceleratorer til patientbehandling med energier fra 1 MeV til og med 50 MeV, nr 48 af 25/01/1999. Bekendtgørelse om medicinske røntgenanlæg til undersøgelse af patienter, nr 975 af 16/12/1998. Bekendtgørelse om anvendelse af åbne radioaktive kilder på sygehuse, laboratorier m.v. nr 954 af 23/10/2000. Bekendtgørelse om lukkede radioaktive kilder, nr 985 af 11/07/2007. Bekendtgørelse om dosisgrænser for ioniserende stråling, nr 823 af 31/10/1997.

[4] Radiation Act 592/1991 27. March,1991 Regulatory Guides on Radiation Safety-STUK Guide S.T. 1.9. 17, March, 2008 Decree of the Ministry of Social Affairs and Health on the medical use of radiation 423/2000 10, May, 2000 Radiation Practices and Radiation Measurements/STUK Guide S.T. 1.9. 17, March, 2008 Nuclear Energy Decree 161/1988 12, Feb., 1988 Regulatory Guide on Nuclear Safety-STUK Guide YVL C.6. 15, Nov., 2013

[5] Act on Radiation Protection and Use of Radiation (No. 36 of May 2000), Forskrift om strålevern og bruk av stråling (strålevernforskriften) (FOR-2010-10-29-1380),

[6] Strålsäkerhetsmyndighetens föreskrifter om SSMFS 2008:33.

Country cont.	**Denmark**	**Finland**	**Iceland**	**Norway**	**Sweden**
11 ***Please mark relevant radiation areas that have legal regulations***					
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X	X		X	X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X	X		X	X
c) Activity measurements for nuclear medicine	X	X		X	X
d) Radiation measurements involved in individual monitoring of workers	X	X			X
e) Radiation measurements involved in monitoring of members of the public		X			X
f) Measurements of radon concentration in air		X			X
g) Radiation dosimetry for early warning networks		X			
h) Environmental activity measurements		X			X
i) Activity measurements of waste		X			X
j) Neutron measurements involved in individual monitoring of workers		X			X
k) Dosimetry in type testing of equipment					
l) Activity measurements in type testing of equipment and radiopharmaceuticals.					
14 ***Mark the calibration areas where your country has national standards***					
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X	X		X	X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X	X		X	X
c) Activity measurements for nuclear medicine	X				
d) Radiation measurements involved in individual monitoring of workers	X	X		X	X
e) Radiation measurements involved in monitoring of members of the public	X	X		X	X
f) Measurements of radon concentration in air		X			
g) Radiation dosimetry for early warning networks		X			
h) Environmental activity measurements		X			
i) Activity measurements of waste		X			
j) Neutron measurements involved in individual monitoring of workers					
k) Dosimetry for type testing of equipment					
l) *Activity measurements for type testing of equipment*					
Country facts, data on infrastructure and use of radiation from EU, Worldometers, IEA, EC and KSA-KSB					
Population, 1000 inhabitants	5660	5472	332	5272	9747
Total electricity generation, TWh/y	34.75	71.25	18.12	133.7	153.03
Share nuclear in electricity production, per cent	0	33	0	0	43
Teletherapy radiotherapy units, TRT per mill. inhabitants	10.45	8.38	6.29	8.38	7.99
Access to radiotherapy in 2012, per cent	116	114	99	105	107
Mean effective doses from x-ray procedures, mSv/y	0.89	0.45	1.70	1.25	0.77
Number of CT procedures per 1000 inhabitants	77	58	140	133	84

Country Group 3 Europe South - West

Country	Italy	Malta	Portugal	Spain
Part I				
3 Does your country have legal regulations of the derived SI-units gray (Gy), sievert (Sv) and becquerel (Bq)?	Yes[1] Gy, Sv, Bq	No	Yes[2] Bq, Gy, Sv	Yes[3] Gy, Sv, Bq, C/kg
5 Text of the regulations in English?	No	No data	No	No
6 Does your org. have a laboratory responsible for keeping and maintaining national standards for ionising radiation units in your country?	Yes	No	Yes	Yes
7 If there is other responsible laboratory in your country, please specify.	Yes ENEA		Yes LMRI	Yes CIEMAT
8 Responsible to disseminate the units in ionising radiation of your country?	Yes		Yes	Yes
Part II				
9 Does your country have legal requirements on traceability (calibration and/or verification of measurements) in your legislation about radiation protection, radiation use and nuclear activities?	Ref[4]	Ref	Ref[5]	Ref[6]

[1] Istituzione del sistema nazionale di taratura, No. 273 11/08/1991

[2] Decree law No. 128/2010 2010/12/03

[3] REAL DECRETO (BOE nº 289 02/12/2000)) 1952/2000 December, 1st. 2000 ORDEN ITC (BOE nº 186 05/08/2006) ITC/2581/2006 July, 28th, 2006 REAL DECRETO (BOE nº 77 29/03/1996) 533/1996 March, 15th, 1996.

[4] Attuazione direttive 89/618/Euratom, 90/641/Euratom, 92/3/Euratom e 96/29/Euratom in materia di radiazioni ionizzanti, 2009/71/Euratom in materia di sicurezza nucleare degli impianti nucleari e 2011/70/Euratom in materia di gestione sicura del combustibile esaurito e dei rifiuti radioattivi derivanti da attivita' civili No. 230 17/03/1995. Attuazione della direttiva 97/43/Euratom in materia di protezione sanitaria delle persone contro i pericoli delle radiazioni ionizzanti connesse ad esposizioni mediche No. 187 26/05/2000

[5] Ordinance No. 1106/2009 2009/09/24

[6] Instrucción sobre cualificaciones para obtener el reconocimiento de experto en protección contra las radiaciones ionizantes IS-03 6/11/2002 Real Decreto sobre Reglamento sobre protección sanitaria contra radiaciones ionizantes 783/2001 6/07/2001 Instrucción IS-28, sobre las especificaciones de funcionamiento de instalaciones radiactivas IS-28 22/09/2010 Ley sobre Energía Nuclear 25/1964 29/04/1964 Instrucción por la que se establecen los requisitos de seguridad relativos a contenedores de almacenamiento de combustible gastado IS-20 28/01/2009 Real Decreto sobre instalaciones nucleares y radiactivas 35/2008 18/01/2008

Country cont.	**Italy**	**Malta**	**Portugal**	**Spain**
11 ***Please mark relevant radiation areas that have legal regulations***				
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X		X	X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X		X	X
c) Activity measurements for nuclear medicine	X		X	X
d) Radiation measurements involved in individual monitoring of workers	X		X	X
e) Radiation measurements involved in monitoring of members of the public	X			X
f) Measurements of radon concentration in air	X			X
g) Radiation dosimetry for early warning networks	X			X
h) Environmental activity measurements	X			X
i) Activity measurements of waste	X			X
j) Neutron measurements involved in individual monitoring of workers	X			X
k) Dosimetry in type testing of equipment	X		X	X
l) Activity measurements in type testing of equipment and radiopharmaceuticals.	X			X
14 ***Mark the calibration areas where your country has national standards***				
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X		X	X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X		X	X
c) Activity measurements for nuclear medicine	X			X
d) Radiation measurements involved in individual monitoring of workers	X		X	X
e) Radiation measurements involved in monitoring of members of the public	X		X	X
f) Measurements of radon concentration in air	X			X
g) Radiation dosimetry for early warning networks	X			X
h) Environmental activity measurements	X			X
i) Activity measurements of waste	X			X
j) Neutron measurements involved in individual monitoring of workers	X		X	X
k) Dosimetry for type testing of equipment	X		X	X
l) *Activity measurements for type testing of equipment*	X			X
Country facts, data on infrastructure and use of radiation from EU, Worldometers, IEA, EC and KSA-KSB				
Population, 1000 inhabitants	60796	429	10375	46440
Total electricity generation, TWh/y	287.81	2.25	50.53	279.28
Share nuclear in electricity production, per cent	0	0	0	56
Teletherapy radiotherapy units, TRT per mill. inhabitants	6.68	4.71	4.53	5.2
Access to radiotherapy in 2012, per cent	82	76	70	80
Mean effective doses from x-ray procedures, mSv/y	1.16	0.68	1.17	1.08
Number of CT procedures per 1000 inhabitants	116	52	140	89

Country Group 4 Europe Central - West

Country	Belgium	France	Luxembourg	Netherlands
Part I				
3 Does your country have legal regulations of the derived SI-units gray (Gy), sievert (Sv) and becquerel (Bq)?	No data	Yes	Yes[1] Sv, Bq	Yes[2]
5 Text of the regulations in English?	No data	No data	No	No
6 Does your org. have a laboratory responsible for keeping and maintaining national standards for ionising radiation units in your country?		Yes LNE-LNHB (CEA-LIST)	Yes LNS/SAR	Yes VSL
7 If there is other responsible laboratory in your country, please specify.		No		No
8 Responsible to disseminate the units in ionising radiation of your country?		Yes[3]	No	Yes
Part II				
9 Does your country have legal requirements on traceability (calibration and/or verification of measurements) in your legislation about radiation protection, radiation use and nuclear activities?	Ref[4]	Ref[5]		Yes[6]

[1] Règlement grand-ducal modifié du 14 décembre 2000 concernant la protection de la population contre les dangers résultant des rayonnements ionisants Mémorial A n° 66 06/06/2001

[2] Metrologiewet Stb. 2006 137 2/02/2006 Meeteenhedenbesluit 12/10/2006

[3] For dose equivalent quantities for neutrons LNE/IRSN/CAD

[4] Royal Decree of 20 July 2001 laying down the General Regulation for the protection of public, workers and the environment against the hazards of ionizing radiation, as amended

[5] Directive 2013/59/Euratom (December 5 2013) to be "translated" in French regulation before 2017
Ordonnance 2001-270 du 28 mars 2001 (Assurant la transcription législative des directives)
Code de la santé publique protection générale de la santé (article L1333-1 à L1333-20
Décret 2007-1582 du 7 novembre 2007 protection générale des personnes
Décret 2003-295 du 31 mars 2003 intervention d'urgence R1333-75 à R1333-92
Décret 2003-270 du 24 mars 2003 patients
Décret 2001-1154 du 5 décembre 2001 qualité des dispositifs médicaux D665-5-4
Code du travail livre IV titre V chapitre 1er (article L122-3-17 et L214-22 et L231-7-1)
Décret 2003-296 du 31 mars 2003 et décret 2007-1570 du 5 novembre 2007 protection des travailleurs sous–section « prévention du risque d'exposition aux rayonnements ionisants »

[6] Besluit van 16 juli 2001, houdende vaststelling van het Besluit stralingsbescherming. Staatsblad 2001 397

Country cont.	**Belgium**	**France**	**Luxembourg**	**Netherlands**
11 ***Please mark relevant radiation areas that have legal regulations***				
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X	X		
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X	X		
c) Activity measurements for nuclear medicine	X	X		
d) Radiation measurements involved in individual monitoring of workers	X	X		
e) Radiation measurements involved in monitoring of members of the public	X	X		
f) Measurements of radon concentration in air		X		
g) Radiation dosimetry for early warning networks		X		
h) Environmental activity measurements		X		
i) Activity measurements of waste		X		
j) Neutron measurements involved in individual monitoring of workers	X	X		
k) Dosimetry in type testing of equipment		X		
l) Activity measurements in type testing of equipment and radiopharmaceuticals.		X		
14 ***Mark the calibration areas where your country has national standards***				
a) Measurements involved in determining patient dose and dose distribution in radiotherapy		X		X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention		X		X
c) Activity measurements for nuclear medicine		X		
d) Radiation measurements involved in individual monitoring of workers		X		X
e) Radiation measurements involved in monitoring of members of the public		X		X
f) Measurements of radon concentration in air		X		
g) Radiation dosimetry for early warning networks		X		
h) Environmental activity measurements		X		
i) Activity measurements of waste		X		
j) Neutron measurements involved in individual monitoring of workers		X		
k) Dosimetry for type testing of equipment		X		
l) *Activity measurements for type testing of equipment*		X		
Country facts, data on infrastructure and use of radiation from EU, Worldometers, IEA, EC and KSA-KSB				
Population, 1000 inhabitants	11258	66352	563	16901
Total electricity generation, TWh/y	82.11	567.37	1.85	100.88
Share nuclear in electricity production, per cent	52	75	0	3
Teletherapy radiotherapy units, TRT per mill. inhabitants	8.59	7.64	5.91	7.58
Access to radiotherapy in 2012, per cent	104	94	87	97
Mean effective doses from x-ray procedures, mSv/y	1.96	1.25	1.79	0.63
Number of CT procedures per 1000 inhabitants	164	109	167	65

Country Group 5 Central Europe South - East

Country	Bosnia and Herzegovina	Croatia	Serbia	Slovenia	Montenegro
Part I					
3 Does your country have legal regulations of the derived SI-units gray (Gy), sievert (Sv) and becquerel (Bq)?	Yes[1]	Yes[2] Gy, Sv, Bq	Yes[3]	Yes[4] Gy, Sv, Bq	Yes[5] Gy, Sv, Bq
5 Text of the regulations in English?	No	No data	Yes	Yes	No
6 Does your org. have a laboratory responsible for keeping and maintaining national standards for ionising radiation units in your country?	Yes Gy, Sv	Yes Gy, Sv	No	Yes Gy, Sv	No
7 If there is other responsible laboratory in your country, please specify.	No	Yes HMI/ IRB	Yes[6] NTI	Yes[7] IJS	No
8 Is your NMI/laboratory/organisation responsible to disseminate the units in ionising radiation of your country?	Yes	Yes	Yes	Yes	No
Part II					
9 Does your country have legal requirements on traceability (calibration and/or verification of measurements) in your legislation about radiation protection, radiation use and nuclear activities?	Yes[8]			Yes[9]	Yes[10]

[1] Law on measurement units Bosnia and Herzegovina (Official Gazette B&H No. 19/01)

[2] Regulation on measurement units NN 145/12 18.12.2013.

[3] Law of Metrology Official Gazette of the RS, No. 30/10 2010 Regulation on limits of exposure to ionizing radiation and measurements to assess the level of exposure to ionizing radiation Official Gazette of the RS, No. 86/11 2011. http://www.ats.rs/sites/default/files/download/law_on_metrology_.pdf For rest: www.srbatom.gov.rs

[4] Odredba o merskih enotah) (Off. Gaz. of the RS, No. 26/01 and 109/09) http://www.ursjv.gov.si/en/legislation_and_documents/legislation_in_force/ The units Gy, Sv and Bq are defined and explained in UV2 (Decree on dose limits, radioactive contamination and intervention levels)

[5] Law on Metrology Official Gazete of Montenegro No. 79/08. also Decree on legal units of measurement Official Gazete of Montenegro No. 022/09 od 25.03.2009, 072/15 from 21.12.2015

[6] Gy, Sv, in Vinca Institute of nuclear sciences (They will soon start a process of becoming DI)

[7] http://www.ursjv.gov.si/en/legislation_and_documents/legislation_in_force/

[8] Instruction on measuring instruments in legal metrology. Official Gazette B&H No. 67/12.

[9] Ionising Radiation Protection and Nuclear Safety Act Off. Gaz. of the RS, No. 67/2002 1/10/2002 Rules on the obligations of the person carrying out a radiation practice and person possessing a ionizing radiation source (SV8) Off. Gaz. of the RS, No. 13/2004 27/02/2004 Rules on radioactivity monitoring (JV10) Off. Gaz. of the RS, No. 20/2007 21/03/2007

[10] Law on protection against ionizing radiation and radiation protection Official Gazete of Montenegro No. 56/09 from 14.08.2009, 58/09 from 28.08.2009 stipulates that all radiation practices must perform laboratories that have authorization and the basic requirement for authorization the accreditation of method in accordance with ISO / IEC 17025 standard. Traceability (calibration and / or verification of measurements) are some of the main requirements of ISO / IEC 17025

Country cont.	**Bosnia and Herzegovina**	**Croatia**	**Serbia**	**Slovenia**	**Montenegro**
11 ***Please mark relevant radiation areas that have legal regulations***					
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X	X	X	X	X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X	X	X	X	X
c) Activity measurements for nuclear medicine	X	X		X	X
d) Radiation measurements involved in individual monitoring of workers	X	X	X	X	X
e) Radiation measurements involved in monitoring of members of the public	X	X	X	X	X
f) Measurements of radon concentration in air		X	X	X	X
g) Radiation dosimetry for early warning networks	X	X	X	X	X
h) Environmental activity measurements	X	X	X	X	X
i) Activity measurements of waste	X	X	X	X	X
j) Neutron measurements involved in individual monitoring of workers	X			X	
k) Dosimetry in type testing of equipment	X	X	X		X
l) Activity measurements in type testing of equipment and radiopharmaceuticals.	X				X
14 ***Mark the calibration areas where your country has national standards***					
a) Measurements involved in determining patient dose and dose distribution in radiotherapy		X			
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention				X	
c) Activity measurements for nuclear medicine					
d) Radiation measurements involved in individual monitoring of workers				X	
e) Radiation measurements involved in monitoring of members of the public				X	
f) Measurements of radon concentration in air					
g) Radiation dosimetry for early warning networks				X	
h) Environmental activity measurements					
i) Activity measurements of waste					
j) Neutron measurements involved in individual monitoring of workers					
k) Dosimetry for type testing of equipment					
l) *Activity measurements for type testing of equipment*					
Population, 1000 inhabitants	3802	4225	8813	2063	625
Total electricity generation, TWh/y	17.15	13.33	39.23	15.79	2.87
Share nuclear in electricity production, per cent	0	0	0	34	0
Teletherapy radiotherapy units, TRT per mill. inhabitants	3.12	3.92	1.55	3.89	3.23
Access to radiotherapy in 2012, per cent	87	53	31	50	68
Mean effective doses from x-ray procedures, mSv/y	No info	0.68	0.77	0.63	0.90
Number of CT procedures per 1000 inhabitants	No info	43	51	47	95

Country Group 6 Europe South - East

Country	Albania	Greece	FYR Macedonia	Turkey
Part I				
3 Does your country have legal regulations of the derived SI-units gray (Gy), sievert (Sv) and becquerel (Bq)?	No data	Partly	Yes[1] Gy, Sv, Bq	Yes[2]
5 Text of the regulations in English?	No data	Yes (unofficial translation)[3]	No	Yes
6 Does your org. have a laboratory responsible for keeping and maintaining national standards for ionising radiation units in your country?	Yes Gy, Sv, Bq	Yes Gy, Sv, C/kg, kV, Gy cm, Gy cm^2	Yes* Gy, Sv IPH	Yes
7 If there is other responsible laboratory in your country, please specify.			No	
8 Is your NMI/laboratory/organisation responsible to disseminate the units in ionising radiation of your country?	Yes	Yes	Yes	Yes
Part II				
9 Does your country have legal requirements on traceability (calibration and/or verification of measurements) in your legislation about radiation protection, radiation use and nuclear activities?	Yes[4]	Yes[5]	No	Yes[6]

*Not legal regulated Sept 2016.

[1] Law of metrologu07-2742/1 4/07/2002 Official Gazette of RM No.104 30.08.2007.http://www.bom.gov.mk. Regulation for definitions, names and symbols, area and way use, obligation in use and way of written of legal measuring units. Official gazete of RM No 104/2007

[2] Turkish Atomic Energy Authority Law 2690 13.07.1982 Radiation Protection Decree 24.03.2000/23999 24.03.2000. http://www.taek.gov.tr/en/belgeler-formlar/documents/Regulations/radiation-safety/Radiation-Safety-Decree/

[3] http://eeae.gr/files/nomothesia/Radiation%20Protection%20Regulations_2001.pdf

[4] Radiation Protection Act 1995 Safe use of ionizing radiation 1998

[5] Ionizing Radiation Regulations 1014 - Gazette No 216-B 06-03-2001.

[6] TAEK Law 2690 13.07.1982 Decree on licensing facilities utilizing therapy level ionizing radiation sources 27968 18.06.2011 TAEK Law 2690 13.07.1982 Protection of Employees working in controlled areas against ionizing radiation risks 27968 18.06.2011

Country cont.	**Albania**	**Greece**	**FYR Macedonia**	**Turkey**
11 ***Please mark relevant radiation areas that have legal regulations***				
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X	X	X	X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X	X	X	X
c) Activity measurements for nuclear medicine	X	X	X	X
d) Radiation measurements involved in individual monitoring of workers	X	X	X	X
e) Radiation measurements involved in monitoring of members of the public		X	X	
f) Measurements of radon concentration in air		X		
g) Radiation dosimetry for early warning networks	X		X	
h) Environmental activity measurements	X	X	X	
i) Activity measurements of waste				
j) Neutron measurements involved in individual monitoring of workers				
k) Dosimetry in type testing of equipment	X	X	X	
l) Activity measurements in type testing of equipment and radiopharmaceuticals.			X	
14 ***Mark the calibration areas where your country has national standards***				
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X	X		X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X	X		X
c) Activity measurements for nuclear medicine	X			X
d) Radiation measurements involved in individual monitoring of workers	X	X	X	X
e) Radiation measurements involved in monitoring of members of the public		X		
f) Measurements of radon concentration in air				
g) Radiation dosimetry for early warning networks	X			
h) Environmental activity measurements	X			
i) Activity measurements of waste				
j) Neutron measurements involved in individual monitoring of workers				
k) Dosimetry for type testing of equipment	X	X		
l) *Activity measurements for type testing of equipment*				
Country facts, data on infrastructure and use of radiation from EU, Worldometers, IEA, EC and KSA-KSB				
Population, 1000 inhabitants	2904	9849	2081	79304
Total electricity generation, TWh/y	6.96	57.11	6.09	240.15
Share nuclear in electricity production, per cent	0	0	0	0
Teletherapy radiotherapy units, TRT per mill. inhabitants	2.22	4.32	1.9	No info
Access to radiotherapy in 2012, per cent	71	84	39	-
Mean effective doses from x-ray procedures, mSv/y	0.85	0.95	0.7	-
Number of CT procedures per 1000 inhabitants	63	94	18	-

Country Group 7 Central Europe - East

Country	Bulgaria	Hungary	Romania	Slovakia
Part I				
3 Does your country have legal regulations of the derived SI-units gray (Gy), sievert (Sv) and becquerel (Bq)?	Yes[1] Gy, Sv	Yes[2] Gy, Sv, Bq	Yes[3] Gy, Sv, Bq	Yes[4] Gy, Sv, Bq
5 Text of the regulations in English?	No	No data	No data	No data
6 Does your org. have a laboratory responsible for keeping and maintaining national standards for ionising radiation units in your country?	Yes[5] Gy, Sv, Bq	Yes	Yes Gy, Sv, Bq	Yes Gy, Sv, Bq
7 If there is other responsible laboratory in your country, please specify.	Yes NCRRP		Yes IFIN-HH	
8 Is your NMI/laboratory/organisation responsible to disseminate the units in ionising radiation of your country?	Yes	Yes	Yes	Yes
Part II				
9 Does your country have legal requirements on traceability (calibration and/or verification of measurements) in your legislation about radiation protection, radiation use and nuclear activities?		Yes[6]	Yes[7]*	Yes[8]

*Regulations under revision

[1] Regulation for measurement units authorized for use in the Republic of Bulgaria 29.01.2010

[2] Act on metrology XLV 1991.

[3] Government Decision (HG) 755 26.06.2004.

[4] Act on metrology and on change and amendment of some Acts as amended 142/2000 17 March 2000 Decree of the Slovak Office of Standards, Metrology and Testing on legal measuring units 206/2000 16 June 2000.

[5] Low on measurements 09.11.2002.

[6] Decree of the Minister of Health on the execution of certain provisions of the Act CXVI of 1996 on Atomic Energy associated with radiation protection 16/2000. (VI. 8.) 2000 Governmental Decree on the monitoring of radiation levels and radioactivity concentrations in Hungary 275/2002. (XII. 21.) 2002 Decree of the Minister of Environment Protection 15/2001. (VI. 6.) on the radioactive releases into the air and into the water in connection with the application of atomic energy, and on their control 15/2001. (VI. 6.) 2001 Governmental Decree on radioactive materials as well as equipment generating ionising radiation, exempted from the scope of the Atomic Energy Act CXVI of 1996 124/1997. (VII. 18.) 1997

[7] Law no. 11/1996 on the safe deployment, regulation, authorisation and control of nuclear activities. Fundamental norms for radiological safety. Order no. 14/24.01.2000. Norms of safety on diagnostic and interventional radiology practices. Order no. 173/2003. Norms on individual dosimetry. Order no. 180/2002.

[8] Act on metrology and on change and amendment of some Acts as amended 142/2000 16 June 2000 Decree of the Slovak Office of Standards, Metrology and Testing No. 210/2000 Coll. on measuring instruments and metrological control as amended 210/2000 16 June 2000 Act on technical requirements for products and on conformity assessment and on amendment of some acts in the wording 264/1999 7 September 1999

Country cont.	**Bulgaria**	**Hungary**	**Romania***	**Slovakia**
11 ***Please mark relevant radiation areas that have legal regulations***				
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X		X	X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X	X	X	X
c) Activity measurements for nuclear medicine			X	X
d) Radiation measurements involved in individual monitoring of workers	X	X	X	X
e) Radiation measurements involved in monitoring of members of the public	X		X	X
f) Measurements of radon concentration in air			X	X
g) Radiation dosimetry for early warning networks	X	X	X	X
h) Environmental activity measurements	X	X	X	X
i) Activity measurements of waste	X	X	X	X
j) Neutron measurements involved in individual monitoring of workers	X	X	X	X
k) Dosimetry in type testing of equipment	X	X	X	X
l) Activity measurements in type testing of equipment and radiopharmaceuticals.	X	X		X
14 ***Mark the calibration areas where your country has national standards***				
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X	X		X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention		X		
c) Activity measurements for nuclear medicine		X		X
d) Radiation measurements involved in individual monitoring of workers	X	X		X
e) Radiation measurements involved in monitoring of members of the public	X			
f) Measurements of radon concentration in air				
g) Radiation dosimetry for early warning networks		X		X
h) Environmental activity measurements	X	X	X	X
i) Activity measurements of waste	X	X		X
j) Neutron measurements involved in individual monitoring of workers				X
k) Dosimetry for type testing of equipment	X	X	X	X
l) *Activity measurements for type testing of equipment*	X	X		X
Country facts, data on infrastructure and use of radiation from EU, Worldometers, IEA, EC and KSA-KSB				
Population, 1000 inhabitants	7202	9849	19861	5421
Total electricity generation, TWh/y	43.07	30.27	58.54	28.51
Share nuclear in electricity production, per cent	33	51	20	55
Teletherapy radiotherapy units, TRT per mill. inhabitants	2.03	3.3	1.56	4.97
Access to radiotherapy in 2012, per cent	34	47	31	81
Mean effective doses from x-ray procedures, mSv/y	0.41	1.78	0.34	0.76
Number of CT procedures per 1000 inhabitants	33	98	27	61

* Not regulated at November 2016, but new regulations under development.

Country Group 8 The Baltic

Country	Estonia	Latvia	Lithuania
Part I			
3 Does your country have legal regulations of the derived SI-units gray (Gy), sievert (Sv) and becquerel (Bq)?	No	Yes Gy, Sv, Bq	No
5 Text of the regulations in English?	No data	No	No data
6 Does your org. have a laboratory responsible for keeping and maintaining national standards for ionising radiation units in your country?			Yes Bq
7 If there is other responsible laboratory in your country, please specify.	Yes	No	No
8 Is your NMI/laboratory/organisation responsible to disseminate the units in ionising radiation of your country?	No	Yes Gy, Sv	Yes
Part II			
9 Does your country have legal requirements on traceability (calibration and/or verification of measurements) in your legislation about radiation protection, radiation use and nuclear activities?	Yes[1]	Yes[2]	Yes

[1] Radiation Act RT I 2004, 26, 173 01/05/2004 Occupational Health and Safety Act RT I 1999, 60, 616 26/07/1999 Medical Devices Act RT I 2004, 75, 520 1/12/2004

[2] The regulation for radiation protection in medicine exposure 97 05/03/2002 The regulations for protection against ionizing radiation 149 09/04/2002 The control and account of exposure for workers 454 21/10/2001

Country cont.	**Estonia**	**Latvia**	**Lithuania**
11 ***Please mark relevant radiation areas that have legal regulations***			
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X	X	X
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X	X	X
c) Activity measurements for nuclear medicine		X	X
d) Radiation measurements involved in individual monitoring of workers	X	X	X
e) Radiation measurements involved in monitoring of members of the public		X	X
f) Measurements of radon concentration in air	X	X	
g) Radiation dosimetry for early warning networks			
h) Environmental activity measurements	X	X	X
i) Activity measurements of waste	X	X	X
j) Neutron measurements involved in individual monitoring of workers		X	X
k) Dosimetry in type testing of equipment			
l) Activity measurements in type testing of equipment and radiopharmaceuticals.			
14 ***Mark the calibration areas where your country has national standards***			
a) Measurements involved in determining patient dose and dose distribution in radiotherapy			
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention			
c) Activity measurements for nuclear medicine			
d) Radiation measurements involved in individual monitoring of workers			
e) Radiation measurements involved in monitoring of members of the public			
f) Measurements of radon concentration in air			
g) Radiation dosimetry for early warning networks			
h) Environmental activity measurements			
i) Activity measurements of waste			
j) Neutron measurements involved in individual monitoring of workers			
k) Dosimetry for type testing of equipment			
l) *Activity measurements for type testing of equipment*			
Country facts, data on infrastructure and use of radiation from EU, Worldometers, IEA, EC and KSA-KSB			
Population, 1000 inhabitants	1313	1986	2921
Total electricity generation, TWh/y	13.28	6.21	4.21
Share nuclear in electricity production, per cent	0	0	0
Teletherapy radiotherapy units, TRT per mill. inhabitants	3.85	5.26	5.54
Access to radiotherapy in 2012, per cent	59	77	84
Mean effective doses from x-ray procedures, mSv/y	1.43	0.89	0.92
Number of CT procedures per 1000 inhabitants	143	-	51

Country Group 9 The Europe North - West

Country	United kingdom	Ireland
Part I		
3 Does your country have legal regulations of the derived SI-units gray (Gy), sievert (Sv) and becquerel (Bq)?	Yes[1]	No
5 Text of the regulations in English?	Yes	
6 Does your org. have a laboratory responsible for keeping and maintaining national standards for ionising radiation units in your country?	Yes	No
7 If there is other responsible laboratory in your country, please specify.		(RPII)
8 Is your NMI/laboratory/organisation responsible to disseminate the units in ionising radiation of your country?	Yes	No
Part II		
9 Does your country have legal requirements on traceability (calibration and/or verification of measurements) in your legislation about radiation protection, radiation use and nuclear activities?	Ref[2]	Ref[3]

[1] Radioactive Substances Act No 12 1993

[2] The ionising radiations regulations no. 3232 1999 The Ionising Radiation (Medical Exposure) Regulations no. 1059 2000 Radiation (Emergency Preparedness and Public Information) Regulations 2001. Health and Safety Executive: Work with ionising radiation. Approved Code of Practice and guidance 2012.

[3] Radiological Protection Act 9 1991 Statutory Instrument 125 2000 Radiological Protection Act 9 1991 Statutory Instrument 152 2012

Country cont.	United Kingdom	Ireland
11 *Please mark relevant radiation areas that have legal regulations*		
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X	
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention	X	
c) Activity measurements for nuclear medicine	X	
d) Radiation measurements involved in individual monitoring of workers	X	X
e) Radiation measurements involved in monitoring of members of the public	X	
f) Measurements of radon concentration in air	X	X
g) Radiation dosimetry for early warning networks	X	
h) Environmental activity measurements	X	X
i) Activity measurements of waste	X	
j) Neutron measurements involved in individual monitoring of workers	X	X
k) Dosimetry in type testing of equipment	X	
l) Activity measurements in type testing of equipment and radiopharmaceuticals.	X	
14 *Mark the calibration areas where your country has national standards*		
a) Measurements involved in determining patient dose and dose distribution in radiotherapy	X	
b) Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention		
c) Activity measurements for nuclear medicine	X	
d) Radiation measurements involved in individual monitoring of workers		
e) Radiation measurements involved in monitoring of members of the public		
f) Measurements of radon concentration in air		
g) Radiation dosimetry for early warning networks		
h) Environmental activity measurements	X	
i) Activity measurements of waste	X	
j) Neutron measurements involved in individual monitoring of workers	X	
k) Dosimetry for type testing of equipment	X	
l) *Activity measurements for type testing of equipment*	X	
Country facts, data on infrastructure and use of radiation from EU, Worldometers, IEA, EC and KSA-KSB		
Population, 1000 inhabitants	64767	4626
Total electricity generation, TWh/y	356.26	25.78
Share nuclear in electricity production, per cent	20	0
Teletherapy radiotherapy units, TRT per mill. inhabitants	5.11	5.82
Access to radiotherapy in 2012, per cent	70	90
Mean effective doses from x-ray procedures, mSv/y	0.39	0.83
Number of CT procedures per 1000 inhabitants	48	59

8.2 Tables showing all countries together

All results from the 9 country groups are summarised in *Table 1* and *Table 2*.

Table 1 Question 11. The calibration areas where the country have regulations for traceability

Country	Dosimetry in RT	Dosimetry in X-ray diagnostic	Activity in NM	Personal dosimetry	Public dosimetry	Radon in air	Early warning	Environmental activity	Activity in waste	Personal neutron dosimetry	Dosimetry for type testing	Activity for type testing
Albania	x	x	x	x			x	x			x	
Austria	x	x	x	x	x	x	x	x	x		x	x
Belgium	x	x	x	x	x					x		
Bosnia & Herzegovina	x	x	x	x	x		x	x	x	x	x	x
Bulgaria	x	x		x	x		x	x	x	x	x	x
Croatia	x	x	x	x	x	x	x	x	x		x	
Czech Republic	x	x	x	x		x			x	x	x	x
Denmark	x	x	x	x								
Estonia	x	x		x		x		x	x			
Finland	x	x	x	x	x	x	x	x	x	x		
France	x	x	x	x	x	x	x	x	x	x	x	x
Germany	x	x	x	x	x	x	x	x	x	x	x	x
Greece	x	x	x	x	x	x		X			x	
Hungary		x		x			x	x	x	x	x	x
Iceland												
Ireland				x		x		x		x		
Italy	x	x	x	x	x	x	x	x	x	x	x	x
Latvia	x	x	x	x	x	x		x	x	x		
Lithuania	x	x	x	x	x			x	x	x		
Luxembourg												
Macedonia, FYR	x	x	x	x	x		x	x			x	x
Malta												
Montenegro	x	x	x	x	x	x	x	x	x		x	x
Netherlands				x						x		
Norway	x	x	x									
Poland	x	x	x	x	x	x	x	x	x	x	x	x
Portugal	x	x	x	x							x	
Romania	x	x	x	x	x	x	x	x	x	x	x	
Serbia	x	x		x	x	x	x	x	x		x	
Slovakia	x	x	x	x	x	x	x	x	x	x	x	x
Slovenia	x	x	x	x	x	x	x	x	x	x		
Spain	x	x	x	x	x	x	x	x	x	x	x	x
Sweden	x	x	x	x	x	x	x	x	x	x		
Switzerland	x	x	x	x	x	x	x	x	x	x	x	x
Turkey	x	x	x	x								
United Kingdom	X	x	x	x	x	x	x	x	x	x	x	x
Total (36)	30	31	27	32	23	21	21	26	23	21	21	15
Percentage / %	83	86	75	89	64	58	58	72	64	58	58	42

Table 2 Question 14. The calibration areas where the country have national standards

Country	Dosimetry in RT	Dosimetry in X-ray diagnostic	Activity in NM	Personal dosimetry	Public dosimetry	Radon in air	Early warning	Environmental activity	Activity in waste	Personal neutron dosimetry	Dosimetry for type testing	Activity for type testing
Albania	x	x	x	x			x	x			x	
Austria	x	x	x	x	x	x	x	x	x		x	x
Belgium												
Bosnia & Herzegovina												
Bulgaria	x			x	x			x	x		x	x
Croatia	x											
Czech Republic	x	x	x	x	x	x	x	x	x	x	x	x
Denmark	x	x	x	x	x							
Estonia												
Finland	x	x		x	x	x	x	x	x			
France	x	x	x	x	x	x	x	x	x	x	x	x
Germany	x	x	x	x	x	x	x	x	x	x	x	x
Greece	x	x		x	x						x	
Hungary	x	x	x	x			x	x	x		x	x
Iceland												
Ireland												
Italy	x	x	x	x	x	x	x	x	x	x	x	x
Latvia												
Lithuania												
Luxembourg												
Macedonia, FYR				x								
Malta												
Montenegro												
Netherlands	x	x		x	x							
Norway	x	x		x	x							
Poland	x	x	x	x	x	x	x	x	x	x	x	x
Portugal	x	x		x	x					x	x	
Romania								x			x	
Serbia												
Slovakia	x		x	x			x	x	x	x	x	x
Slovenia		x		x	x		x					
Spain	x	x	x	x	x	x	x	x	x	x	x	x
Sweden	x	x		x	x							
Switzerland	x	x	x	x	x	x	x	x	x	x	x	x
Turkey	x	x	x	x								
United Kingdom	x		x					x	x	x	x	x
Total (36)	22	19	14	22	17	9	13	15	13	10	16	12
Percentage / %	61	53	39	61	47	25	36	42	36	28	44	33

8.3 The respondent's opinion.

In the last question of the questionnaire, the respondent was asked to give the opinion on legal requirements for the traceability of IR measurements. The answers, as shown on Figure 4, present the necessity of having legal requirements on traceable measurements in most of the areas listed with the lowest score of "yes" at the area of "radon in air" measurements and the highest at the area of "dosimetry in X-ray diagnostic and intervention" measurements. Find blow the percentages of answers "yes" or "no" for question about the necessity of having legal requirements on traceable measurements in the respondent's country.

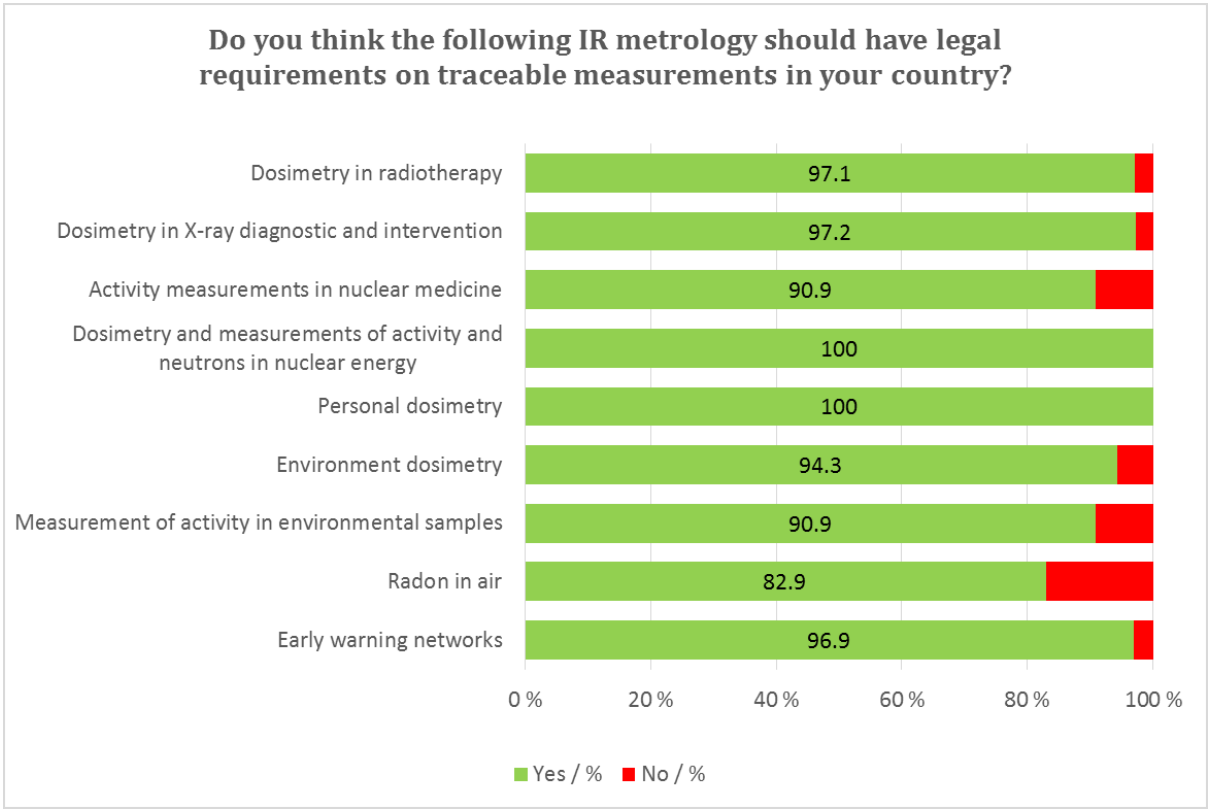

Figure 4 Percentage respondent's opinion about legal regulations

9 Evaluation of the results

We leave to the reader the opportunity to evaluate county's regulations of national IR standards against international recommendations and/or requirements. Our focus was on the collection of facts about infrastructure of radiation and how governments and scientists in IR metrology facilitate and prioritise national calibration service. Facts on use of ionising radiation in the country group tables enable evaluation of infrastructure of radiation use in each country. Facts of three type of uses supply the evaluation of the results from the survey; the share percentage nuclear in electricity production, percentage access to radiotherapy and mean effective dose from x-ray procedures. A reproduction of a European radon map also give background facts.

In 1976, the International Atomic Energy Agency (IAEA) together with the World Health Organization (WHO) established a Network of Secondary Standards Dosimetry Laboratories (SSDLs), known as the IAEA/WHO SSDL Network. This Network, through SSDLs designated by IAEA Member States, provides direct linkage of dosimetry standards to standards at the BIPM and at Primary Standards Dosimetry Laboratories (PSDLs). It includes 80 (29 in Europe) laboratories and 15 (9 in Europe) affiliated members (PSDLs). The Network has proved to be an effective framework for metrology of ionising radiation as reported in the SSDL Newsletter [20] and it facilitates an important network for the dosimetry infrastructure in Europe, as can be seen from this survey.

On Figure 4 the results of the respondents' opinion about legal requirements on traceability can be found. All state that personal dosimetry should have legal regulations of traceability. All responded that there should be regulations on dosimetry and measurements of the gamma and beta activities and neutrons in nuclear energy. For dosimetry in radiotherapy, x-ray diagnostic/intervention and early warning networks, 97 % of the respondents marked *yes* for legal regulations of traceability, 91 % marked *yes* for activity measurements for nuclear medicine and for environmental samples, while only 83 % marked *yes* for legal regulations on measurements of radon in air. There is a noticeable higher score from the respondents' opinion than from the reported situation in the countries for these topics. One could say that there is a space and need for more regulations when you asking people working in the field of ionising radiation metrology.

In the following chapters, we present the evaluation of the results from the survey questionnaire in topics' chapters containing small discussions and maps in different colours depending on country's answers. A grey colour on a country means no data form the respondents, or no regulation and no national standard in the country.

Data for the maps are taken from Table 1 and 2. The total number and percentage of countries having regulation of traceability or national standard are taken from the last two rows in the tables.

9.1 Regulation of the ionising radiation units Gy, Sv and Bq?

The survey results revealed that 72 % of the 36 European countries have in their metrology regulations covered the ionising radiation (IR) units gray (Gy), sievert (Sv) and becquerel (Bq). Respondents from 10 of the 36 countries could not find a regulation of IR metrology. Among these 10 countries without regulations for ionising radiation units are 6 countries that are not so populated and two with high and medium high population. The details are on Figure 5.

In many countries the users of radiation in radiotherapy, x-ray diagnostics and intervention, nuclear medicine and nuclear power plants have to go abroad for calibrations. The consequence of no governmental regulation of the ionising units is that the radiation protection is less national organised and competence among the users is more scattered. A user usually has less resources and scientific network for maintenance of reference instruments, and additionally international metrology network is not available because it is only accessible by national metrology or designated institutions. Many European ionising radiation user communities are lacking easy access to calibrations because of missing ionising metrology regulations. In the ionising radiation, risk assessment is directly linked to dose measurements and its uncertainty, and the consequence of increased uncertainty in dose assessments will be higher risk in the use of ionising radiation.

75 % of the countries (28 of 36 on Figure 6) reported to have a type of national standards for the three IR units. 28 countries have a national laboratory responsible for the dissemination of IR units. Some countries have national standards even if there is no governmental regulations. Smaller countries usually have fewer types of national standards available in the whole area of IR calibrations. Detailed information from the survey is displayed in the tables of the country groups.

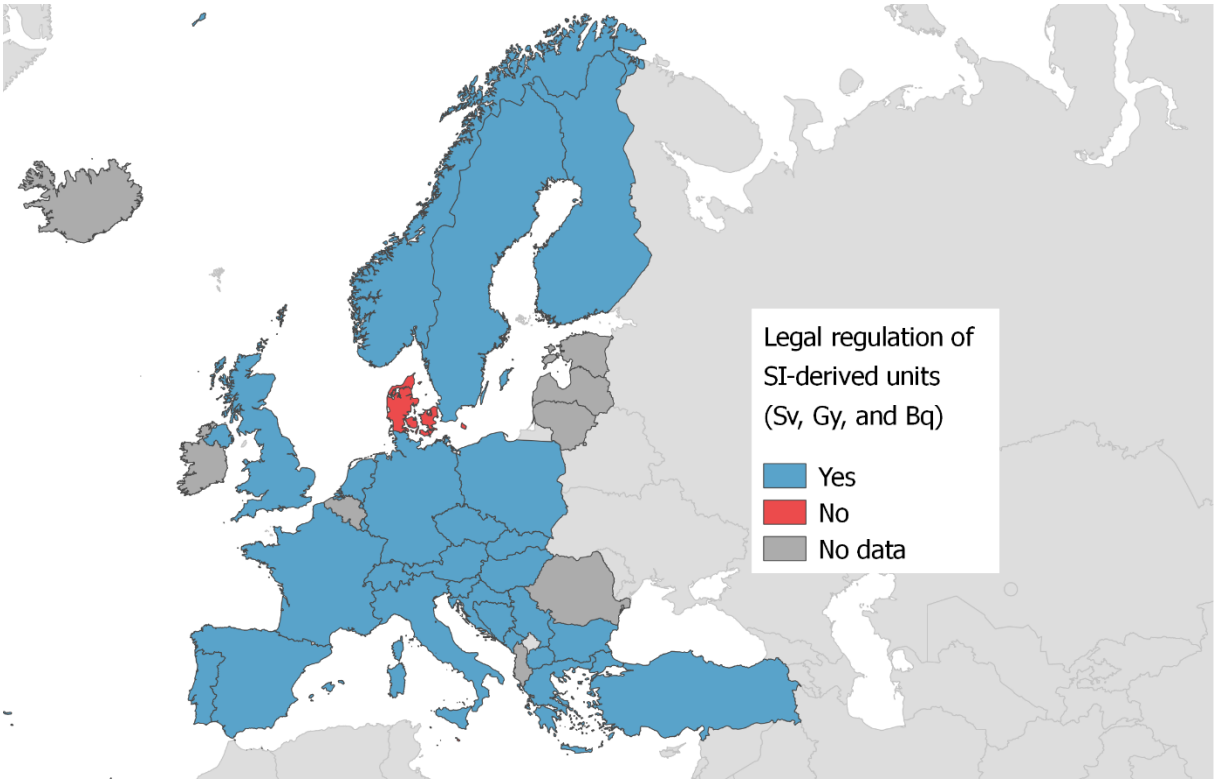

Figure 5 European countries having regulated use of the derived SI-units, gray, sievert and becquerel.

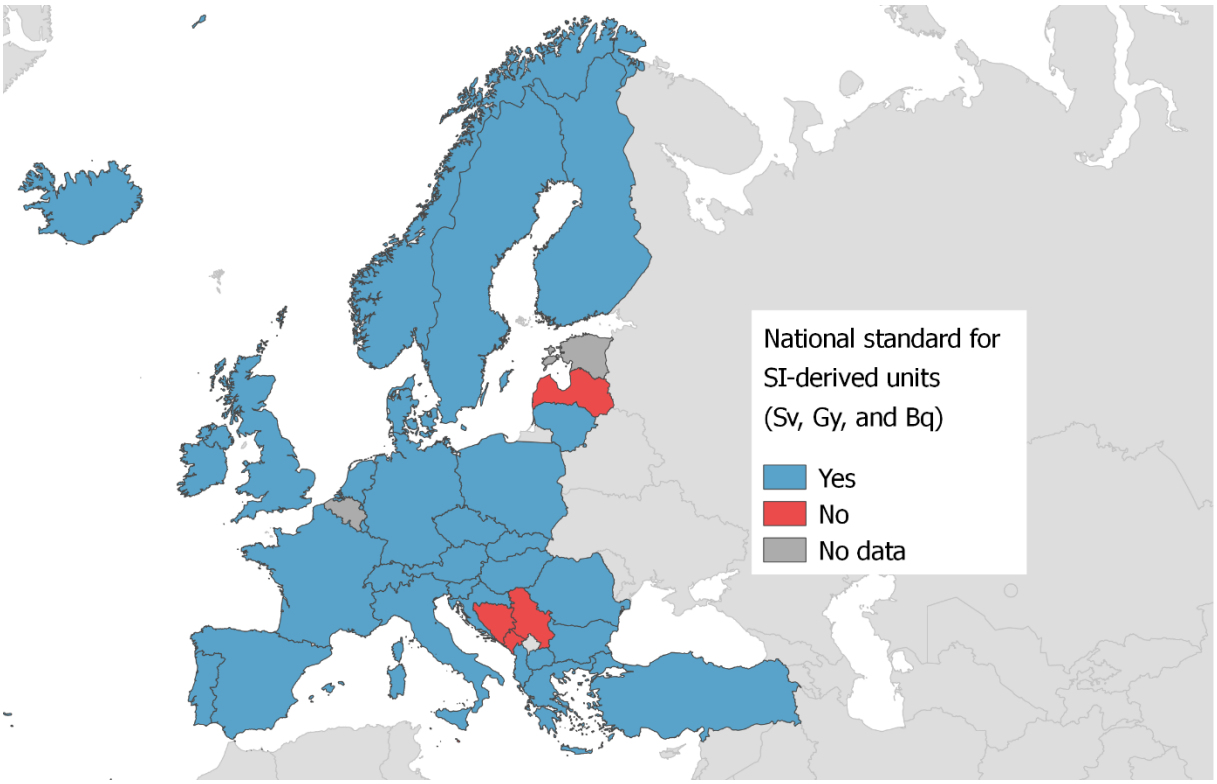

Figure 6 European countries having national standards for ionising radiation

9.2 Dosimetry for medical radiation use

In this evaluation we used the country facts from Datta et al. [12] showing the percentage access to radiotherapy in 2012 as it can be seen on Figure 9. We also used data from European Commission in Medical Radiation Exposure of the European Population [13]. Figure 11 shows the mean effective dose per caput in mSv/year for European countries split into three categories high, medium and low dose.

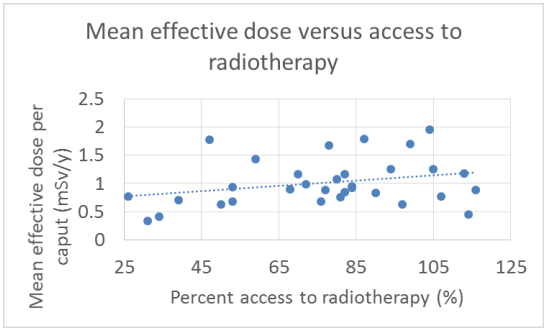

Figure 7 Country facts show a correlation 0.30 between mean effective dose and number of teletherapy units per mill. inhabitants. Produced on facts from Detta et al. [12] and EC [13].

Figure 7 shows a plot of the mean effective dose in mSv/year as a function of percent access to teletherapy. There is a low correlation calculated to 0.30. A more frequent use of CT procedures shows a low correlation to the access to radiotherapy in the European countries. The country facts in the country-grouped tables also show a small correlation between the number of teletherapy units per million inhabitants and number of CT procedures per 1000 inhabitants. Figure 8 shows a correlation of 0.46, a little higher than on Figure 7.

We grouped the countries in five parts related to the percentage access to radiotherapy: very low, low, medium, high and full. Table 3 gives the number of countries in each group and how many of them have regulations for radiotherapy dosimetry traceability, and how many have access to national standards for radiotherapy dosimetry calibrations. The European map on Figure 9 groups the countries according to the data in Table 3.

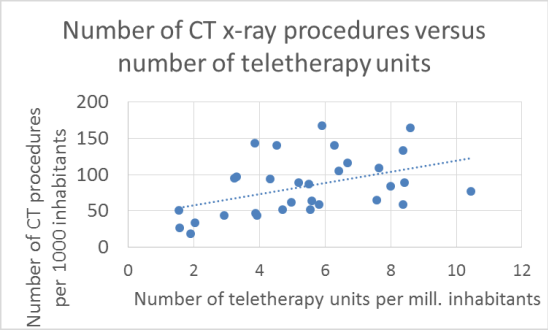

Figure 8 Country facts show a correlation of 0.46 between number of CT procedures per 1000 inhabitants and percent access to radiotherapy. Produced on facts from Detta et al. [12] and EC [13].

In this survey we see that 83 % of the countries have regulations for traceable dosimetry in radiotherapy (Figure 10). Furthermore, for traceability in x-ray diagnostic and intervention we found regulations in 86 % of the countries (Figure 12). The availability of calibration of dosimeters in radiotherapy is 61 %, and 53 % for x-ray diagnostic and intervention.

Low access to radiotherapy also shows infrequent available national standards, but medium access to radiotherapy gives the highest availability to national standards.

Datta et al. [12] reported the radiotherapy infrastructure in Europe and pointed at steps to fill the gaps on the availability of radiotherapy treatments. Results from Datta et al. reveal that the number of teletherapy units in the European countries relates directly to the GNI/capita.

Table 3 The number of countries grouped after percentage access to radiotherapy. The two last columns give the number and percentage of countries in each group having regulated traceability in the radiation protection regulations, and the existence of national standards for radiotherapy, respectively.

Access group	Percentage access to RT	Total in group	Regulations	National standard
Very low	< 40 %	4	3 (75 %)	1 (25 %)
Low	41-60 %	6	6 (100 %)	4 (67 %)
Medium	61-80 %	9	8 (89 %)	6 (67 %)
High	81-94 %	9	7 (78 %)	5 (56 %)
Full	>95 %	8	6 (75 %)	6 (75 %)
Total		36	30 (83 %)	22 (61 %)

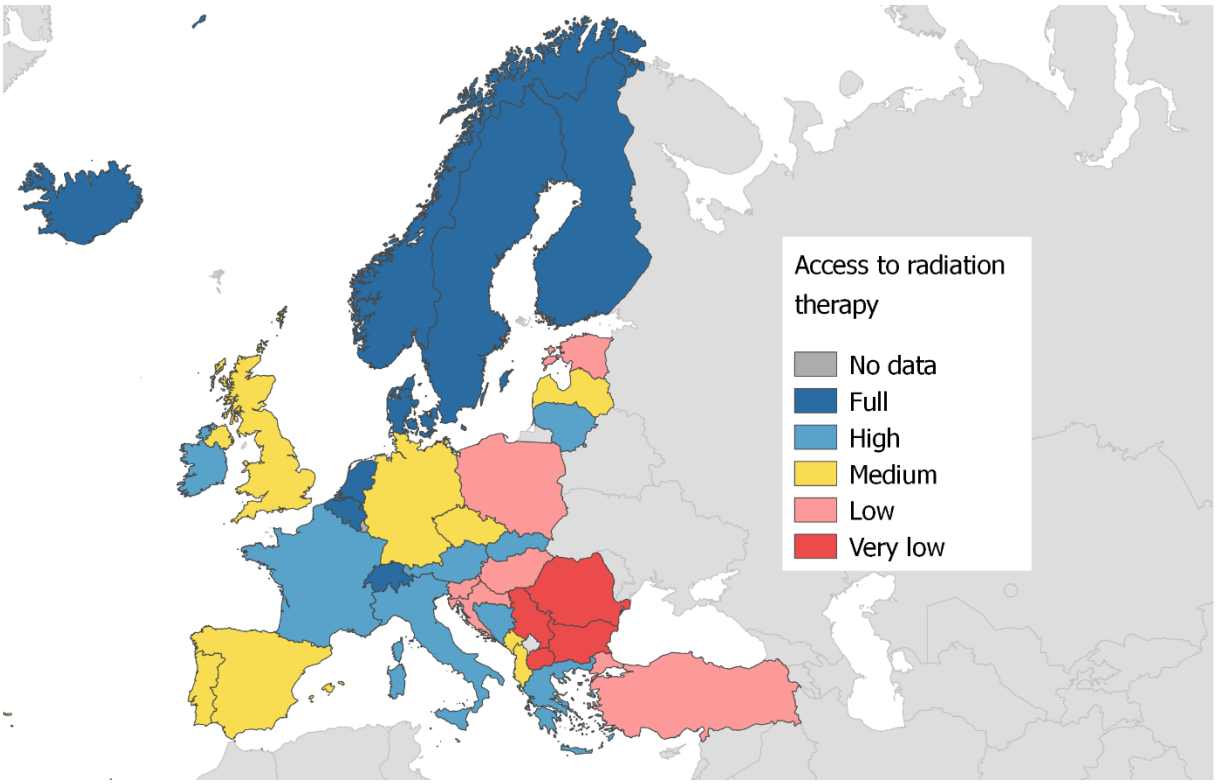

Figure 9 The countries grouped after percentage access to radiotherapy. See Table 3 for explanation.

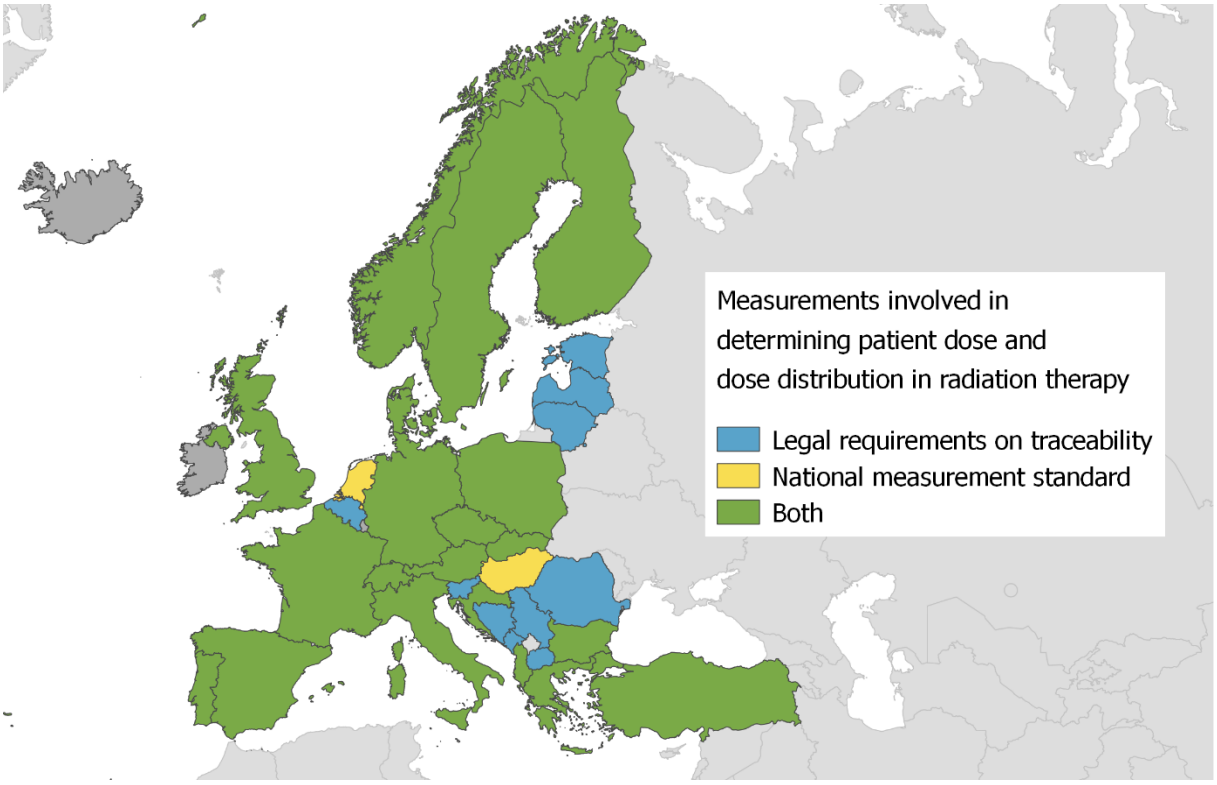

Figure 10 The countries in blue have legal regulations on dosimetry in radiotherapy but no national standard. With yellow colour are marked countries which have standard, but no legal regulations. Green colour shows countries which have both. A grey colour on a country means no data form the respondents, or no regulation and no national standard in the country.

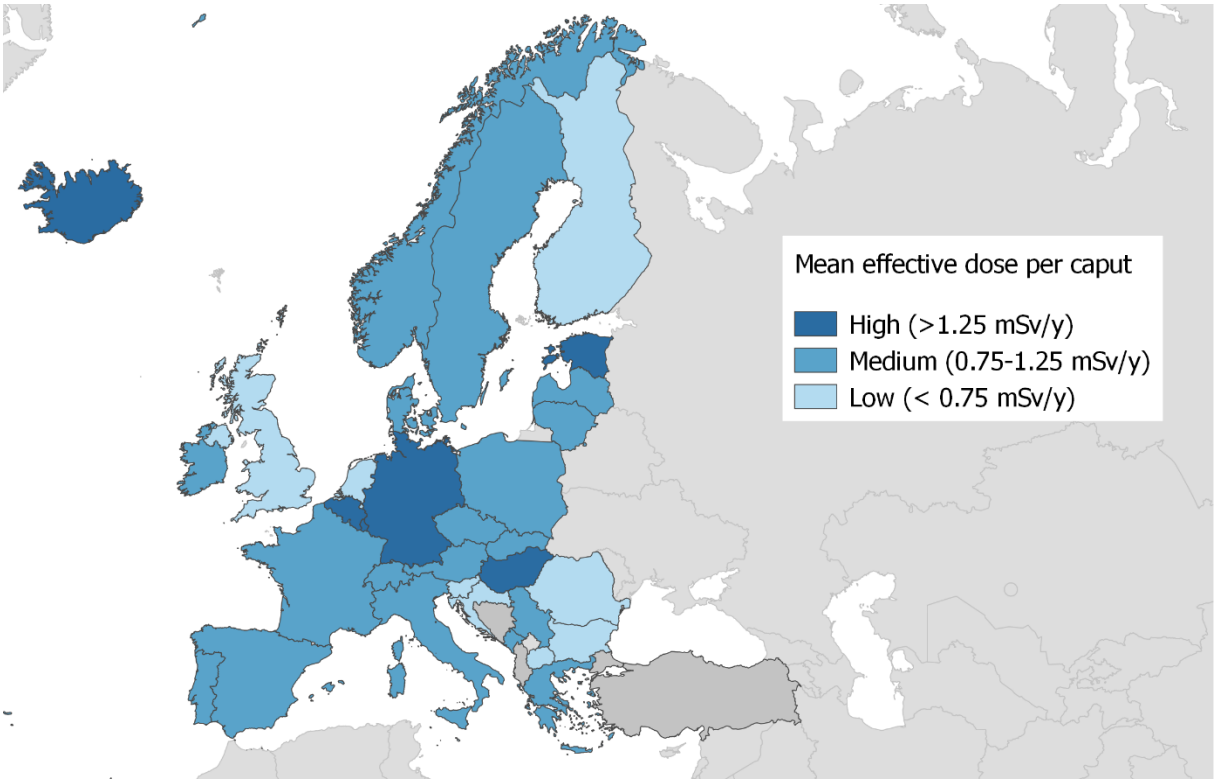

Figure 11 Map showing mean effective dose per caput produced on data from EC Medical Radiation Exposure of the European Population [13]. Grey colour means missing data.

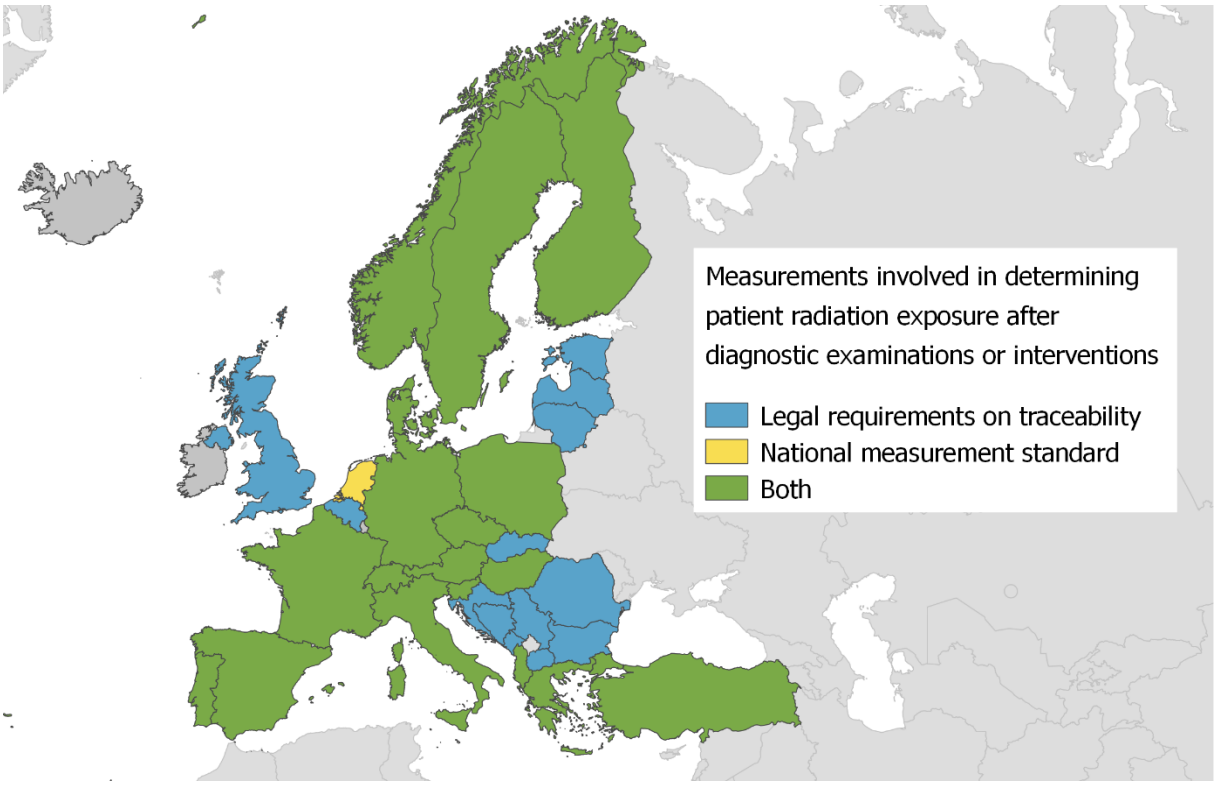

Figure 12 The countries in blue have legal regulations on dosimetry in x-ray diagnostic and intervention, but no national standard. Yellow shows country having standard, but no legal regulations. Green shows countries having both. A grey colour on a country means no data form the respondents, or no regulation and no national standard in the country.

9.3 Nuclear medicine – activity measurements

The results from the survey show that 27 of the 36 countries have regulations for calibration of activity meters for the unit Bq in nuclear medicine. Only 14 countries have national standards for these measurements. This means that medical physicist in 61 % of the countries (22 of 36) must get traceability from abroad. The results also show that calibrations for activity measurements for nuclear medicine are not available in two of the country groups, and only Country Group 1 (on page 22 and the next) has this service in all countries. Medical physicists in countries that don't have calibrations for activity meters available in the country also seldom find this calibration in neighbour countries. See Figure 13.

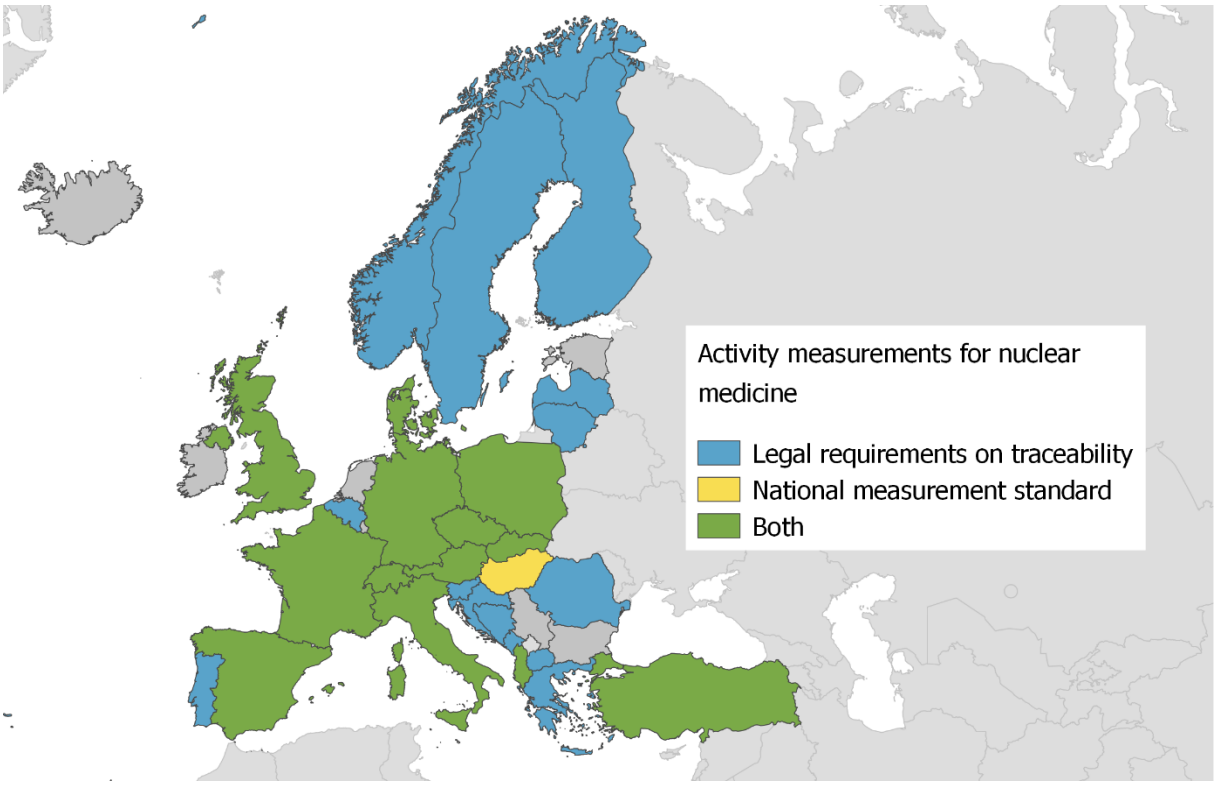

Figure 13 The countries in blue have legal regulations on activity measurements for nuclear medicine, but no national standard. Yellow shows country having standard, but no legal regulations. Green shows countries having both. A grey colour on a country means no data form the respondents, or no regulation and no national standard in the country.

9.4 Nuclear energy production – overview

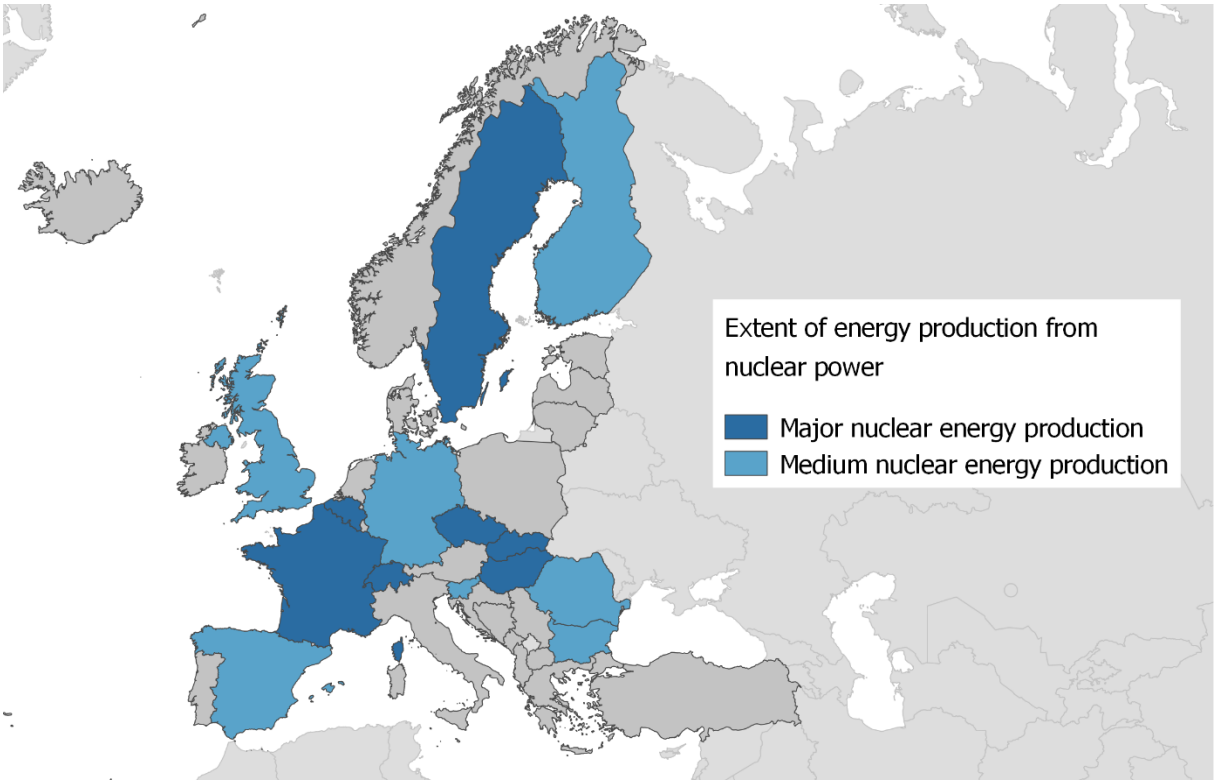

Figure 14 Dark blue colour shows 7 countries having more than 35 % of electricity generation from nuclear energy. Light blue highlights 7 countries having less than 35 % from nuclear energy. Grey means no nuclear power.

We found that all countries having medium share part of electricity generation coming from nuclear fuel have legal requirements on traceability, while countries with a major share part missed some regulations on traceability. National standards where available in a majority of the countries. Table 4 summarise the legal requirements and national standards in the two groups of countries having nuclear power for electricity production.

Table 4 Tabulated measurement needs in countries with nuclear electricity production. An overview of the answers from the 14 countries having nuclear energy (half-and-half major and medium, see Figure 14*). The table contains the six actual calibration areas for nuclear energy from question 9 and 11 in the survey.*

Share nuclear in electricity production / # countries	Major / Medium 7 / 7	Major / Medium 7 / 7
Calibration area where the country has:	Legal requirements on traceability	National standards
Radiation measurements involved in individual monitoring of workers	7 / 7	6 / 5
Radiation measurements involved in monitoring of members of the public	5 / 7	4 / 5
Radiation dosimetry for early warning networks	5 / 7	5 / 4
Environmental activity measurements	5 / 7	5 / 6
Activity measurements of waste	6 / 7	5 / 5
Neutron measurements involved in individual monitoring of workers	7 / 7	5 / 3

9.5 Individual monitoring of workers

The results on Figure 15 show that 31 countries had regulations on traceability of individual monitoring of workers, and 22 of the 36 countries had national standards for calibration. Strict regulations usually exist on individual monitoring personal dose to radiation workers, and calibration of the personal dosimetry service needs regulation for secure risk assessment from the dose readings.

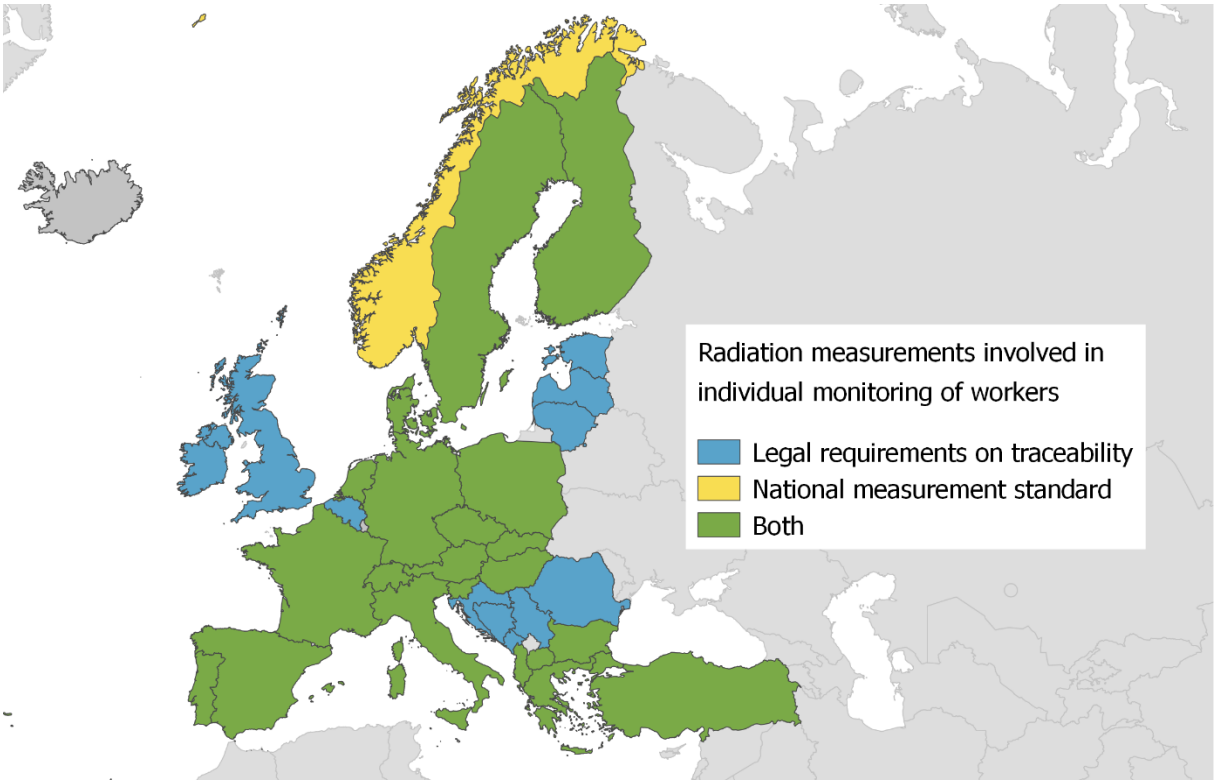

Figure 15 The countries in blue have legal regulations on measurements involved in individual monitoring of wokers (gamma radiation), but no national standard. Yellow colour highlights country having standard, but no legal regulations. Green shows countries having both. A grey colour on a country means no data form the respondents, or no regulation and no national standard in the country.

For the personal neutron dosemeters, only three of the seven countries having a medium part of the electricity generation based on nuclear fuel have calibration, while five out of seven countries with major part of nuclear electricity generation have calibration service in the country. See Table 3 and Figure 16. Two of seven with medium part and one with the major part did not have calibration service for individual monitoring of workers. This survey did not ask for foreign supply of these calibrations, which is an alternative for the personal dosimetry service traceability.

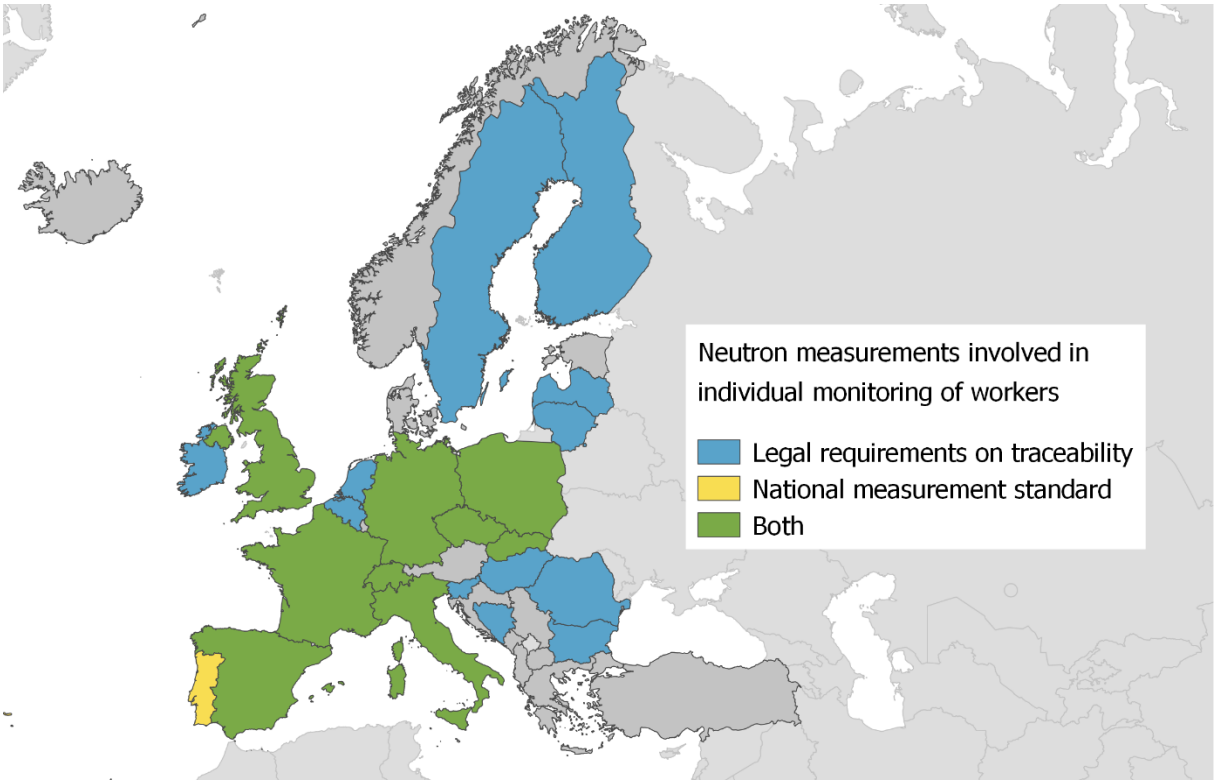

Figure 16 The countries in blue have legal regulations on measurements involved in individual monitoring of wokers (neutron radiation), but no national standard. Yellow shows country having standard, but no legal regulations. Green shows countries having both. A grey colour on a country means no data form the respondents, or no regulation and no national standard in the country.

9.6 Activity measurements for the environment and waste

Security in nuclear industry depends on risk assessments based on dosimetry and measurements of activity. At nuclear power plants, national legal regulations regulate monitoring programs. For countries where a major part of electricity production is from nuclear energy, two of seven countries reported no regulation on traceability of environmental measurements and two countries have no national standards for these measurements. For the waste, six of seven countries are regulating traceability of activity measurements of waste, and two of the seven countries have no national standards for activity measurement of waste.

For countries where a medium part of electricity production comes from nuclear energy, all countries reported regulation on traceability of environmental activity measurements and of activity of waste. Six countries have national standard for environmental activity measurements, and for the waste two of the seven countries don't have a national standard for activity measurement of waste, see Figure 17.

At the power plants the instruments for surface contamination or measurements of emission rate from radionuclides to detect possible contamination are in regular use. This quantity was not included in the survey.

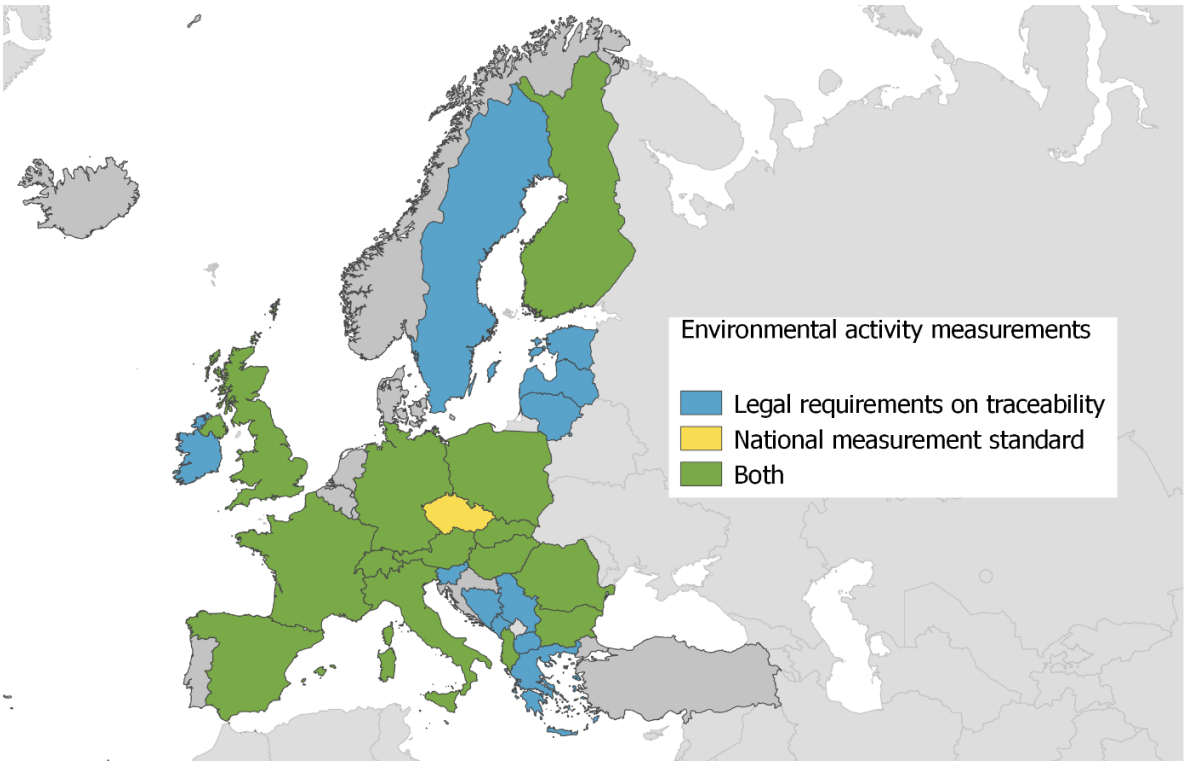

Figure 17 The countries in blue have legal regulations on environmental acivity measurements, but no national standards. Yellow colour shows country having standard, but no legal regulations. Green shows countries having both. A grey colour on a country means no data form the respondents, or no regulation and no national standard in the country.

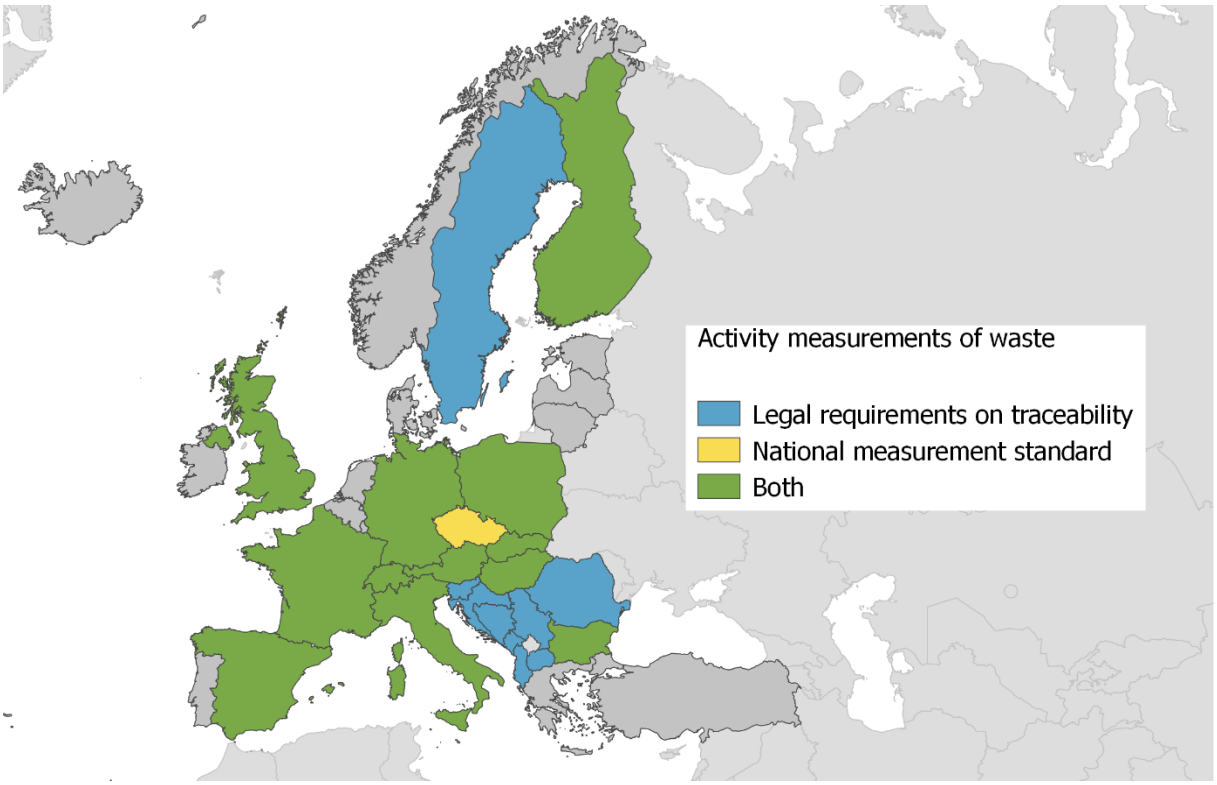

Figure 18 The countries in blue have legal regulations on activity measurements of waste, but no national standard. Yellow shows country having standard, but no legal regulations. Green shows countries having both. A grey colour on a country means no data form the respondents, or no regulation and no national standard in the country.

9.7 Nuclear energy production – early warning networks and public monitoring

Figure 19 shows the results from the survey for early warning networks. Except for one country the same map applies to public monitoring.

For the early warning networks, all of the medium part countries have regulations while five of the major part have regulations. For calibration of early warming networks, only nine of the countries have national standard available, five of the major and four of the medium.

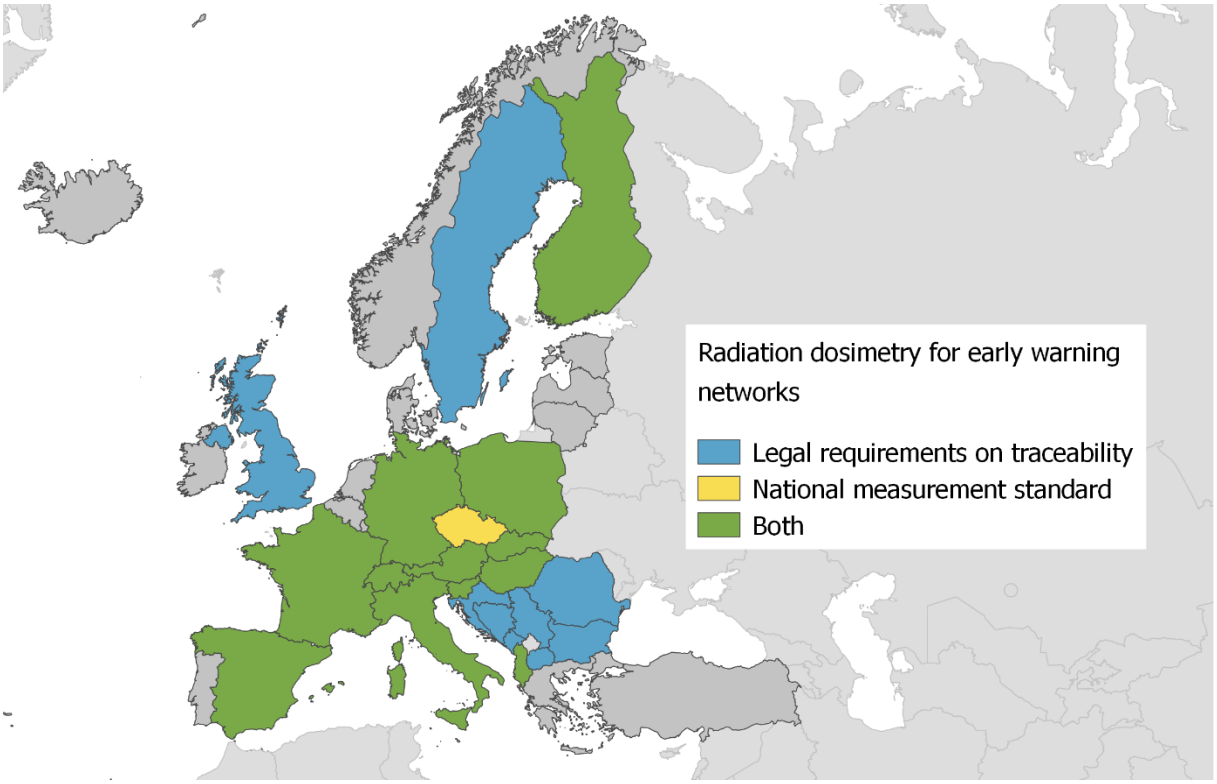

Figure 19 The countries in blue have legal regulations on dosimetry for early warning networks, but no national standard. Yellow shows countries having standard, but no legal regulations. Green shows countries having both. A grey colour on a country means no data form the respondents, or no regulation and no national standard in the country.

9.8 Indoor radon activity measurements

Soil radon gas transports easily into buildings via pressure driven flow of soil gas through cracks in the foundations of buildings. The European Commission, Joint Research Centre (JRC) published map of indoor radon concentration (Bq m^{-3}) [21] reproduced on Figure 20. The measurements reported to JRC make the base for the development of these maps and need to have a known uncertainty of radon concentration measurement. In 2015 an international workshop, IWEANR was organised by JRC in Verbania, Italy. The objectives of the workshop was to present the status and discuss progress of the European Atlas of Natural Radiation project. [22]. A short review of the presentations revealed two of thirty-eight presentations stating the uncertainty together with stated measured radon concentration.

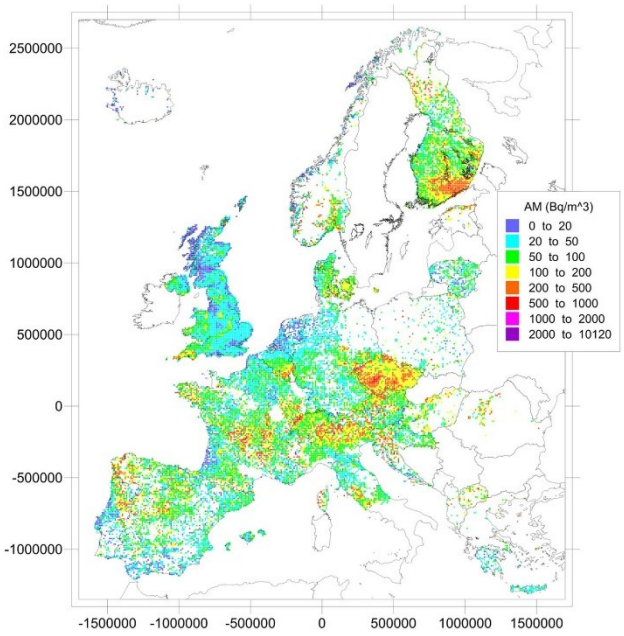

Figure 20 The European indoor Rn map. Mapped quantity: annual mean indoor Rn concentration in living rooms in ground floors, arithmetic mean within 10 x 10 km cells. Latest update, September 2014. The cell mean is neither an estimate of the population exposure, nor of the risk. Reproduced from JRC [21].

The survey results on infrastructure for activity measurements of radon in air, mapped on Figure 21, show few countries with both national standards and regulations. 20 of the 36 countries reported to have regulation on activity measurement of radon in air, while only nine countries have national standards for this measurement.

Reports on “inter-comparisons” or proficiency tests are a valuable supplement to the lack of national standards, even if the quality (link to SI-system) and uncertainty of these measurements usually doesn’t follow the metrology rules for evaluating and reporting of deviations and degree of equivalence. These proficiency tests may give a too optimistic understanding of the uncertainty for the radon metrology infrastructure for radon in air. Only Austria of the EURAMET member countries maintain a national standard for activity per unit volume, Bq m^{-3} [7], with a relative expanded uncertainty of 10 %. The survey results mapped on Figure 21 indicates a minor infrastructure for the measurements of indoor radon. The European Atlas of Natural Radiation can improve on the basis of better metrology infrastructure.

9.9 Dosimetry and activity measurements in type testing

The survey also asked for regulations regarding type testing of equipment. Type testing of radiation sources, measuring equipment or equipment using radiation sources have regulations for traceable dosimetry and activity measurements in 21 and 15 countries, respectively. Maintenance of national standards in dosimetry and activity measurements for type testing are reported in 16 and 12 countries, respectively.

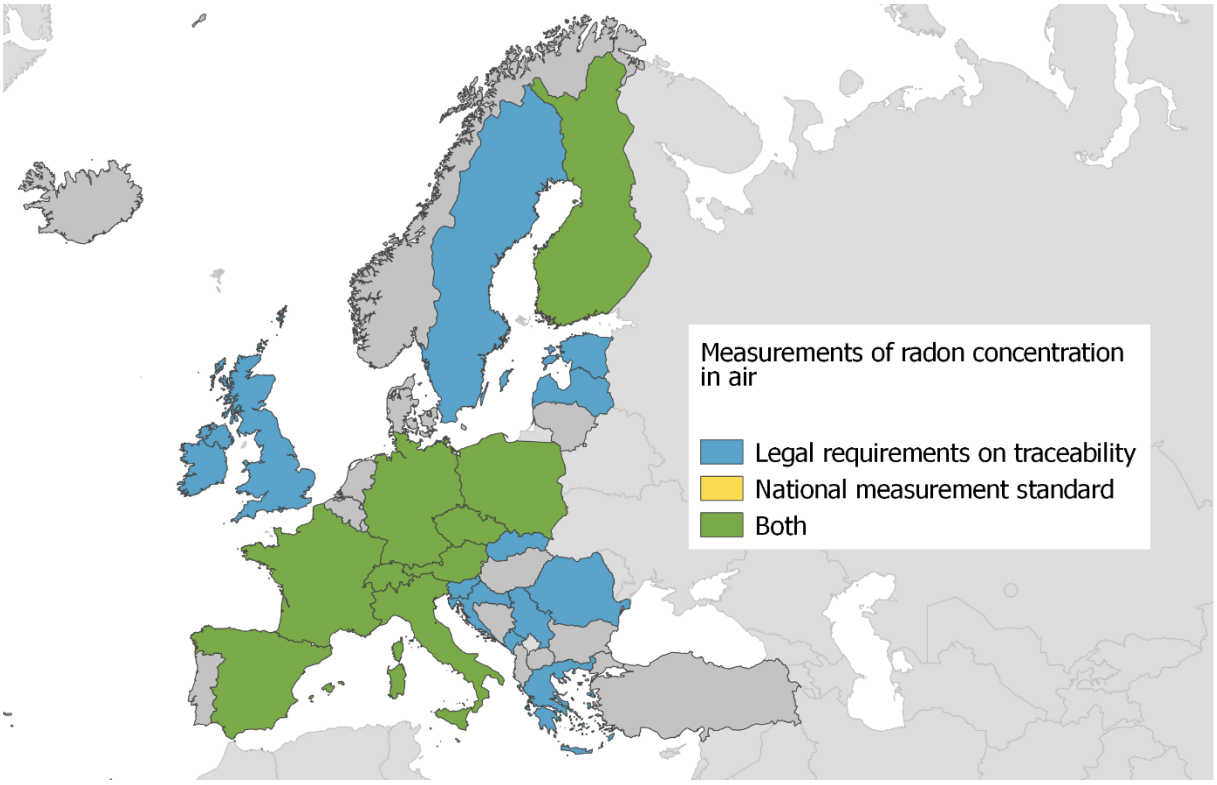

Figure 21 The countries in blue have legal regulations on measurements of radon in air, but no national standard. Yellow shows counties having standard, but no legal regulations. Green shows countries having both. A grey colour on a country means no data form the respondents, or no regulation and no national standard in the country.

9.10 Evaluation related to the EURAMET 2020 strategy

The findings in the survey indicate possible improvement in reaching the strategic goals for IR measurements in handling of indoor radon and in the nuclear energy industry: development of key partners and understanding stakeholder needs. The evaluation of medical use of ionising radiation shows needs for improvements to ensure safety and efficacy of healthcare in member countries of EURAMET. During the time of preparing this report (three years) we noticed that countries in South-East Europe improved their regulations on traceability and developed of national standards. This report gives some input to understand the true needs of the members and may provide input to the development of relevant policies as planned in the EURAMET 2020 strategy.

10 Discussion and conclusions

Currently, there are about 4 million new cases of cancer in Europe per year. This figure is predicted to increase in the future due the global ageing of the population in Europe and to the improvement of diagnostic methods a larger percentage of cancers will be discovered. In the last decades the application of ionising radiation based techniques in healthcare has evolved considerably allowing advanced diagnostic and therapeutic modalities. The therapeutic application dominates by external beam radiotherapy applied in the treatment of cancer. Advanced technologies have enabled the introduction of dynamic complex forms of radiotherapy in the treatment of cancer, while for diagnostic applications such as computerized tomography with three- and four-dimensional online imaging techniques improve the diagnostic outcome.

After several decades of development and exploitation, but particularly after the Chernobyl and the Fukushima accidents, nuclear industry has to meet many challenges both for making it acceptable to the public and for enforcing its safety and sustainability. Many nuclear facilities are coming to the end of their life. New generation power plants will be developed and built. New processes like spallation sources and transmutation of long-lived isotopes are under development.

It is not our task to judge about the needs for capacity building and new infrastructure in the regulations for metrology or radiation protection. That is for the governments to decide on. Country's needs and development of national IR standards will also lay in the hands of the government. However, this report may give information for counties to make better judgements.

HERCA and EURAMET are the two European organisations having important roles in making international recommendations and giving support to countries' infrastructure. EURAMET [2] makes this in the field of metrology and HERCA [8] in the field of the use of ionising radiation. These two organisations are representing two major fields of principles for the society. EURAMET has its principles from the meter convention and the MRA, while HERCA has the radiation protection principles. The ionising radiation metrology community takes advantage of both of them. However, with an effective and comprehensive metrological infrastructure for ionising radiation, one more easily identify the effectiveness of radiotherapy and risk assessment of ionising radiation use.

C. H. Clark et al. published in 2015 [23] a review that examines the development of dosimetry audit in UK over the past 30 years, including the involvement of UK in international audits. In their discussion of audit or comparison in metrology terms, they use both of the principals from metrology and radiation protection: *Dosimetry audits can be used to help assure accuracy of both basic and advanced radiotherapy techniques, determine their benefit to clinical trials and inform the arguments for further national/international audits. Undertaking regular external audit allows centres to demonstrate compliance with national standards, provide assurance that patients are receiving the prescribed dose accurately according to protocol, ensure accurate basic radiation dosimetry and be motivated to modernise and develop techniques*.

This report from a EURAMET European survey shows the legal regulations of ionising radiation national standards in the European countries, and of the legal regulations of traceability of the dosimetry and activity measurements linked to the use volume of ionising radiation. The information from the respondents and the quality check of the information, map the situation in the different countries as far as it was possible in this project.

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97/43/Euratom and 2003/122/Euratom. Official Journal L13, 17.01. 2014 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.013.01.0001.01.ENG&toc=OJ:L:2014:013:TOC (17.03.2016)
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12 Acknowledgement

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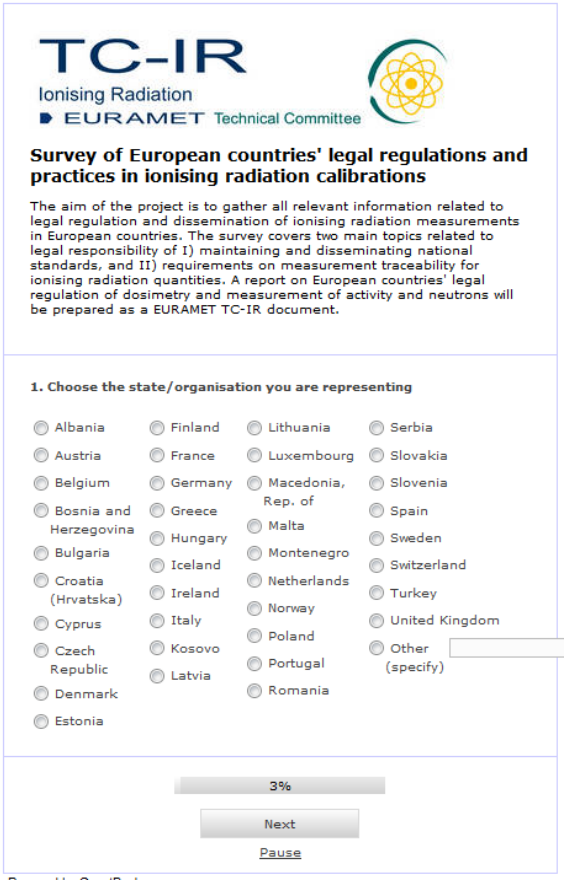
13 Appendixes

13.1 The questionnaire

All text and design in the questionnaire is reproduced in this chapter.



TC-IR
Ionising Radiation
EURAMET Technical Committee

Survey of European countries' legal regulations and practices in ionising radiation calibrations

The aim of the project is to gather all relevant information related to legal regulation and dissemination of ionising radiation measurements in European countries. The survey covers two main topics related to legal responsibility of I) maintaining and disseminating national standards, and II) requirements on measurement traceability for ionising radiation quantities. A report on European countries' legal regulation of dosimetry and measurement of activity and neutrons will be prepared as a EURAMET TC-IR document.

1. Choose the state/organisation you are representing

Albania	Finland	Lithuania	Serbia
Austria	France	Luxembourg	Slovakia
Belgium	Germany	Macedonia, Rep. of	Slovenia
Bosnia and Herzegovina	Greece	Malta	Spain
Bulgaria	Hungary	Montenegro	Sweden
Croatia (Hrvatska)	Iceland	Netherlands	Switzerland
Cyprus	Ireland	Norway	Turkey
Czech Republic	Italy	Poland	United Kingdom
Denmark	Kosovo	Portugal	Other (specify)
Estonia	Latvia	Romania	

3%

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Survey of European countries' legal regulations and practices in ionising radiation calibrations

Why this survey?

In the European countries you will find ionising radiation in home land security, industry and health care, as well as radiation protection of human and environment.
Some examples from where you find ionising radiation is given in the picture below.

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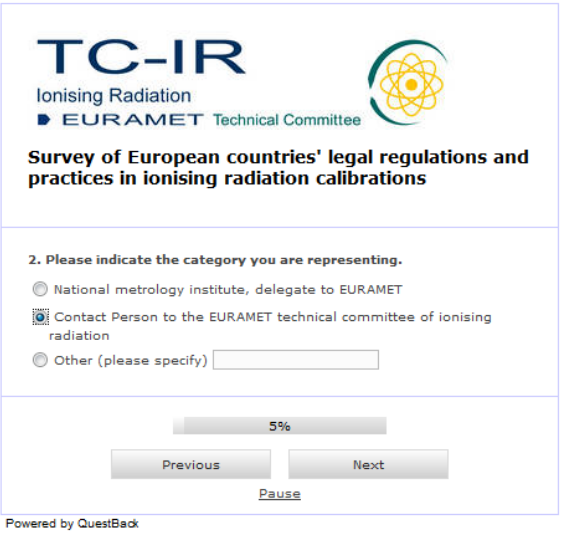

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2. Please indicate the category you are representing.

- National metrology institute, delegate to EURAMET
- Contact Person to the EURAMET technical committee of ionising radiation
- Other (please specify)

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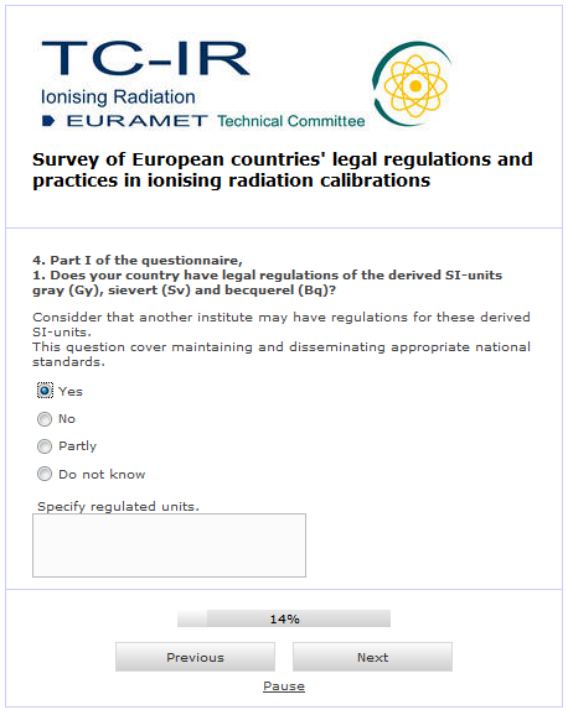

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4. Part I of the questionnaire,
1. Does your country have legal regulations of the derived SI-units gray (Gy), sievert (Sv) and becquerel (Bq)?

Considder that another institute may have regulations for these derived SI-units.
This question cover maintaining and disseminating appropriate national standards.

- Yes
- No
- Partly
- Do not know

Specify regulated units.

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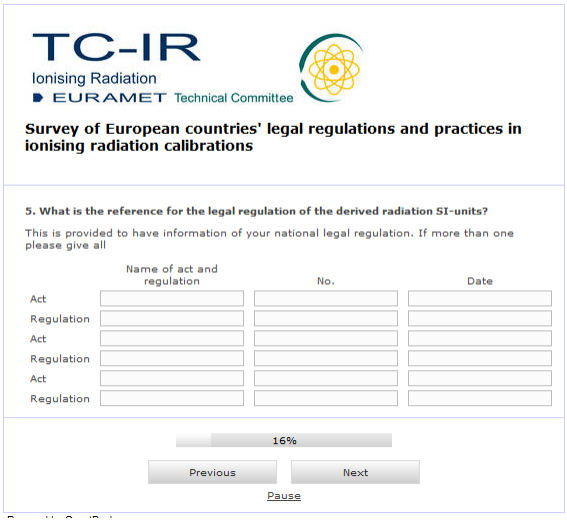

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5. What is the reference for the legal regulation of the derived radiation SI-units?

This is provided to have information of your national legal regulation. If more than one please give all

	Name of act and regulation	No.	Date
Act			
Regulation			
Act			
Regulation			
Act			
Regulation			

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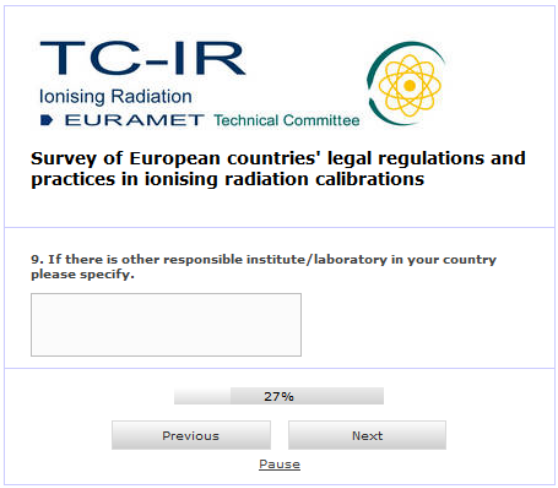

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9. If there is other responsible institute/laboratory in your country please specify.

27%

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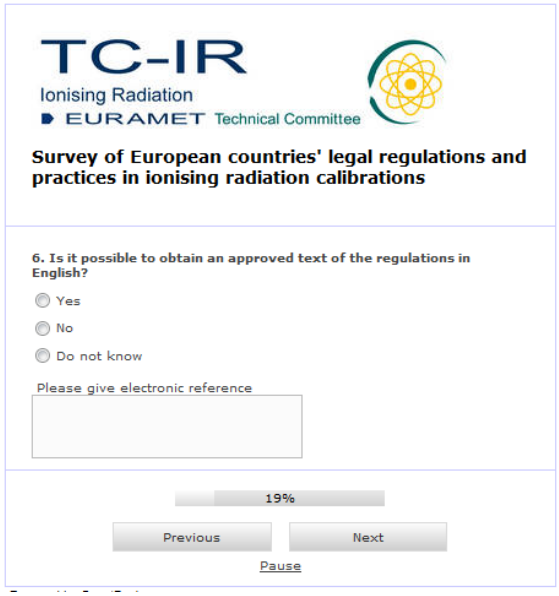

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6. Is it possible to obtain an approved text of the regulations in English?

- Yes
- No
- Do not know

Please give electronic reference

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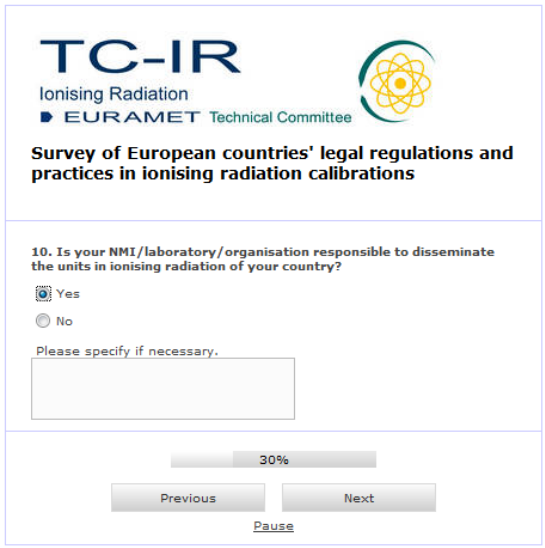

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10. Is your NMI/laboratory/organisation responsible to disseminate the units in ionising radiation of your country?

- (•) Yes
- ( ) No

Please specify if necessary.

30%

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7. Does your organisation have a laboratory responsible for keeping and maintaining national standards for ionising radiation units in your country?

- (•) Yes
- ( ) No
- ( ) Partly, there are other national calibration laboratories

Please specify units [Gy] [Sv] [Bq]

22%

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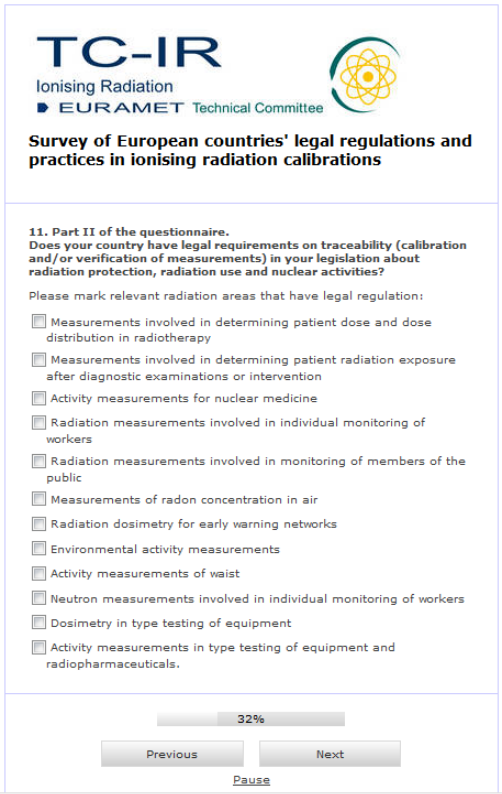

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11. Part II of the questionnaire.
Does your country have legal requirements on traceability (calibration and/or verification of measurements) in your legislation about radiation protection, radiation use and nuclear activities?

Please mark relevant radiation areas that have legal regulation:

- [ ] Measurements involved in determining patient dose and dose distribution in radiotherapy
- [ ] Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention
- [ ] Activity measurements for nuclear medicine
- [ ] Radiation measurements involved in individual monitoring of workers
- [ ] Radiation measurements involved in monitoring of members of the public
- [ ] Measurements of radon concentration in air
- [ ] Radiation dosimetry for early warning networks
- [ ] Environmental activity measurements
- [ ] Activity measurements of waist
- [ ] Neutron measurements involved in individual monitoring of workers
- [ ] Dosimetry in type testing of equipment
- [ ] Activity measurements in type testing of equipment and radiopharmaceuticals.

32%

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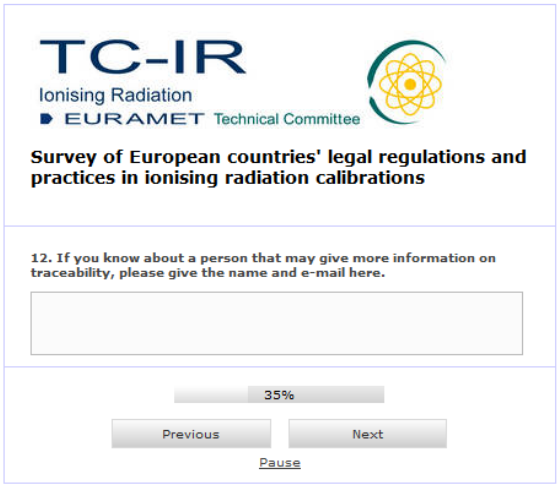
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12. If you know about a person that may give more information on traceability, please give the name and e-mail here.

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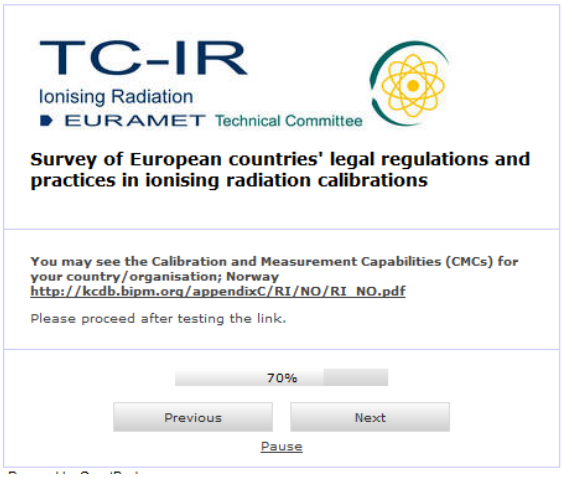
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You may see the Calibration and Measurement Capabilities (CMCs) for your country/organisation; Norway
http://kcdb.bipm.org/appendixC/RI/NO/RI_NO.pdf

Please proceed after testing the link.

70%

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13. What is the reference for this legal regulation?

This is provided to have information of your national legal regulation.

	Name of act and regulation	No.	Date
Act			
Regulation			
Act			
Regulation			
Act			
Regulation			

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Survey of European countries' legal regulations and practices in ionising radiation calibrations

15. Do you think the following ionising radiation metrology should have legal requirements on traceable measurements in your country?

	Yes	No
Dosimetry in radiotherapy	☐	☐
Dosimetry in X-ray diagnostic and intervention	☐	☐
Activity measurements in nuclear medicine	☐	☐
Dosimetry and measurements of activity and neutrons in nuclear energy	☐	☐
Personal dosimetry	☐	☐
Environment dosimetry	☐	☐
Measurement of activity in environmental samples	☐	☐
Radon in air	☐	☐
Early warning networks	☐	☐

95%

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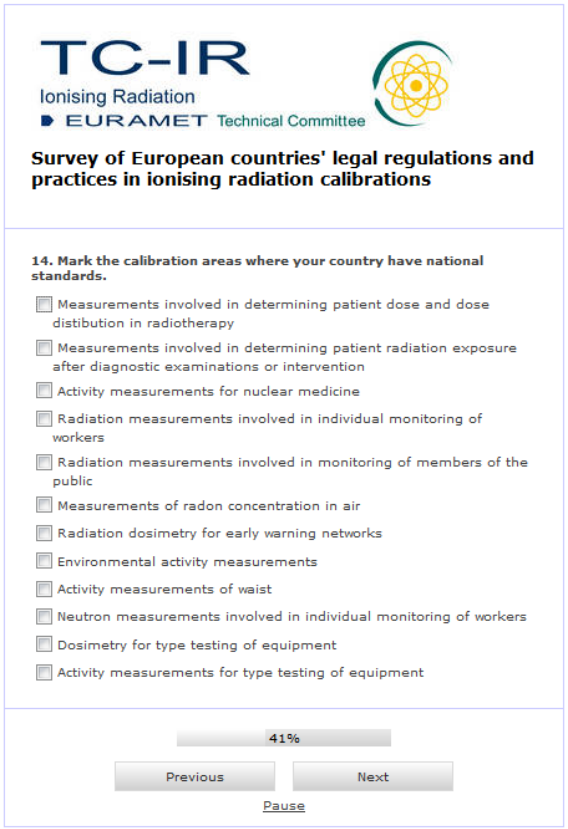
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EURAMET Technical Committee

Survey of European countries' legal regulations and practices in ionising radiation calibrations

14. Mark the calibration areas where your country have national standards.

- ☐ Measurements involved in determining patient dose and dose distibution in radiotherapy
- ☐ Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention
- ☐ Activity measurements for nuclear medicine
- ☐ Radiation measurements involved in individual monitoring of workers
- ☐ Radiation measurements involved in monitoring of members of the public
- ☐ Measurements of radon concentration in air
- ☐ Radiation dosimetry for early warning networks
- ☐ Environmental activity measurements
- ☐ Activity measurements of waist
- ☐ Neutron measurements involved in individual monitoring of workers
- ☐ Dosimetry for type testing of equipment
- ☐ Activity measurements for type testing of equipment

41%

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16. If you have further comments please give them here.

100%

Previous Done

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13.2 The questionnaire text.

Title

Survey of European countries' legal regulations and practices in ionising radiation calibrations.

Introducing text

The aim of the project is to gather all relevant information related to legal regulations and dissemination of ionising radiation measurements in European countries. The survey covers two main topics related to legal responsibility of I) maintaining and disseminating national standards, and II) requirements on measurement traceability for ionising radiation quantities. A report on European countries' legal regulations of dosimetry and measurement of activity and neutrons will be prepared as a EURAMET TC-IR document.

Question 1

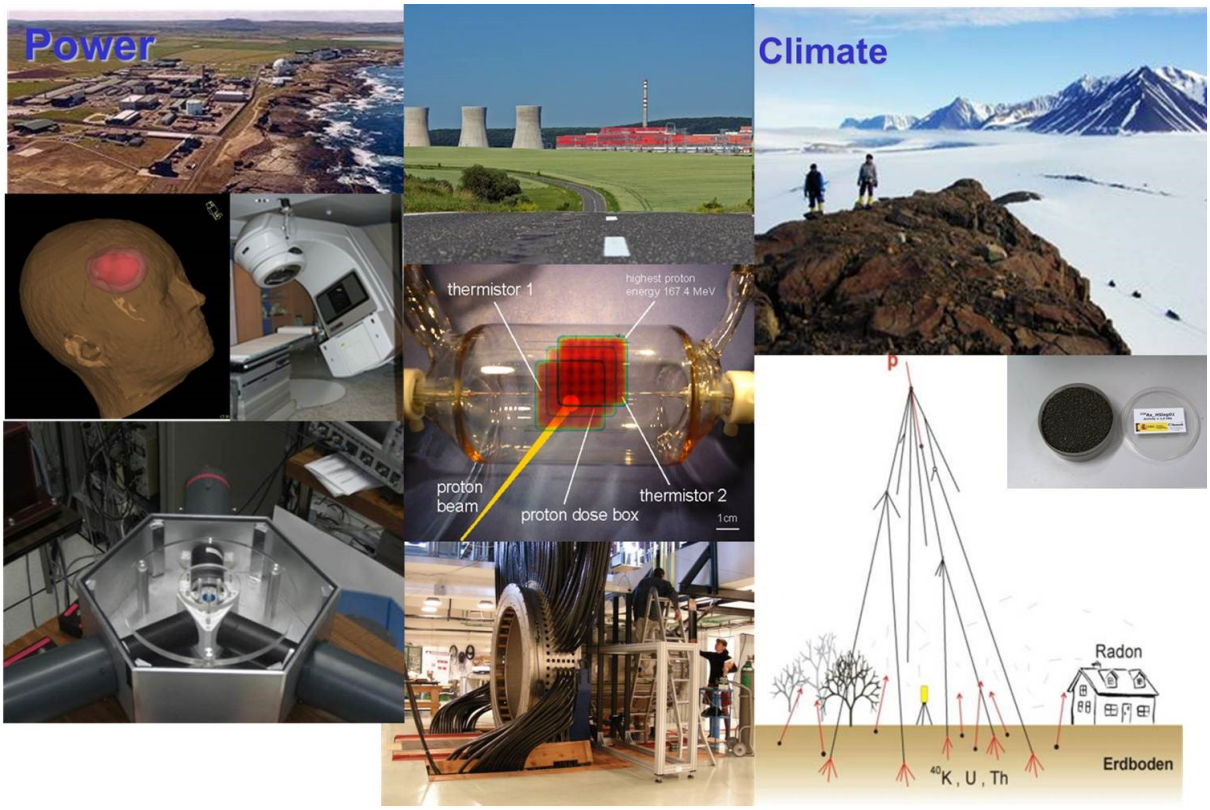
Choose the state/organisation you are representing.

It was possible to choose among 39 county names.

Question 2

Please indicate the category you are representing.

Three categories for answer: *National metrology institute, delegate to EURAMET, Contact Person to the EURAMET technical committee of ionising radiation and Other (please specify).*



Information

Why this survey?
In the European countries you will find ionising radiation in home land security, industry and health

care, as well as radiation protection of human and environment.
Some examples from where you find ionising radiation is given in the picture below.

Question 3

Part I of the questionnaire,

Does your country have legal regulations of the derived SI-units gray (Gy), sievert (Sv) and becquerel (Bq)? Consider that another organisation may have regulations for these derived SI-units. This question covers maintaining and disseminating appropriate national standards.

The answers were "*Yes", "No" and "Partly"* and the respondent was asked to give units.

Question 4

What is the reference for the legal regulations of the derived radiation SI-units?

This is provided to have information of your national legal regulations. If more than one please give all.

The respondent was asked to give name, number and date of act and regulations.

Question 5

Is it possible to obtain an approved text of the regulations in English?

The answers were "*Yes", "No" and "Do not know"*. The respondent was asked to give an electronic reference.

Question 6

Does your organisation have a laboratory responsible for keeping and maintaining national standards for ionising radiation units in your country?

The answers were "*Yes", "No" and "Partly", there are other national calibration laboratories* and the respondent was asked to specify units.

Question 7

If the respondent answers Partly on question 6 then:

Please specify the name of laboratory.

Question 8

Is your NMI/laboratory/organisation responsible to disseminate the units in ionising radiation of your country?

The answers were "*Yes" or "No".*

Question 9

Part II of the questionnaire.

Does your country have legal requirements on traceability (calibration and/or verification of measurements) in your legislation about radiation protection, radiation use and nuclear activities?

Please mark relevant radiation areas that have legal regulations:

- *Measurements involved in determining patient dose and dose distribution in radiotherapy*
- *Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention*
- *Activity measurements for nuclear medicine*
- *Radiation measurements involved in individual monitoring of workers*

- *Radiation measurements involved in monitoring of members of the public*
- *Measurements of radon concentration in air*
- *Radiation dosimetry for early warning networks*
- *Environmental activity measurements*
- *Activity measurements of waste*
- *Neutron measurements involved in individual monitoring of workers*
- *Dosimetry in type testing of equipment*
- *Activity measurements in type testing of equipment and radiopharmaceuticals.*

Question 10

If the respondent did not answer question 9 then:

If you know about a person that may give more information on traceability, please give the name and e-mail here.

Question 11

If the respondent did not answer question 9 then:

Mark the calibration areas where your country has national standards

- *Measurements involved in determining patient dose and dose distribution in radiotherapy*
- *Measurements involved in determining patient radiation exposure after diagnostic examinations or intervention*
- *Activity measurements for nuclear medicine*
- *Radiation measurements involved in individual monitoring of workers*
- *Radiation measurements involved in monitoring of members of the public*
- *Measurements of radon concentration in air*
- *Radiation dosimetry for early warning networks*
- *Environmental activity measurements*
- *Activity measurements of waste*
- *Neutron measurements involved in individual monitoring of workers*
- *Dosimetry for type testing of equipment*
- *Activity measurements for type testing of equipment*

Information

Here the respondent gets a link to the BIPM appendix C where the actual country's CMCs list is.

Question 12

Do you think the following ionising radiation metrology should have legal requirements on traceable measurements in your country?

- *Dosimetry in radiotherapy*
- *Dosimetry in X-ray diagnostic and intervention*
- *Activity measurements in nuclear medicine*
- *Dosimetry and measurements of activity and neutrons in nuclear energy*
- *Personal dosimetry*
- *Environment dosimetry*
- *Measurement of activity in environmental samples*
- *Radon in air*
- *Early warning networks*

Question 13

If you have further comments please give them here.

13.3 The European IR CMCs

Table 5 gives an overview of the calibration and measurement capabilities (CMCs) in the European countries. Details about the CMCs are published on the BIPM web page http://kcdb.bipm.org/appendixC/default.asp .

Table 5 The number of IR CMCs published by country.

No	Country/laboratory	Dosimetry	Activity	Neutron	Published total
1	Austria/BEV	52	100		152
2	Bugaria/BIM NCM	7	16		23
3	Czech republic/CMI	7	104	12	123
4	Denmark/DTU	7			7
5	Finland/STUK	30			30
6	France/LNE-LNHB	82	206	15	303
7	Germany/PTB	88	158	20	266
8	Greece/GAEC	35			35
9	Hungary/MKEH	26	74		100
10	IAEA/DOL	26			26
11	EU/IRMM		110		110
12	Italy/ENEA	76	13	9	98
13	Netherlands/VSL	21	57		78
14	Norway/NRPA	22			22
15	Poland/GUM	4	68		72
16	Portugal/ITN	43			43
17	Romania/IFIN-HH		37		37
18	Slovakia/SMU	30	37	9	76
19	Slovenia/MIRS/IJF/F-2	7	5		12
20	Spain/CIEMAT	52	97		149
21	Sweden/SSM	24			24
22	Switzerland/METAS	3	21		24
23	Turkey/TAEK		3		3
24	United Kingdom/NPL	22	116	42	180
24	**Total EURAMET**	664	1222	107	1993
42	**All IR CMCs**	832	2551	177	3560

13.4 Respondents in the survey

Table 6 All respondents to the survey

Country	First name	Last name	Respondent type	Institution
Albania	Bardhyl	Grillo	IR Contact	
Austria	Robert	Edelmaier	Delegate	BEV
Austria	Franz-Josef	Maringer	TC-IR CP	BEV
Belgium	Miruna	Dobre	TC-IR CP	SMD
Bosnia & Herzegovina	Jelena	Marinkovic	IR Contact	
Bulgaria	Dimka	Ivanova	Delegate	BIM
Bulgaria	Rosen	Ivanov	TC-IR CP	BIM
Bulgaria	Ivailo	Petkov	IR Contact	
Croatia	Maja	Vojnić Kortmiš	IR Contact	
Croatia (Hrvatska)	Branko	Vekic	TC-IR CP	HMI/IRB-SSDL
Czech Republic	Jiri	Šurán	TC-IR CP	CMI
Denmark	Arne	Miller	TC-IR CP	DTU
Estonia	Toomas	Kübarsepp	Delegate	Metrosert
Finland	Antti	Kosunen	TC-IR CP	STUK
France	Jean-Marc	Bordy	TC-IR CP	LNE-LNHB
Germany	Herbert	Janßen	TC-IR CP	PTB
Germany	Dieter F.	Regulla	IR Contact	Helmholtz
Greece	Costas J.	Hourdakis	TC-IR CP	IRCL/GAEC-EIM
Hungary	Zsofia	Nagyné-Szilágyi	Delegate	MKEH
Hungary	Laszlo	Szücs	TC-IR CP	MKEH
Iceland	Gudmundur	Arnason	Delegate	NEST
Ireland	Veronica	Smith	IR Contact	RPII
Italy	Maria Pia	Toni	TC-IR CP	ENEA-INMRI
Latvia	Juris	Maurans	Delegate	LATMB
Latvia	Viesturs	Silamikelis	IR Contact	
Latvia	Oksana	Skripnika	Contact	SSDL laboratory
Lithuania	Arunas	Gudelis	TC-IR CP	VMT/FTMC
Luxembourg	Ulrich	Pechstein	Delegate	CRP Henri Tudor
Macedonia, FYR	Velko	Velev	TC-IR CP	IPH
Malta	Joseph	Bartolo	Delegate	MCCAA
Netherlands	Jacco	de Pooter	TC-IR CP	VSL
Norway	Hans	Bjerke	TC-IR CP	NRPA
Poland	Michal	Derlacinski	TC-IR CP	GUM
Poland	Ryszard	Broda	IR Contact	POLATOM
Portugal	João	Cardoso	TC-IR CP	IST/ITN

Country	First name	Last name	Respondent type	Institution
Romania	Sorin	Bercea	TC-IR CP	IFIN-HH
Romania	Mirella	Buzoianu	Delegate	INM
Serbia	Nikola	Skundric	TC-IR CP	DMDM
Slovakia	Jaroslav	Compel	TC-IR CP	SMU
Slovenia	Denis	Glavič-Cindro	TC-IR CP	MIRS/IJS
Spain	Miguel	Embid Segura	TC-IR CP	CIEMAT
Sweden	Jan-Erik	Grindborg	TC-IR CP	SSM
Switzerland	Beat	Jeckelmann	Delegate	METAS
Turkey	Emin	Yeltepe	TC-IR CP	TAEK
United Kingdom	Lena	Johansson	TC-IR CP	NPL
Persons giving additional information when writing the report				
Montenegro	Tomislav	Andjelić		
Bosnia and Herzegovina	Amra	Šabeta		
Serbia	Jelena	Bebic		DMDM
Germany	Oliver	Hope		PTB
Greece	Eleftheria	Carinou	TC-IR CP	IRCL/GAEC-EIM
United Kingdom	Vere	Smyth		NPL

Statens strålevern
Norwegian Radiation Protection Authority

2017

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Årsrapport

StrålevernRapport 2017:2
Ionising radiation metrology infrastructure in Europe

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