

RADIOACTIVE WASTE MANAGEMENT AND DECOMMISSIONING IN ITALY

1. NATIONAL FRAMEWORK FOR MANAGEMENT AND REGULATION OF RADIOACTIVE WASTE AND DECOMMISSIONING

1.1 National Framework

1.1.1 Overview of national policy

Commercial utilisation of nuclear power in Italy started in 1963 and by 1981 four nuclear power plants, namely the NPPs of Garigliano (BWR), Latina (MAGNOX), Trino (PWR) and Caorso (BWR), and a LEU fuel fabrication installation (Bosco Marengo S.p.A.) had been commissioned. During that period the Nuclear Energy Research Agency (CNEN) – now the Agency for New Technologies, Energy and the Sustainable Economic Development (ENEA) - developed an extensive R&D programme on the nuclear fuel cycle with the operation of experimental fuel cycle installations (e.g. ITREC and EUREX).

The three NPPs of Latina, Trino and Caorso continued to be operated until 1987, when they were definitely shut down based on a governmental decision which interpreted the results of a national referendum, called upon after the Chernobyl accident, as the will to abandon the nuclear option. The NPP of Garigliano had been already shut down in 1978, for technical reasons.

At the same time the nuclear programme was cancelled, the Interministerial Committee for the Economical Planning (CIPE) required the National Electricity Company (ENEL S.p.A.) to start the decommissioning of the NPPs and a “Safe storage” (IAEA level 1/2) option was initially adopted.

In 1999, all ENEL S.p.A. liabilities and assets connected to nuclear power were assigned to a newly established company, named Sogin (Società Gestione Impianti Nucleari) S.p.A., whose shareholder is the Ministry of Economy and Finance, while the Ministry of Economic Development gives the strategic and operational objectives. The primary mission of the Sogin S.p.A., as detailed in the Ministerial Decrees of May 7th, 2001 and of December 2nd, 2004, and as a consequence of the change of the national decommissioning policy to the DECON strategy (IAEA level 3), is to cover the complete decommissioning of all Italian nuclear installations by 2024 and the safe management of the spent fuel and radioactive waste.

The spent fuel and the largest part of the radioactive waste to be managed in Italy derive from the operation of the above mentioned NPPs and fuel cycle facilities. As far as spent fuel is concerned, part of that has already been transferred abroad for reprocessing and the spent fuel still present in Italy is currently being sent in France for reprocessing. It is also envisaged that the conditioned waste resulting from the reprocessing will be returned to Italy.

Italy ratified the Joint Convention on the Safety of the spent fuel management and on the safety of the radioactive waste management” on February 2006.

In 2009 the Italian Government, with the aim to restart a new nuclear programme, promulgated a new Law (Law 99/2009) establishing the necessary legislative provisions, including the institution of the ASN (Agency for the Nuclear Safety). Other Legislative Decrees have been issued or were in preparation, but, after the Fukushima accident, a public debate brought to a another popular referendum on June 2011 that sanctioned again the abandon of the nuclear programme in Italy.

On December 2011 the Law n° 214/2011 abolished the new Nuclear Safety Agency (created with the Law 99/2009, but not yet applied) and the functions have been temporary assigned to ISPRA (that in fact continue its work as nuclear authority) waiting for a definitive asset of the regulatory organization.

1.1.2 Overview of relevant institutions

The competent national bodies involved in the regulation of activities related to the peaceful use of nuclear energy and, among them, to radioactive waste management and decommissioning of nuclear installations are:

Ministry for Economic Development

The Ministry for Economic Development (formerly of Productive Activities) is the authority that issues the operating licence for all nuclear and radioactive installations, taking the technical advice of ISPRA into account. For installations related to radioactive waste storage and disposal, the concerted agreement of the Ministries of the Environment Land and Sea, Interior, and Labour Health and Social Affairs, is also required.

ISPRA (Institute for Environmental Protection and Research)

ISPRA, established in 2008 from the former APAT, is responsible for control and regulatory inspections of nuclear installations in matters of nuclear safety and radiation protection. Any licence granted by the Ministry for Economic Development incorporate the corresponding technical prescriptions and legally binding requirements formulated by ISPRA. Moreover, ISPRA approval is required for detailed designs of any structure, system and component relevant to safety in any nuclear installation.

ISPRA is a governmental Institute, with administrative and financial autonomy, under the supervision of the Ministry of the Environment.

1.2 National, technical regulatory organisation(s)

1.2.1 Regulatory function

The key regulatory functions (licensing, assessment, inspection and enforcement) related to nuclear safety and radiation protection matters, including also the safe management of spent fuel and radioactive waste and decommissioning of nuclear facilities, are exploited in Italy by the following main bodies:

- a) The Ministry of Economic Development, as the authority which grants the licence/authorization for nuclear activities (from the design and construction to the decommissioning and waste disposal) and for major practices involving the use of ionising radiations. Authorizations are granted on the basis of the technical advice and specifications formulated by the Regulatory Authority (ISPRA – Institute for the Environmental Protection and Research), on the basis of the environmental assessment provided by the Ministry of the Environment Land and Sea, when applicable, and on the basis of the advice provided by the Ministries for the Interior, Labour Health and Social Affairs, and by the Region where the installation is located.
- b) ISPRA – Department of Nuclear, Industrial and Technological Risk, entrusted with the role of Regulatory Authority, is responsible for the assessment and the inspection on nuclear installations and on activities involving the use of radiation sources. ISPRA also approves detailed designs or activities related to the construction of nuclear facilities, which are part of the general construction licence granted by the Ministry of Economic Development. Any licence/authorization issued by the Ministry of Economic Development is based on the technical advice and specifications formulated by ISPRA,

which supervises, throughout its inspection activity, the compliance with the requirements established in the law, with the technical specifications issued in the Ministerial authorization Decrees and with the conditions attached to its approval. ISPRA inspectors are entitled by the law with the proper authority to request the licensee any information deemed necessary to ascertain compliance with legal requirements and licence conditions. ISPRA inspectors also report the results of their inspections to the Public Attorney of the jurisdiction the installation belongs to. ISPRA is also the competent body entitled to support the Governmental rule-making function in the field of nuclear safety and radiation protection and it is also entitled to issue technical guides pertaining the different operational aspects of the regulatory process.

It has also to be mentioned that duties and responsibilities assigned to ISPRA include supervision activities on safeguards and physical protection, the exploitation of a technical support function in the field of emergency preparedness and of a control function in the field environmental radioactivity.

In 2011, the regulatory framework has been modified with the abrogation of the “Technical Commission on Nuclear safety and Radiation Protection”. This Commission was entitled to formulate an independent technical advice to ISPRA during the assessment process connected to the granting of licences, authorizations and approval of detailed designs.

1.2.2 Organization and resources

Within ISPRA the duties of the Regulatory Body are carried out by the Nuclear, Technological and Industrial Risk Department, where, at present, about 40 specialists, including inspectors, are working.

In relation to the key role played by ISPRA in the licensing process and in the supervision activity, and taking also into account the significant effort planned at national level in the fields of spent fuel and radioactive waste management and decommissioning, the increase of ISPRA human resources is expected, in order to ensure, in the next future, the preservation of competencies as well as the adequate coverage of all the regulatory issues relevant for the safe management of radioactive waste and decommissioning.

It should be noticed that, as provided by the Law n° 214/2011, the new Nuclear Safety Agency has been abolished (created with the Law 99/2009, but not yet applied) and the functions have been temporary assigned to ISPRA (that in fact continue its work as nuclear authority) waiting for a definitive asset of the regulatory organization.

1.3 National implementing organisations

1.3.1 Scope of responsibility

The organization in Italy in charge of the decommissioning of both NPP's and R&D ENEA nuclear fuel cycle facilities is SOGIN.

SOGIN is a shareholder company, totally owned by the Government through the Ministry of Economy and Finance. It is an engineering and site operation company and it is also the nuclear license holder, being therefore responsible of the licensing processes.

The overall program is to complete the decommissioning projects by 2025, provided that external conditions will be met, in particular the availability of a national waste repository.

Every year SOGIN has to submit to the National Authority for the Electricity and Gas an updated report on technical and economic plan of the global decommissioning project. The yearly reports have also to contain an update of the decommissioning plan and cost estimate. The levy on kWh, paid from the end

users (so called A2 component), are adjusted every 3 years on the basis of the content of the yearly reports. In this way, possible additional costs due to changes of strategies and the activities needed for safety reasons, can be endorsed by the National Authority for Electricity and Gas.

SOGIN is also able to provide nuclear and conventional services not only in the field of decommissioning both in Italy and abroad, combining plant design and operation knowledge.

1.3.2 Organisation and resources

SOGIN has a central headquarter with about 400 people and manages 8 sites (with 9 nuclear installations) where most of the personnel is SOGIN (about 350 people), but also people from ENEA have been incorporated temporarily.

Transition from operation to decommissioning has required and it is still requiring great attention in terms of organization, of skill assessment and of personnel motivation. A recent reorganization is aimed at identify responsibilities in a more clear way and to foster the decommissioning activities.

2. LEGAL FRAMEWORK

2.1 Primary Legislation and General Regulation

The present Italian legislative and regulatory framework related to nuclear and radiation safety is the result of an evolution of rules and standards that begun in the early 60^{ies} and that took into account the experience of licensing and operation of NPPs of different types and generations and of other nuclear installations. The system also covers the government of safety of spent fuel and radioactive waste management and decommissioning.

2.1.1 Statutes and Legislative acts

Law n° 1860 of 31st December 1962 published in the Italian Republic's Official Journal no. 27 of 30 January 1963, as amended by the President's Decree no. 1704 of 30 December 1965 (Italian Republic's Official Journal no. 112 of 9 May 1966) and by the President's Decree no. 519 of 10 May 1975 (Italian Republic's Official Journal no. 294 of 6 November 1975).

Law n° 225 of 24th February 1992, as modified by Legislative Decree 393 of 26th July 1996 promulgated in order to create National Service for the Civil Protection.

Legislative Decree n° 230 of 17th March 1995 published in the Supplement to Italian Republic's Official Journal no. 136 of 13 June 1995, implementing six EURATOM Directives on radiation protection (EURATOM 80/836, 84/467, 84/466, 89/618, 90/641 and 2006/117). The Decree replaced the previous DPR n°185 issued in 1964 and establishes radiation protection requirements for workers, public and environment.

Legislative Decree n° 241 of 26th May 2000 transposing EU (European Union) directive 96/29/Euratom laying down basic safety standards for the radiation protection of workers and the public; the standards laid down in the directive incorporate the 1990 Recommendations of the International Commission on Radiation Protection (ICRP) into EU radiation protection legislation. Decree no. 241 has modified and integrated Legislative Decree no. 230 of 1995.

Legislative Decree n° 257 of 9th May 2001 promulgated in order to modify certain details in Legislative Decree no. 241 of 2000 concerning requirements for notification and authorisation of non nuclear installations where ionising radiation is used for industrial, research and medical purposes.

Prime Minister Decree of 14th February 2003 declaring the emergency status in relation to the decommissioning and radioactive waste management activities in those regions involved.

Ordinance of the Prime Minister n° 3267 of 7th March 2003 establishes the measures for the implementation of provisions aimed at enhancing the level of protection of Nuclear Installations.

Law n° 368 of 24th December 2003 establishing the procedures for the site selection of a national repository for HLW.

Law n° 239 of 23rd August 2004 promulgated for the rearrangement of the energy sector extends the procedures established by the Law n°368 of 2003 also for the site selection of a national repository of LLW.

Decree of 2nd December 2004 of the Ministry of Economic Development provides directives to SOGIN for the implementation of decommissioning and radioactive waste management activities. The Decree also charges SOGIN to explore the feasibility of sending all the spent fuel currently stored in ITALY to abroad for reprocessing.

Law n° 282 of 16th December 2005 promulgated for the ratification of Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.

Legislative Decree n° 23/2009 related to the transposal of EU Directive 2006/117/Euratom, on the supervision and control of shipments of radioactive waste and spent fuel

Law n° 99/2009, related to the process to start a new nuclear programme, in Article 29, establishes a new Nuclear Safety Agency with the role of Regulatory Body. As already mentioned, the Agency will be made by the resources of the Nuclear Department of ISPRA and by resources from the Agency for New technologies, Energy and sustainable development (ENEA). The full establishment of this new Safety Authority has, however, still to be completed.

Legislative Decree n° 31/2010 related to the future nuclear development in Italy, provides criteria for the site selection procedure with the involvement of local administration, for the approval and for the compensation of the local municipality. The Decree includes also provisions for the site selection procedure of the national site for radioactive waste disposal giving the responsibility to SOGIN.

Legislative Decree n° 41/2011 amended the Legislative Decree 31/2010 with reference to the future nuclear development in Italy.

Law n°75 of May 26th 2011, That modifies all the provisions given in the Law n°99/2009 and in the Legislative Decree n° 31/2010, as amended by the Legislative Decree n°41/2011, relevant to the development of new NPP in Italy, relinquishing the nuclear development in Italy. The provisions for the development of the national site for LLW disposal and ILW-HLW interim storage has been confirmed. Furthermore, by abrogating the Articles 8 and 9 of the Legislative Decree no. 230 of 1995, The Law 75/2011 slightly modifies the regulatory process by cancelling of the “Technical Commission on Nuclear safety and Radiation Protection”. This Commission was entitled to formulate an independent technical advice to ISPRA during the assessment process connected to the granting of licences, authorizations and approval of detailed designs.

On the consequences of the Fukushima accident, the recent Referendum held on 12 June 2011 definitely sanctioned the abandon of the nuclear power development programme in Italy started in 2009.

Law n° 214 of December 2011 abolished the Nuclear Safety Agency (created with the Law 99/2009, but not yet applied) and the functions have been temporary assigned to ISPRA (that in fact continue its work as nuclear authority) waiting for a definitive asset of the regulatory organization.

Legislative Decree n. 1/2012 on the economic development, through the Art. 24, establishes new procedures to reduce the timing of the licensing phases for decommissioning activities with a strong involvement of local administrations.

2.2 Regulations concerning specific activities or facilities

2.2.1 *Radioactive waste management*

Activities connected with the treatment and the storage of radioactive waste in the facilities where it was generated are regulated by specific conditions attached to the licence and by the technical specification of the facilities. New and relevant waste management activities to be performed on a site (for example the construction of a temporary storage facility) are authorised following the approval requirements established for the management of plant modifications of nuclear installations, as defined by Section 6 of Law n. 1860/1962 and according to the procedure defined in the ISPRA Technical Guide n° 2/1975 “*Authorization procedure for nuclear installations modifications*”.

2.2.2 *Decommissioning*

The authorisation of decommissioning activities is regulated by articles 55, 56 and 57 of the mentioned Legislative Decree n. 230/1995. The applicant shall submit a Global Decommissioning Plan and a more detailed report related to the first decommissioning phase. Activities have to be authorised by the Ministry of Economic Development after consultation with the Ministries of the Environment Land and Sea, Interior, Labour Health and Social Affairs, together with the interested Regional Government and ISPRA. In the application of the licensing procedure, ISPRA has also the role to collect and integrate the advises formulated by the other administrations.

The authorisation may be granted either for a single phase, or for a number of intermediate phases, until the “green field” status of the site. In this case the documentation for each phase shall include a status report of the plant at the beginning and at the end of each phase and licenses will be issued for each phase.

This possible subdivision into intermediate phases must be shown to be part of an overall decommissioning plan, to be attached to the application for the authorisation concerning the first phase. For each phase the above bodies are sent a plan of the operations to be carried out and a description of the state of the installation, which will primarily include:

- an inventory of the radioactive materials;
- a description of the state of the installation itself at the end of the specific phase;
- a safety analysis concerning the operations to be carried out and the state of the installation itself at the end of the specific phase;
- the intended destination of the resulting radioactive materials;
- an assessment of the radiological impact to the environment of the decommissioning operations;

- a radiation protection programme also for emergency conditions.

For each decommissioning phase, the activities to be performed have to be described, together with their safety, environmental and radiation protection implications. The description has to include the initial and final state of the site and the solution envisaged for waste management and waste disposal. Identification and analysis of possible hazard and accident scenarios must be addressed in the application for each phase of the decommissioning plan, together with any implication for the off-site emergency plan and proposal for its updating.

All decommissioning activities must be performed complying with conditions and technical specifications laid down in the decommissioning licence; the set of rules and procedures related to the operation phase are progressively dropped as soon as they are no longer applicable. Systems, components and equipment relevant to safety and radiation protection are subject to a general regime of rules and procedures either specified in the decommissioning licence or, possibly, in sections of the operation licence still in force. ISPRA supervises decommissioning operations and carries out inspections to verify compliance with specifications concerning safety and radiation protection.

For installations which have filed the application for a decommissioning licence, in the wait the licensing process is completed, specific preliminary decommissioning activities, useful to improve the existing radiation protection level of workers and the general public, can be separately authorized.

For the decommissioning of NPPs, the implementation of an Environmental Impact Assessment (EIA) procedure is also required. The applicant shall prepare an Environmental Impact Study (EIS) to be approved by the Ministry of the Environment Land and Sea, describing the project, its purpose and scope, and justifying the preferred strategy. The Ministry of the Environment Land and Sea, on the basis of the advice of the concerned Region and of the EIA Commission, and in agreement with the Ministry for Cultural Heritage, gives its opinion about the environmental compatibility of the proposed project. The EIA process includes a Public Inquiry, whose comments are taken into account by the EIA Commission in making its advice.

2.3 Guidance on Implementation

2.3.1 Radioactive waste management

The reference regulatory document on radioactive waste management in Italy is the Technical Guide n° 26, issued by ISPRA, which provides waste classification as well as the technical requirements for the waste forms and the waste packages.

Other relevant guidelines are provided in the Technical Guide n. °8 “Quality Assurance Criteria”, and in the “Qualification and Control Programme for the Conditioning of the IInd Category waste” (Technical Position n.1/26), where it is stated that the operator must submit to the regulatory authority a complete documentation concerning:

- Quality Assurance Programme
- Adopted criteria for the waste conditioning facility design, operation and control
- Results of product characterization.

Within the framework of the National Standardization Organization (UNI) – Nuclear Energy Commission, the main Nuclear Operators, which ISPRA provides any needed information to, are involved in the preparation of technical standards defining specific aspects of radioactive waste management. In

particular, and with the reference to a generic Near Surface Disposal Facility, the following standards have been recently approved:

1. Criteria for qualification of conditioned solid radioactive waste
2. LLW radiological characterization for near surface disposal
3. Waste package identification procedures
4. Packages and containers for LLW
5. Record keeping in a near surface disposal facility
6. Basic design criteria for an Engineering LLW disposal facility
7. Qualification criteria for the engineering barriers of a LLW disposal facility
8. Monitoring system for a LLW disposal facility

2.3.2 *Decommissioning*

The licensing procedure to apply for decommissioning and the general content of the documents to be submitted are stated in the already mentioned articles 55, 56 and 57 of the Legislative Decree 230/95. More detailed technical guides are planned to be issued taking the very recent experience of the decommissioning license given to the first Italian NPP.

Technical Standards have been issued by the above mentioned National Standardisation Organisation such as the following, specifically addressed to decommissioning:

1. UNI 9498/1 - General criteria
2. UNI 9498/2 - Decontamination techniques
3. UNI 9498/3 - Storage and surveillance
4. UNI 9498/4 - Dismantling of structures and components
5. UNI 9498/5 - Radioactive inventory
6. UNI 9498/6 - Radiological characterisation and classification of materials
7. UNI 9498/7 - Criteria for partial release of a nuclear plant and/or site
8. UNI 9498/8 - Requirements for the temporary storage of radioactive wastes and materials

3. WASTE MANAGEMENT STRATEGY AND CURRENT PRACTICE

3.1 Waste classification and quantities

As established by the Technical Guide n° 26, radioactive waste are classified into three Categories on the basis of the radioisotopes characteristics and concentrations, and considering the possible options for final disposal as main guiding criterion:

Category I: Waste which decay in a few months to radioactivity level below safety concerns (mainly hospital and research waste with $T_{1/2} < 1$ year). (*disposal performed according to general waste regulations*)

Category II: Waste which decay to radioactivity level of few hundreds of Bq/g within few centuries. Activity of several radionuclides shall not exceed given values. (*near surface disposal*)

Category III: Long lived waste not included in category I and II; high level waste from reprocessing of spent fuel and alpha bearing waste from the fuel cycle and R&D activities. (*deep geological disposal*)

For the IInd Category waste, the document lists conditioning requirements and specific acceptance criteria for shallow land disposal.

Within Category II, two subcategories are defined:

- solid waste whose activities concentration is below established limits, as listed in Tab.1, which can be disposed of without further conditioning process;
- waste with activity concentration above the established limits which need to be conditioned and must fulfil further requirements, as listed in Tabs.2 and 3, to be accepted for final disposal.

Presently, the TG n°26 provides specific criteria and guidance only for the management and interim storage of Ist and homogeneous IInd Category waste, giving for the IIIrd Cat. only some general criteria.

With respect to the Category III waste (spent fuel, ILW and HLW), ISPRA is planning the revision of the Technical Guide n° 26 and the issuing of specific Safety Criteria and Technical Positions relevant to the management and the interim storage of radioactive waste resulting from the reprocessing.

Table 1 Limits under which a low-level waste can be disposed of without a conditioning process		
Radionuclides with $T_{1/2} > 5y$	370 Bq/g	(10 nCi/g)
$^{137}\text{Cs} + ^{90}\text{Sr}$	740 Bq/g	(20 nCi/g)
Radionuclides with $T_{1/2} \leq 5y$	18,5 kBq/g	(500 nCi/g)
^{60}Co	18,5 kBq/g	(500 nCi/g)

Table 2 Technical requirements for the IInd Cat. conditioned wastes	
Compressive strength	at least 5 MPa (UNI - Destructive tests for concrete)
Thermal cycling	after 30 thermal cycles [(-40°C) ÷ (+40°C)] compressive strength must be at least 5 MPa
Radiation resistance	after an absorbed dose of 108 rads compressive strength must be at least 5 MPa
Fire resistance	incombustible or self-extinguishing according to the ASTM D 635-81 test method
Leaching rate	measurement according to long term leaching test
Free liquids	measurement according to ANSI/ANS 55-1
Biodegradation resistance	compressive strength >5 MPa after biodegradation test ASTM G21 and G22
Immersion resistance	compressive strength >5 MPa after 90 days of water immersion
Radionuclide concentrations	not exceeding values of the Table 3

Table 3	
Radionuclide concentrations limits for the IInd Cat. conditioned wastes	
A emitters $T_{1/2} > 5$ y	370 Bq/g
B/ γ emitters $T_{1/2} > 100$ y	370 Bq/g
B/ γ emitters $T_{1/2} > 100$ y in activated metals	3,7 kBq/g
B/ γ emitters 5 y $< T_{1/2} < 100$ y	37 kBq/g
$^{137}\text{Cs} + ^{90}\text{Sr}$	3,7 MBq/g
^{60}Co	37 MBq/g
^3H	1,85 MBq/g
^{241}Pu	13 kBq/g
^{242}Cm	74 kBq/g
Radionuclides $T_{1/2} < 5$ y	37 MBq/g

Waste Inventory

The inventory of the Italian radioactive waste, at December 2011, is: about 26.500 m³ of IInd Category waste (4.300 m³ of VLLW and 22.200 m³ of LLW), and 1.700 m³ of IIIrd Category waste (ILW and HLW). To this amount it should be added some 20 m³ of vitrified HLW arising from reprocessing of spent fuel will be returned from Sellafield in the UK. Similar amount of radioactive waste will have to return in Italy from the reprocessing of the 235 t of spent fuel in France. In addition, some 30.000 m³ of L-ILW from decommissioning of nuclear facilities.

The national inventory of radioactive waste, disused sources and spent fuel presently stored at nuclear 21 installations is currently maintained by ISPRA. The Data Base is able to present the data in terms of volumes, mass, activity and physical status.

3.2 Waste management strategy

The large part of the radioactive waste existing in Italy has been produced in the past during the operation of the nuclear installations connected to the national nuclear power programme, definitely shut down in 1987 and currently under decommissioning. For these wastes the directives issued to Sogin by the Ministry of Economic Development with Decree of 2nd December 2004 indicate a target of 10 years to complete treatment and conditioning activities. The main additional waste to be managed in the future is clearly the one which will result from the decommissioning activities, as well as the high level conditioned waste which will result from the reprocessing of nuclear fuel abroad and which will be returned to Italy. A fraction to be managed is represented by the radioactive waste produced by R&D, medical and industrial applications.

At present, almost all the waste generated by the operation of nuclear installations is stored at the sites of origin and the waste produced by R&D, medical and industrial applications is stored in some facilities specifically devoted to the scope.

With references to spent fuel management, since the beginning of its nuclear programme, Italy had pursued the option of reprocessing abroad the spent fuel produced in its NPPs. After the political decision to stop all nuclear power activities, the shipments abroad of spent fuel for reprocessing were suspended with the last shipment to UK occurred in 2005, in the frame of a service agreement already in place.

As far as the spent fuel still present in Italy is concerned, the option of adopting an on-site dry storage was initially selected (strategic document of 1999 and Ministerial Decree of May 7, 2001). This strategy however resulted difficult to be implemented, mainly due to the strong opposition of local communities, who considered the presence of the dry stored spent fuel as an obstacle for the release of the site. This led the Government to reopen the option of reprocessing. In this regard, the Ministerial Decree of December 2, 2004 already included directives to Sogin to perform a feasibility evaluation of the shipping abroad of the spent fuel still existing in NPPs' and in interim storage sites, for its reprocessing with the subsequent re-entry in Italy of the resulting conditioned waste.

In November 2006 an Agreement between the Italian and the French Governments regulating the transfer to France of the spent fuel present in Italy (about 235 t) was signed. On this basis, in April 2007, Sogin signed a contract with AREVA. In June 2010, the shipment of spent fuel from Caorso NPP to France was completed and transfer of the spent fuel stored in the Avogadro AFR storage pool and in the Trino NPP is expected to be completed by 2013-14.

This Agreement provides indeed relevant elements of the Government new policy for radioactive waste management. By implying specific commitments to the Italian Government, it has the potential to overcome difficulties so far encountered (i.e.: selection of a site for the localisation of national waste storage facility and type of facility, construction of on-site temporary storage facilities) and then to expedite the implementation of the decommissioning operations. In fact this Agreement establishes a national road map for enacting all the modifications and integrations to existing legislative provisions as necessary to rule the implied matter (e.g. selection of a national site for a waste storage facility) and to execute all the construction works in order to have facilities ready and operational according to a time schedule to be established for the re-entry of the high and intermediate level waste packages.

In 2010, within the framework of Legislative Decree 31/2010, Sogin was selected as the Organisation responsible for the identification of the national site and the construction of the repository (surface and reversible). Within the same decree is laid out the siting procedure for the repository, which will be part of a technology park including a centre of Excellence for research and training in the field of decommissioning and radioprotection.

3.3 Waste management issues at national level

As already mentioned, almost all the radioactive waste produced by the past nuclear activities are stored in the nuclear installations of origin. In order to enhance the safety level of waste, plans of interventions are being to be implemented. They are referred to specific treatment and conditioning projects and to new interim storage facilities on the sites (by refurbishing existing buildings or by constructing new buildings). These new facilities will also be used to ensure temporary storage capacity for waste resulting from decommissioning preliminary activities.

Among the main foreseen activities on radioactive waste management, it is worth to mention the treatment and the conditioning of the operational waste at Caorso NPP; a conditioning system for fuel splitters at the Latina NPP; the conditioning of the liquid waste in the two reprocessing facilities Eurex and ITREC.

In connection with radioactive waste disposal, several preparatory studies and government initiatives were conducted in the past to identify suitable sites for a national repository. It is worth to mention the so called "*Task Force Site*" coordinated by ENEA, which operated in 1999-2000 with the mandate to prepare a list of potentially national qualified sites, and the work done by a Parliament/Region Commission tasked to prepare a document aimed at proposing a possible path to identify a site and to reach the necessary consensus. In 2003 and 2004, the Laws n. 368 of December 2003, and n. 239 of August 2004, provisions for the location of national sites to build repositories for the disposal of low and intermediate level waste and of high level waste. It must be said that substantial difficulties were encountered in the practical implementation of this law, in particular in relation to the site identification, due to the lack of acceptability by local population and authorities for such a type of facilities.

Law n. 368/2003 also establishes that, until the disposal site will be operative, the local municipalities where the nuclear installations are presently located will receive compensation by an annual fee commensurate to the radiological inventory of the actually stored spent fuel and radioactive waste.

Later on, in February 2008 the Ministry of Economic Development established a working group having the mandate to define the type of a centralized storage facility for the disposal of intermediate and low level waste radioactive waste and the medium term storage of high level waste as well as methodology and procedures for site selections. The group produced its report in September 2008.

More recently, in connection with the mentioned road map associated to the Agreement for the reprocessing of the spent fuel still stored in Italy, the Legislative Decree 31/2010 establishes the procedure for the localization and the construction of a national repository for the LLW disposal and the ILW-HLW long term storage, and assigns to SOGIN the role of the Implementer responsible for the construction and operation of the national repository. Legislative Decree 31/2010 also assigns SOGIN the role to propose areas suitable for the localization of the facility based upon criteria established by the IAEA and the Agency for Nuclear Safety.

The steps to be made in order to realize a national storage facility are described below, together with the timeframes to perform each of them.

At first, a list of suitable areas is proposed by the Implementer (SOGIN S.p.A.). Such a list should be defined based upon requirements from the IAEA and the new Italian Agency for Nuclear Safety (ASN).

After this preliminary selection, a period of 60 days for a public consultation is foreseen. A public presentation through a seminar by inviting the central and local interested Administrations will be organized by Sogin in this period.

Once the potential sites are approved by the Regulatory Authority, SOGIN invites the involved Regions to present its interest within 60 days. Once one (or more) Region shows interest, Sogin performs its extensive investigations on the site and within 4 months submit a request for authorization to the Regulatory Body, which express its judgement within 1 year. The license is foreseen to be unique (the authorization is given for construction, operation and closure).

In the case of lack of interest, Sogin will submit to the Ministry of Economic Development the list of the candidate areas indicating the first three more suitable sites, and within 30 days an inter-institutional Committee will be created, with the participation of representatives from different Ministries and Regions.

Due to the suppression of the new Nuclear Safety Agency (created with the Law 99/2009, but not yet applied), in 2012 ISPRA has been charged with the task to develop a Regulatory Guide on technical siting criteria for the identification of potential area where to realize a LLW near surface disposal facility and an Interim storage for ILW and HLW. A first draft of the Regulatory Guide has been prepared and a process of national and international review is on going.

Waiting for the availability of a national repository, radioactive waste are being stored in the nuclear installations of origin. Action plans are in progress to enhance the safety level of waste by implementing specific treatment and conditioning projects, by refurbishing existing buildings or by realizing new storage facilities on the sites. New facilities will also be used to ensure temporary storage capacity for waste resulting from decommissioning activities.

3.4 Research and Development

3.4.1 Research infrastructure

R&D is conducted by several agencies, institutions and universities, mainly at laboratory scale. Main activities are performed by ENEA within its Research Centres (CR) of Casaccia (near Rome), Bologna, and Saluggia (near Vercelli). ENEA is the name for the Italian National Agency for New Technologies, Energy and Sustainable Economic Development. Pursuant to art. 37 of Law no. 99 of July 23rd, 2009, the Agency's activities are targeted to research, innovation technology and advanced services in the fields of energy - including nuclear.

All nuclear research is carried out within the framework of: national R&D programmes funded by the Italian Ministry for Economic Development and the Ministry of Universities and Research; EU projects funded by EURATOM; other important international initiatives.

ENEA collaborates with the major national and international institutions, universities and research bodies. It is active part of agreements signed with the most important international nuclear organizations (International Atomic Energy Agency, Nuclear Energy Agency, EURATOM), and participates in the main EU research programmes (SNETP, EERA, ESNII, etc.). It also collaborates and exchanges researchers with the two major French nuclear research bodies (Commissariat à l'Énergie Atomique and Institut de Radioprotection et de Sûreté Nucléaire) as well as with US-DOE labs.

A three-year Nuclear Fission R&D national programme has received support by the Minister of Economic Development, based on "strategic funding devoted to the National Electric System R&D" (funded with a levy on kWh paid from the end users, so called A5 component) and focused on participation to international initiatives like INTD (International Near Term Deployment) and Generation IV nuclear systems and on studies and research on Near Surface Disposal of LLW, Long Term Storage and Geological Disposal of HLW. Total fund for the first three years amounts to about 20 MEuro (1,2 for R&D on radioactive waste management) and comparable funds are expected for the next three-years programme.

Main institution involved in these R&D programmes are:

- Government research institutions: ENEA, INFN (National Institute for Nuclear Physics) and - at a limited extend - CNR (National Research Council);
- Universities still active in nuclear field, grouped in the CIRTEN Consortium: Polytechnic of Milan, Polytechnic of Turin, University of Pisa, University of Roma1 "La Sapienza", University of Bologna, University of Padova, University of Palermo;

- Industries: Ansaldo Nucleare; Mangiarotti, SIET, FN

3.4.2 *Content of R&D plans*

Since its foundation, ENEA performs R&D on nuclear fission. Within the government programme relaunching nuclear energy as electric power source (before Fukushima), the Agency intensified its participation in the most important international research programmes by supporting the national industry's growth in know-how and skills. The technical and scientific activities are mainly R&D on advanced and innovative nuclear systems and medium-, long-term problem solving associated with the availability of fuel resources and minimization of long-life radioactive waste.

ENEA also performs training and dissemination of information aimed at increasing the sector's expertise and the public knowledge of the different aspects of nuclear energy in order to increase its acceptability.

Main R&D activities are:

- New-generation nuclear systems (advanced LWRs, Generation IV reactors) and on small and medium nuclear fission reactors (SMR). Particularly as regards Generation IV nuclear reactors, ENEA develops and manages technology infrastructures supporting the design and feasibility demonstration of liquid-metal-cooled reactors (LFR – Lead-cooled Fast Reactor, SFR – Sodium-cooled Fast Reactor) and gas-cooled reactors (VHTR – Very High Temperature Reactor).
- Development of test facilities for qualifying prototypical components and systems of innovative Nuclear Power Plants (SMR, LFR, etc.).
- Diagnosis and medical therapy techniques by using modular neutron flow-channels of nuclear research reactors (neutron radiography and tomography); characterization of materials under irradiation; neutronic codes validation.
- Development of engineering models and reactor processes simulation for safety and design studies on current and future nuclear systems and their fuel cycle; simulation of advanced control and protection systems; decision support models for plant operators; innovative man-machine interface systems.

For the **Radioactive Waste Management** the last R&D Plan has been focused on following main issues:

- support politic's decision making;
- critical review of the national inventory of radioactive waste to identify shortcomings, especially in terms of characterization, and needs for studies and R&D on radioactive waste;
- radioactive waste characterization; procedures for the physical, chemical and radiological characterization, definition of the whole integrated infrastructure technologies and services necessary for the characterization of radioactive waste in Italy; other specific issues: radiological characterization of waste containing HTMR (Hard To Measure Radionuclides); neutron detectors alternative to ³He proportional counters; active and passive neutron measurements.
- safe transport of radioactive waste;
- communication, information and training;
- site characterization procedures, performance assessment codes and transport phenomena modelling of radionuclides in the repository;

- environmental monitoring during the institutional surveillance phase;
- geological disposal of radioactive waste of high activity and long life: ENEA and CIRTEN are partners in IGD-TP;
- innovative processes for the treatment and conditioning of radioactive waste coming from advanced fuel cycles); pyrometallurgical separation processes for lanthanides/actinides, glass/glass-ceramic matrices for conditioning radioactive waste coming from those processes.

3.5 Financing of Radioactive Waste Management

3.5.1 Framework and responsibilities

Financial resources for radioactive waste management are included in the funds allocated for the decommissioning of the nuclear installation (see chapter 4.5), except the R&D funds, which are described in chapter 3.4.

3.5.2 Status of financing schemes

The cost of waste disposal is generally considered to be the most significant component of the cost of waste management, which in turn is one of the most significant components of the cost of nuclear facility decommissioning. Thus, it is important to have an early estimate of waste disposal costs for the purpose of calculating the long-term funding liabilities. These costs will depend on the charges for disposal of waste in the national repository. As this has not yet been designed the likely charges are unknown.

4. DECOMMISSIONING STRATEGY AND CURRENT PRACTICE

4.1 Decommissioning strategy

In 1999, the Ministry of Industry, Commerce and Crafts, now Ministry of Economic Development, issued a strategic document providing guidelines for the management of liabilities resulting from past national nuclear activities, including the previously mentioned establishment of Sogin S.p.A.

Other key aspects of this new policy were:

- the treatment and conditioning of all radioactive waste stored in the nuclear sites;
- the start up of a concerted procedure, by means of a specific agreement between the Government and the local authorities, for the selection of a national site where to build a near surface repository for low and intermediate level waste and an interim storage facility of the spent fuel and the high level waste;
- the adoption of the strategy for an immediate decommissioning (IAEA level 3) of all national shut-down nuclear installations, thus abandoning the previous “safe storage” option;
- the establishing of a National Agency for the management and disposal of radioactive waste, whose main mandate would be to realize and operate the national radwaste disposal site;
- the special fund allocation for all these activities by means of a specific withdrawal from the electric energy bills.

The directive of the Ministry of Economic Development indicated the year 2020 as the reference time for the completion of such activities.

The new policy was implemented by a Ministerial Decree of January 26, 2001, which established the plans and procedures for funding the activities associated with decommissioning of NPPs and nuclear fuel-cycle facilities. The strategy defined in this Decree was further detailed by another Ministerial Decree of May 7, 2001, which directed SOGIN to implement prompt decommissioning of the four national NPPs with a view to unconditional release of their respective sites within twenty years. The Decree also charged SOGIN with the safe management of radioactive waste and spent fuel from these NPPs using funds provided by the levy on electricity sale.

Following the directives included in the Ministerial Decrees of 2001, in summer 2003 SOGIN took under his responsibility also the fuel cycle facilities owned by other Organisations (ENEA and FN), with the main objectives to conduct the activities related to their decommissioning.

4.2 Status of decommissioning projects

As already said, all the Italian NPP's were definitely shut down many years ago and decommissioning plans have been submitted by Sogin to obtain the overall decommissioning license (IAEA level 3), to be granted according to the provisions envisaged in the Legislative Decree of March 17, 1995, n. 230.

In 2012 the decommissioning licences for Garigliano and Trino NPPs has been issued.

Main general features of the authorisation for decommissioning are:

- a general permit to pursue the decommissioning in the frame of the specific set of criteria and constraints,
- a specific permit to implement the actions identified as less critical, on the basis of specific controls on the specific activities to be performed by ISPRA, and
- a set of conditions for the activities that are most important to safety, radiation protection and waste management.

As far as the fuel cycle facilities are concerned, they were also shut down several years ago. At present their main activities regard the safe management of spent fuel and radioactive waste present on the site. The licensing process for decommissioning of Bosco Marengo LEU fabrication facility was completed in November 2008 and in 2011 the decommissioning plan for ITREC reprocessing facility has been submitted to ISPRA. For other facilities, activities related to the treatment of existing waste and to the management of the spent fuel have to be conducted. Also for these installations preliminary decommissioning activities are conducted based on specific approvals granted according to the procedure for authorising plant modifications.

With reference to the solid material produced in decommissioning activities, a general criterion is in force for unrestricted release from any installation subject to either notification or authorization requirements. Radioactive materials from such practices can be unconditionally released from regulatory control if the radionuclides concerned comply with conditions regarding both activity concentration and radioactive half life:

- activity concentration ≤ 1 Bq/g, and

- half-life < 75 days.

If both conditions above are not complied with, a specific authorisation is required for releases, reuse and recycle of the materials concerned. The authorisation can be given provided that the following criteria are complied with:

- a) Effective dose $\leq 10 \mu\text{Sv}/\text{year}$, and
- b) either Effective collective dose $\leq 1 \text{ man}\cdot\text{Sv}/\text{year}$ or the analysis demonstrates that exemption is the optimum option.

and with the additional condition of activity concentration < 1 Bq/g, general threshold of the Italian Law

In order to implement the above criteria, derived concentration values are established, making reference to EU documents.

With the reference to the above criteria, specific clearance levels for unconditional releases have been issued for different installations according to European Union directives and recommendations, and, in particular, specific levels of activity concentrations are included in the recently issued decommissioning licences for Trino and Garigliano NPPs for solid material release and building reuse or demolition.

4.3 Decommissioning issues at national level

For the installations having the spent fuel still stored at the pools, the schedule of decommissioning plan is strongly influenced by the implementation of the strategy related to the removal of the fuel.

A general key issue is represented by the current lack of a concrete programme for the construction of a waste repository. There is the need to realize interim storage structures on the site for materials resulting from decommissioning activities. In order to solve these issues it is necessary to gain the consensus of local communities and authorities.

The following regulatory issues are recognized during the assessment activities performed in the application of the NPPs decommissioning license procedure:

- decommissioning plans are strongly influenced by the decisions related to the fuel presently stored on site and to the availability of the waste repository;
- the ageing and obsolescence of some structures that have to operate during the decommissioning phase has still to be dealt with in a systematic way;
- the time since the final plants' shutdown is elapsing and the competences are going to be lost with the retirements of the most knowledgeable persons that had experience from plants' operation;
- there is a tendency to introduce frequent organizational changes in the Company in charge to perform decommissioning;
- the main dismantling techniques need to undergo extensive testing by use of mock up features to establish their effectiveness and radiological impact on workers.
- decommissioning and waste management are at present the most relevant remaining nuclear activities in the country: the lack of perspectives in the nuclear business reduces the motivation and the appointment of new resources.

As far as future developments in policy and regulations are concerned, efforts will be addressed to update Technical Guides pertaining decommissioning and radioactive waste management. This will be done taking into account the results of the WENRA activity on harmonization of safety reference levels on decommissioning and on the radioactive waste storage.

In addition, in relation to national activities regarding the site identification and construction of a national repository there is the need to establish safety requirements relate to its siting, design, construction, operation and closure.

4.4 Research and development

4.4.1 Research infrastructure

No significant R&D activities are on going in the field of the decommissioning, which is now an industrial activity under the responsibility of SOGIN, including the decommissioning of the old fuel cycle research facilities owned by ENEA.

4.4.2 Contents of R&D plans

Within the wider context of the Technology park which will host the National Repository for LILWs and the interim storage for the HLWs, the legislative decree 31/2010 mandates a Center of Excellence for the scientific research and industrial development in the field of nuclear decommissioning. Laboratories are envisioned carrying out researches on:

- Radioactive waste and materials characterization
- Nuclear waste Packaging
- Laser on decommissioning
- Robotics in hostile environment
- Siting for geological disposal

4.5 Financing

When the nuclear power plants were still into operation, ENEL, on the basis of autonomous decision, started to set aside funds for the decommissioning. The early shut down of these plants prevented the possibility to set aside all the necessary financial resources. As far as concern research facilities of ENEA no funds were set aside for decommissioning.

According to the decommissioning strategy initially identified (SAFE STORE), ENEL calculated the amount of funds on the basis of the estimated costs to put the NPPs in the Safe Enclosure condition, maintaining them for 40 years before dismantling. In 1998 an additional fund has been set aside for the closure of the Creys-Malville NPP fuel cycle, after the decision taken by ENEL to give up its share in the NERSA Company.

As result of the change in the decommissioning strategy (DECON), the evaluations performed by SOGIN indicated an increase of the costs for dismantling, which are larger than those initially estimated for the previous strategy, due to the wider use of costly techniques (for example, remote operation) and additional expenses for the earlier need of the financial resources; these factors imply therefore the increase in the amount of the necessary funds, only partially compensated by the elimination of the expenses to

maintain the NPPs in the Safe Enclosure condition for 40 years. In any case the results are strongly dependant from the assumptions on the discount rate.

In this connection, in order to finance the additional decommissioning cost, the Ministry of Economic Development issued the Decree of 26th January 2000, which established the related instrument with a levy on the price of the electricity (so called “A2 component”).

4.5.1 Framework and responsibilities

The funds accumulated by ENEL have been transferred to Sogin S.p.A., which, as stated in Section B, is responsible for performing decommissioning and waste treatment activities for all nuclear installations (including ENEA ones). For this purpose, Sogin has been also charged to perform plans and cost estimations. The cost estimation is done as a best estimate. However, it includes a contingency depending on the specific activity and on the time of expenditure, together with the management costs of the new Company. The Levy raised on the price of electricity is set apart in a segregated fund under the supervision of the National Authority for Electricity and Gas (AEEG).

Every year Sogin has to submit to the Authority an updated report on technical and economic plan of the global decommissioning project. The yearly reports have also to contain an update of the decommissioning plan and cost estimate. The levy on kWh, paid from the final users, is adjusted every 3 years on the basis of the contents of the yearly reports. This ongoing process ensures that the decommissioning activities will always be funded and the total decommissioning costs will have adequate financing. In this way, the National Authority can endorse possible additional costs due to changes of strategies and the activities needed for safety reasons, for Electricity and Gas. Efficiency criteria related to the program management and to the progress of activities are taken into account in performing such adjustments.

Every three years the AEEG approves the updated overall decommissioning budget (up to a greenfield status of the sites) inclusive of an estimate of the costs of final disposal of all materials to the National Repository.

The AEEG has no competence in deciding the way decommissioning costs are estimated. It can, however, bring forward its preferred methodology or suggestions. In any case, the technical choices and methodologies related to the decommissioning activities have always been shared by Sogin with the AEEG.

4.5.2 Status of financing schemes

N.A.

ACRONYMS AND ABBREVIATIONS

ISPRA	Institute for the Environmental Protection and Research
APAT	National Agency for Environment Protection and Technical Services
CIPE	Interministerial Committee for Economic Planning
CIRTEN	Interuniversity Consortium for Technological Nuclear Research (www.cirten.it)
ENEA	Agency for New Technologies, Energy and Sustainable Economic Development (www.enea.it)
ENEL	National Electricity Company
SOGIN	Nuclear Installations Management Company