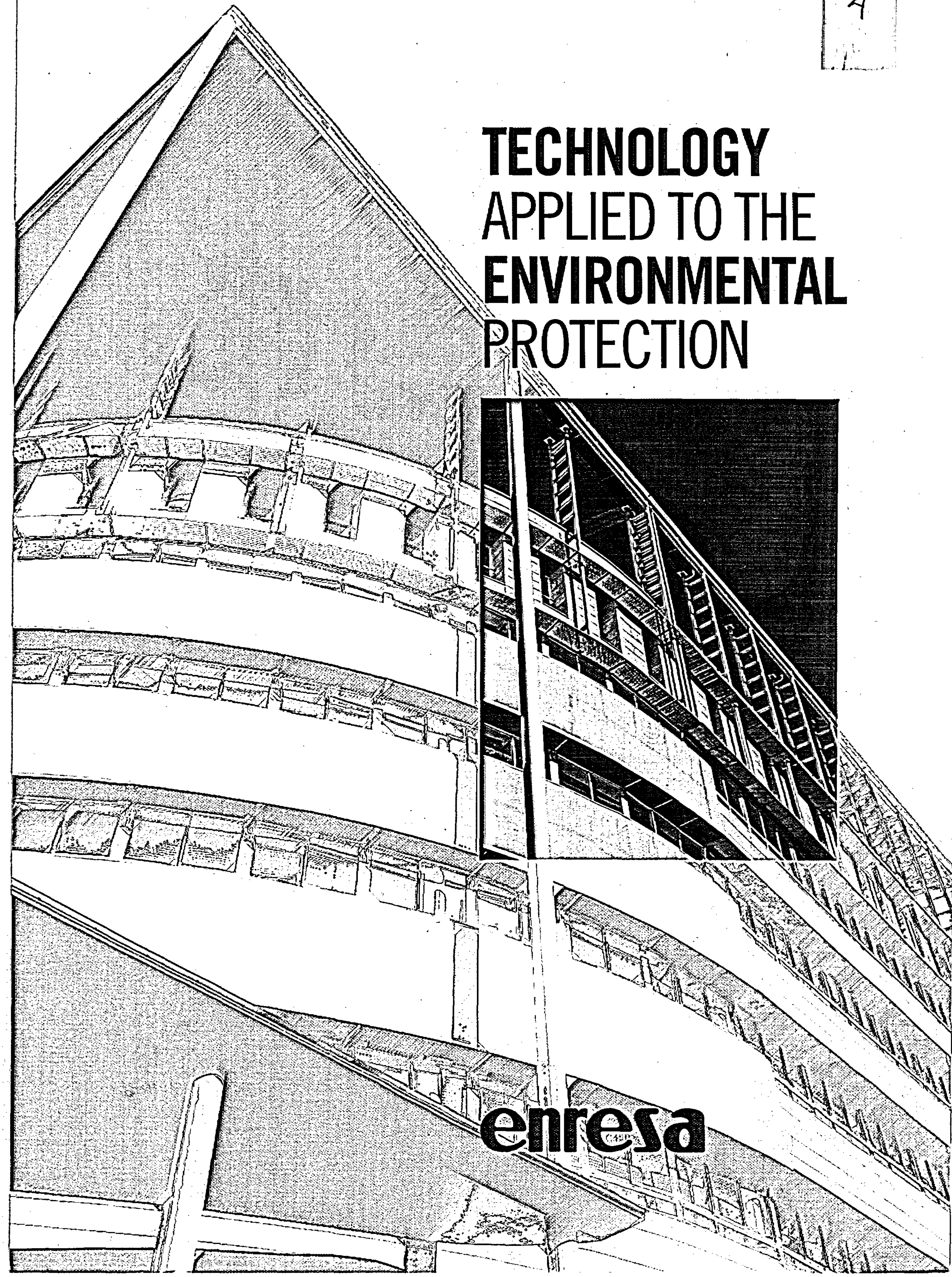
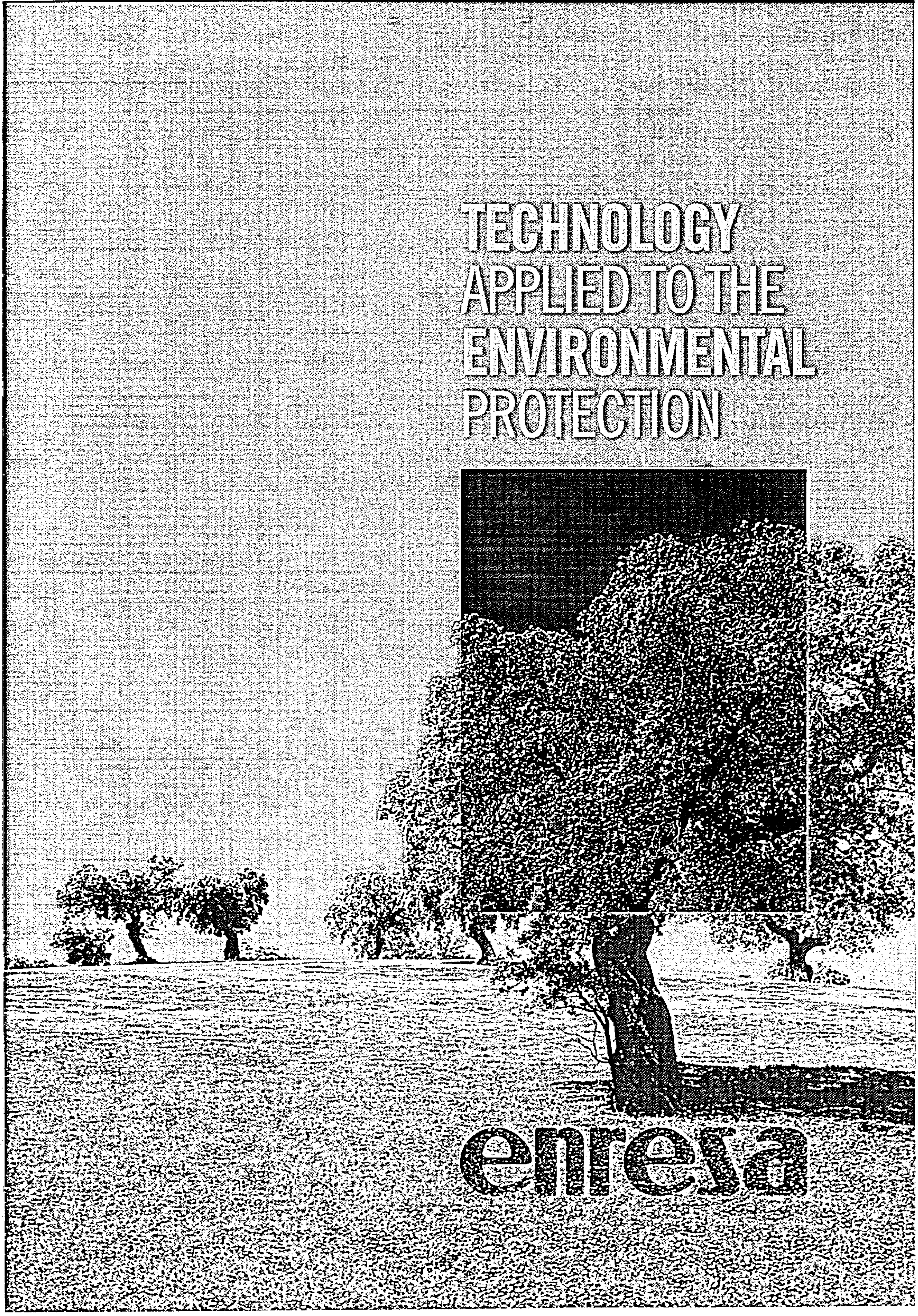
4

TECHNOLOGY APPLIED TO THE **ENVIRONMENTAL** PROTECTION

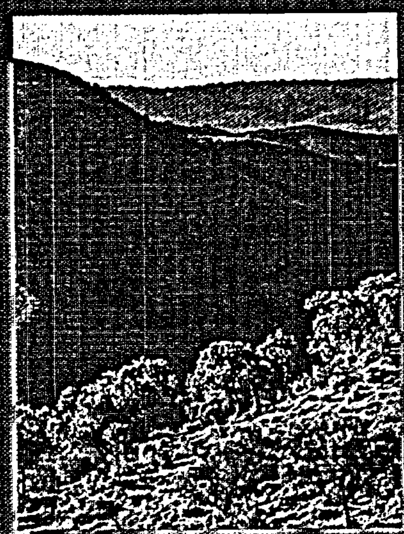


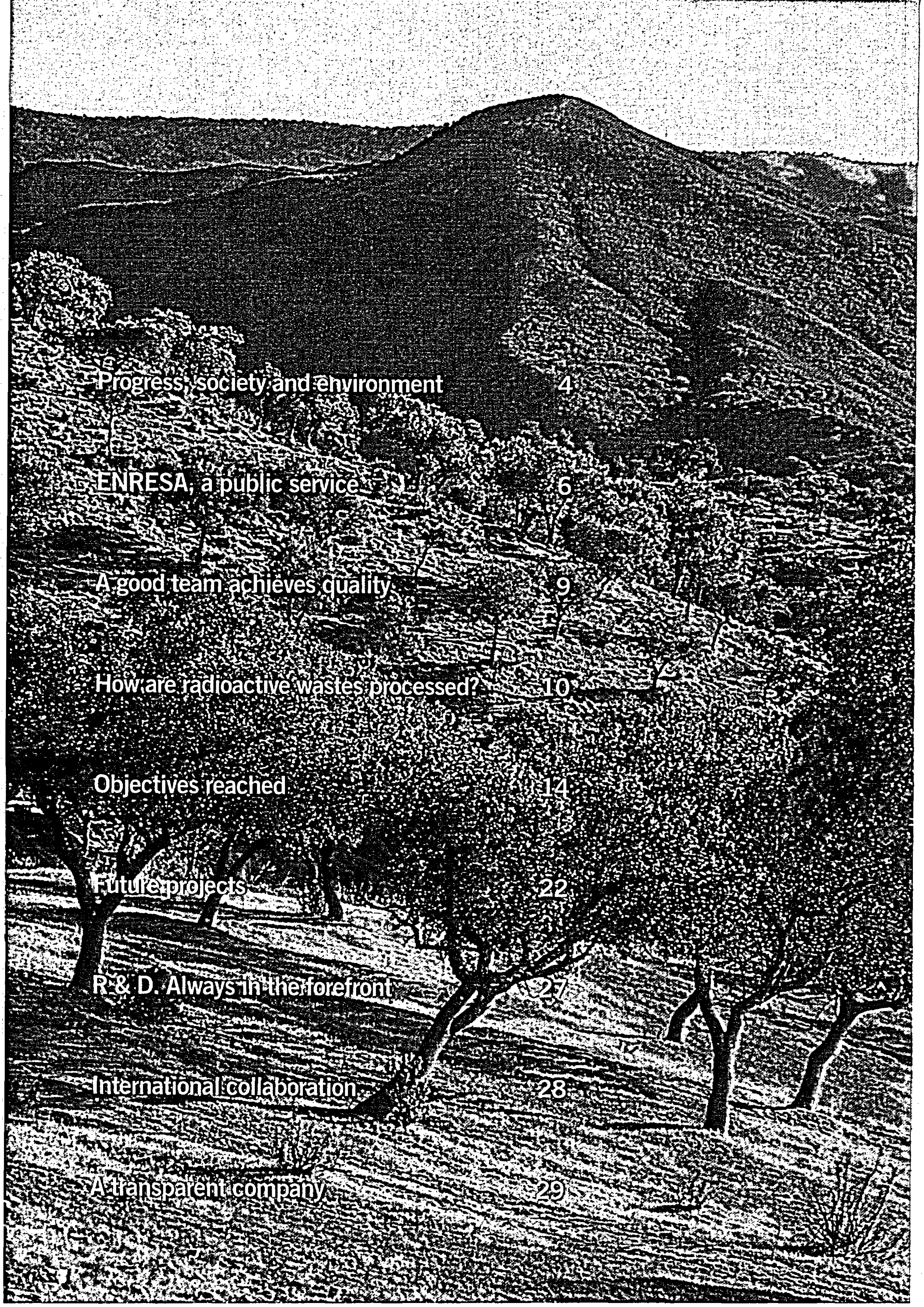
enresa

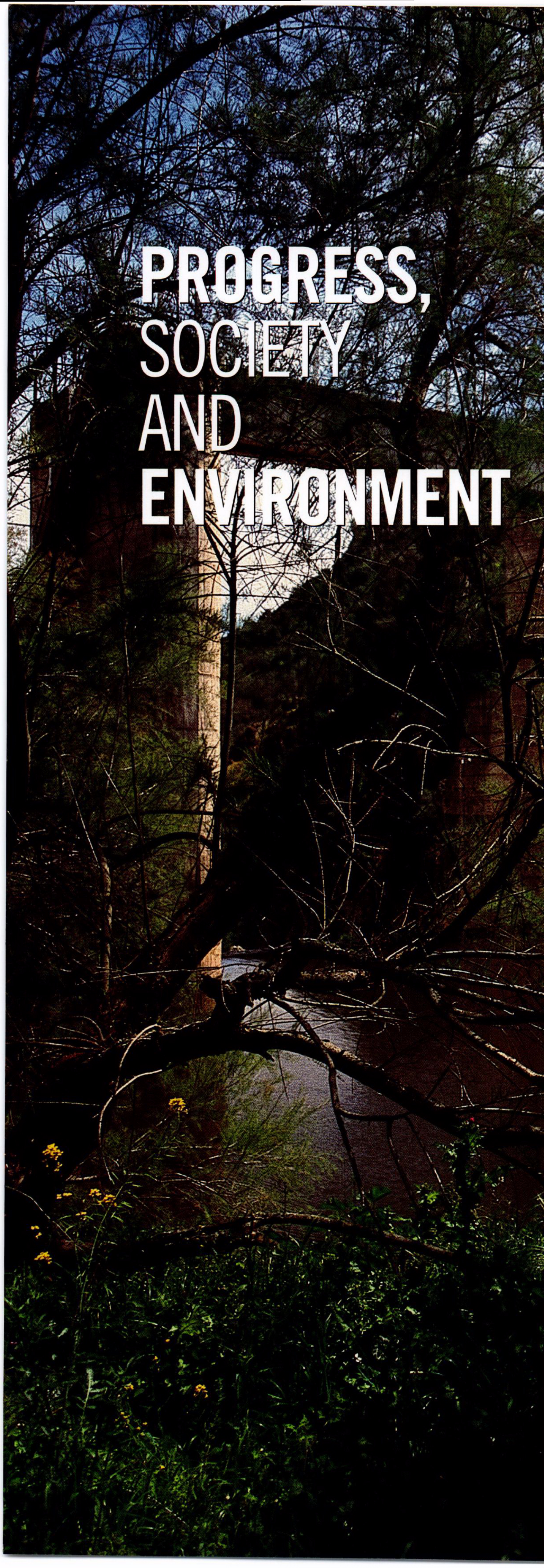
TECHNOLOGY APPLIED TO THE ENVIRONMENTAL PROTECTION



enresa

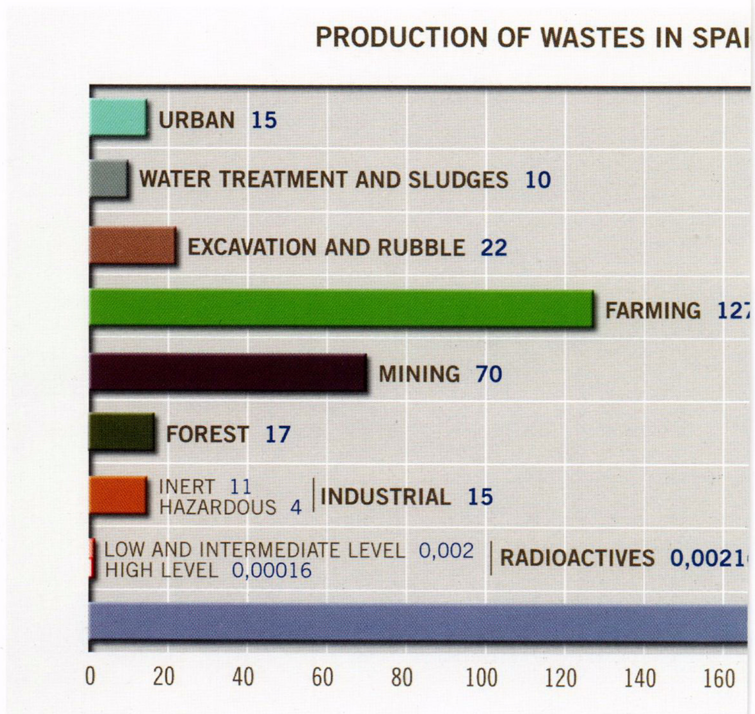






PROGRESS, SOCIETY AND ENVIRONMENT

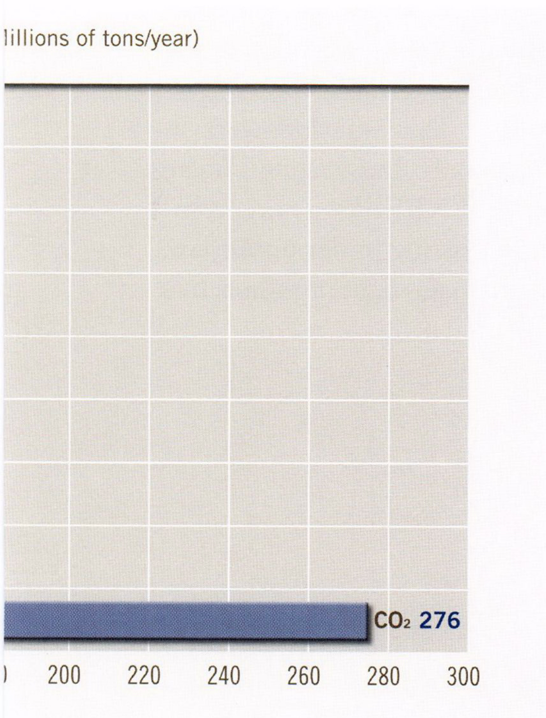
Since his very beginnings, man has shown great interest in improving his quality of life, bringing all his intelligence and resources to bear in striving to achieve this objective. Industrial development, scientific progress, new technologies and, in general, everything that has contributed to the well being of current society, have also resulted in the appearance of waste products with the potential to affect the environment.



Among these products are radioactive wastes, generated as a result of the application of nuclear technologies in different fields: the generation of electricity, industry, medicine, agriculture, research, etc.

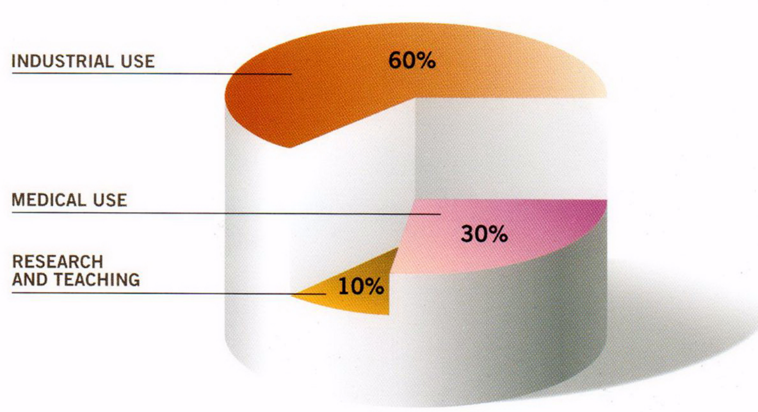
C01

At present, around a third of the electricity consumed in Spain is generated by the nine reactors operating at the country's seven nuclear power plants. In addition, there are some one thousand three hundred medical, research and teaching installations and industrial facilities authorised to use radioisotopes, of which six hundred generate radioactive wastes, this implying 10% of the total production of this type of wastes.

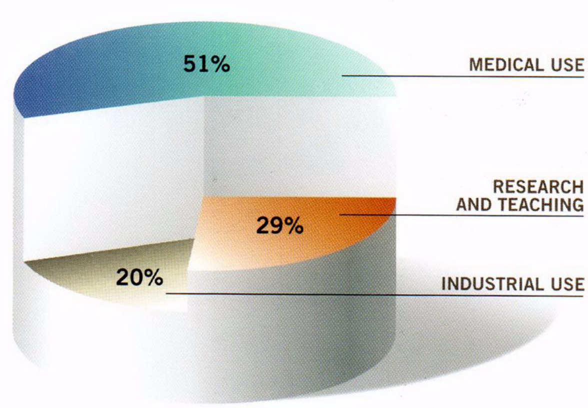


Diferent types of wastes produced in Spain.

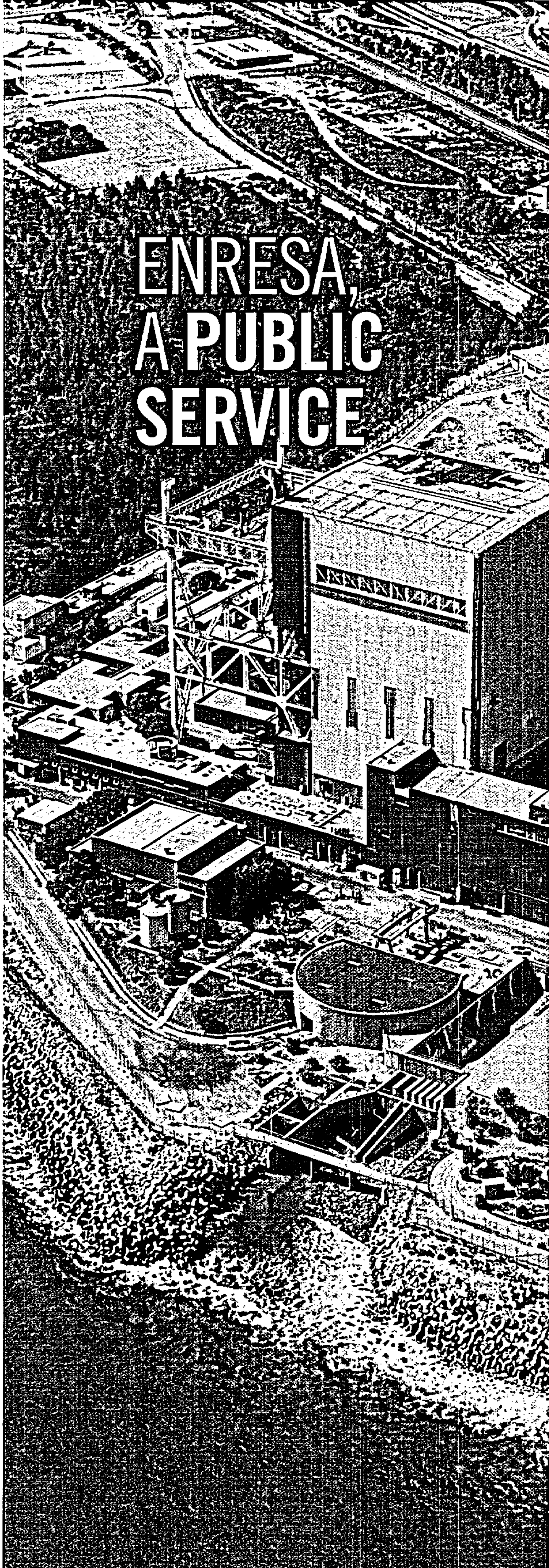
Installations authorised to use radioisotopes



Installations generating radioactive wastes



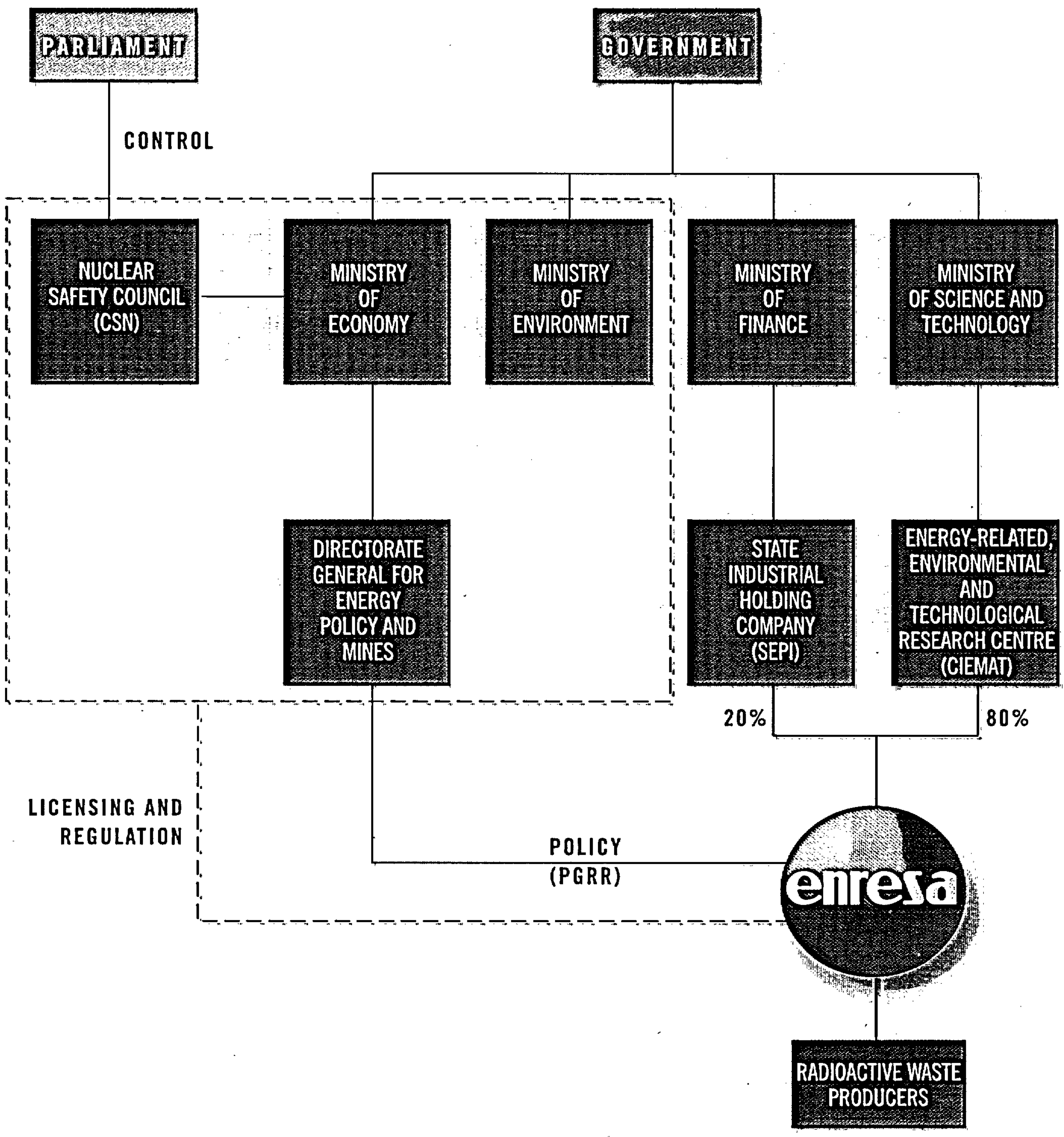
CO2

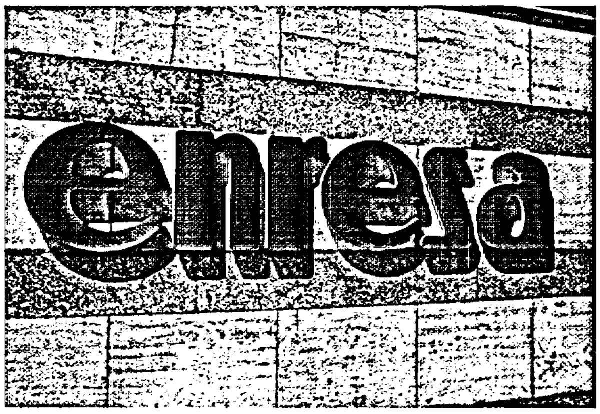


The development of techniques and applications deriving from nuclear energy reached a peak during the second half of the 20th century. This led the countries using these technologies to establish formulae to guarantee protection for people and the environment, against both the risks deriving from their use and the wastes generated by them.

In 1980, the Spanish Parliament decided to create an organisation to control the safety and radiological protection of people and the environment. The result was the constitution of the Nuclear Safety Council, the body with competence in these areas. This was followed, in 1984, by the National Radioactive Waste Management Agency (ENRESA), a non profit-making organisation existing under public law, responsible for the management of radioactive wastes in Spain.

Organisation chart

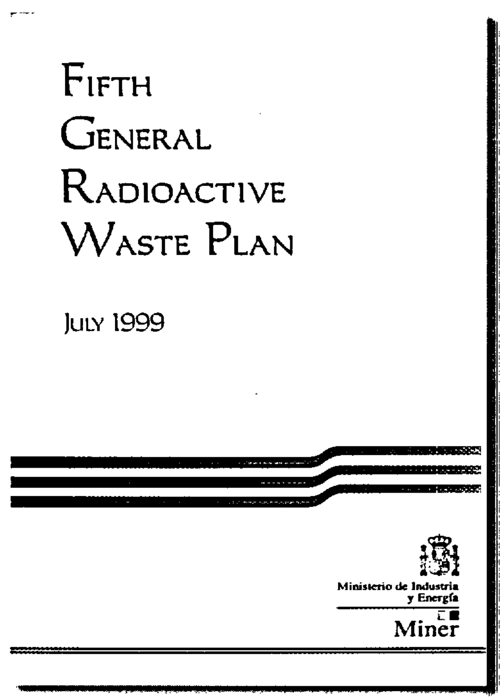




ENRESA's main missions are as follows:

- **The collection, transport, treatment, disposal and control of the radioactive wastes generated in Spain.**
- **The dismantling of disused nuclear and radioactive installations.**
- **The environmental restoration of uranium mines.**
- **Research and development.**

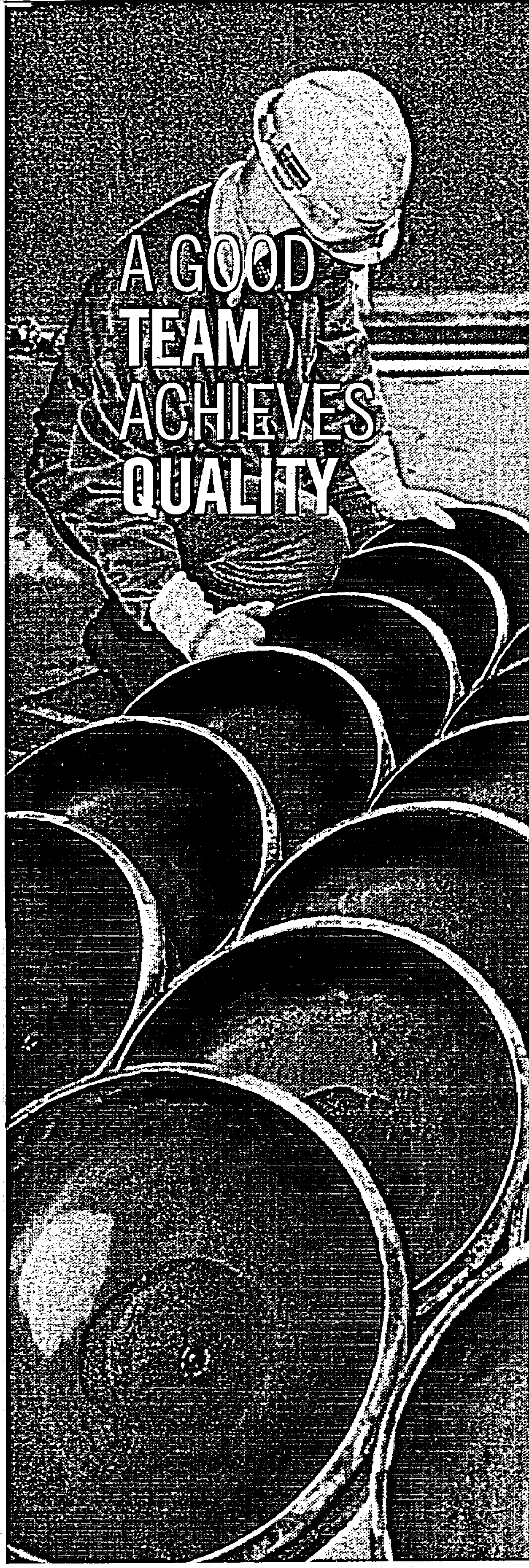
The Government establishes the course of action to be adhered to in order to achieve these objectives through the General Radioactive Waste Plan, a public document that is periodically updated.


FIFTH GENERAL RADIOACTIVE WASTE PLAN

JULY 1999

Ministerio de Industria y Energía

Miner



A GOOD TEAM ACHIEVES QUALITY

Technological development and an abundance of material resources are insufficient without the intervention of a motivated and highly specialised team of people.

In addition to the 300 people that work at the agency's own installations, more than 600 specialists collaborate with ENRESA from engineering companies, universities, research centres and other areas, guaranteeing compliance with the objectives mapped out in the General Radioactive Waste Plan, which constitutes the key tool for the management of radioactive wastes in Spain.

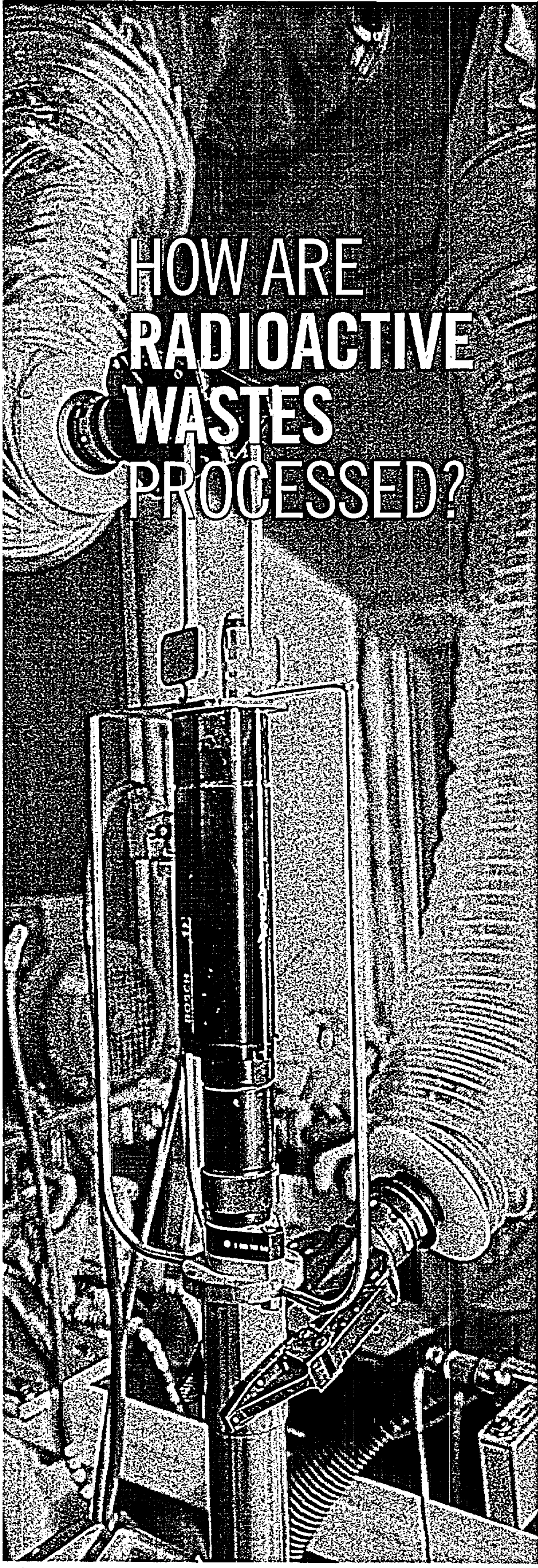
A reflection of ENRESA's commitment to quality is the fact that all its activities are covered by the AENOR quality certificate.

AENOR ER Empresa Registrada ER-0098/1/92

IQNet

Dismantling of the Vandellós I NPP.

HOW ARE **RADIOACTIVE WASTES** PROCESSED?



El Cabril Disposal Facility.
Quality verification laboratory.

LILW from medical applications.

Radioactive wastes are classified into two groups:

- **Low and Intermediate Level Wastes (LILW):**
  These contain short-lived beta and/or gamma emitting radioactive elements (half life equal to or shorter than 30 years) and do not give off heat.

- **High Level Wastes (HLW):**
  These generally contain alpha-emitting radioactive elements with a half life in excess of 30 years, and may give off heat.

Radioactive waste management requires a series of processes that constitute ENRESA's main activity, these being described below:

Low and intermediate level wastes

Inventory and characterisation

For the optimisation of the management of these materials, reducing their volume and designing the best techniques for their treatment, there is a detailed inventory that, among other things, includes their physical, chemical and radiological characteristics.

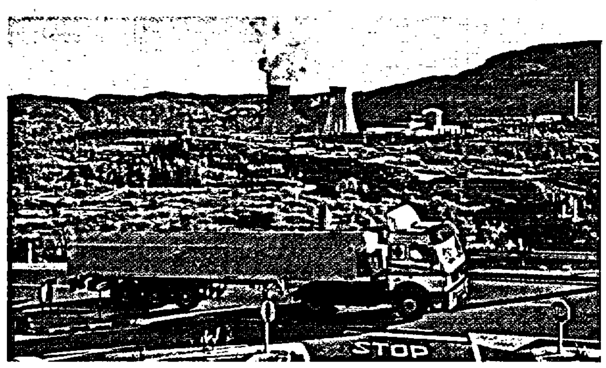
Collection and transport

Contracts are in place with all those installations that produce radioactive wastes. These contracts establish the way in which the producers are required to segregate the wastes and prepare them for removal by ENRESA, as well as the applicable tariffs.

ENRESA performs an examination prior to removing radioactive wastes, based on officially established technical specifications.

Transport is accomplished in accordance with the standards in force, which are applied in all the countries of the European Union, and under the strict technical control of the competent authorities.

LILW dose rate measurement.



LILW transport.

Conditioning

Prior to disposal, all LILW are subjected to a process of immobilisation to facilitate their handling and prevent dispersion. In certain cases, the wastes may be compacted to reduce their volume and take the fullest advantage of the storage capacity.

ENRESA uses its own facilities to condition the radioactive wastes from hospitals, industry and research centres. The nuclear power plants, however, perform their own preliminary waste conditioning, in accordance with the technical criterion agreed on with ENRESA and approved by the authorities.

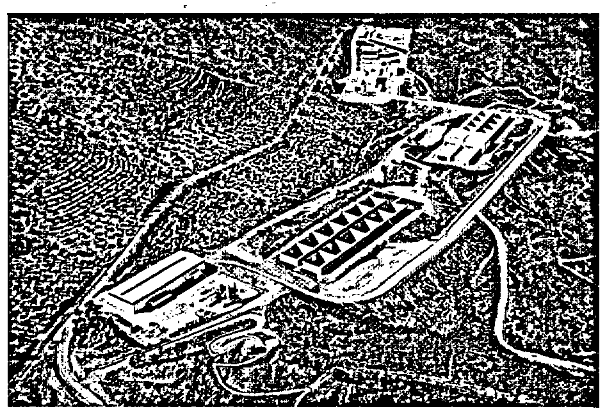
El Cabril Disposal Facility.
Concrete samples for quality control.

Quality control and verification

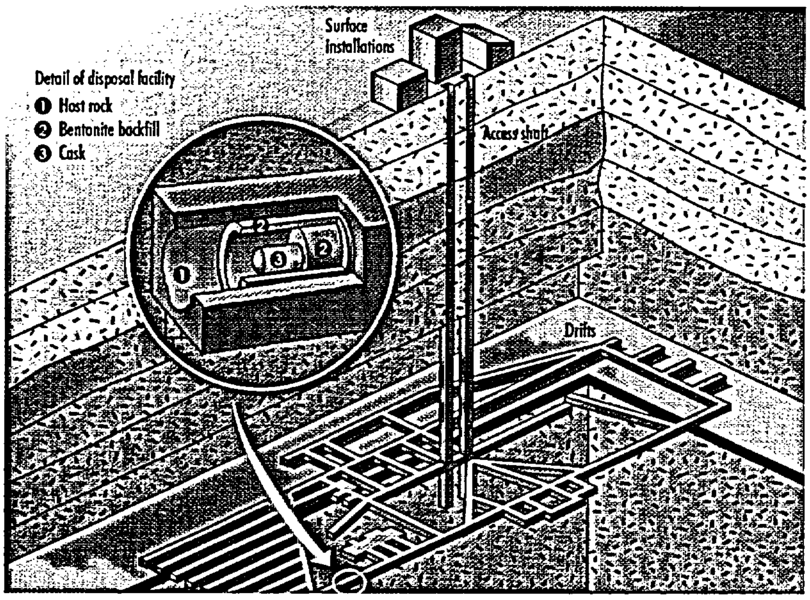
Prior to disposal, ENRESA controls and verifies the quality of radioactive waste conditioning, using the technical systems in place at the El Cabril waste Disposal Facility.

Disposal

The low and intermediate level wastes from industry, medicine, research and electricity generation are disposed of at ENRESA's El Cabril Facility, in Córdoba.



El Cabril (LILW) Disposal Facility.

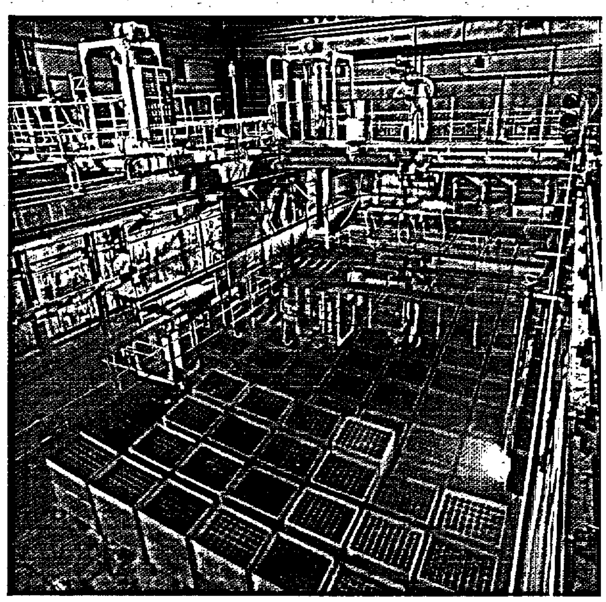


Deep geological disposal concept (AGP).

Spent fuel and high level wastes

The spent fuel from the nuclear power plants is required to undergo a prolonged period of cooling before final treatment. For this purpose, it is initially kept in the spent fuel pools of the plants themselves. Subsequently, it may be stored under dry conditions, in casks or other storage systems (silos, vaults) pending transport to processing or definitive disposal installations.

Spent fuel, or the high level wastes arising from its reprocessing or treatment by means of transmutation techniques, must be disposed of in stable geological formations at great depth.



NPP fuel storage pool.

OBJECTIVES REACHED

Since its creation, ENRESA has gone through a series of highly important stages in meeting its objectives, the following being the most relevant:

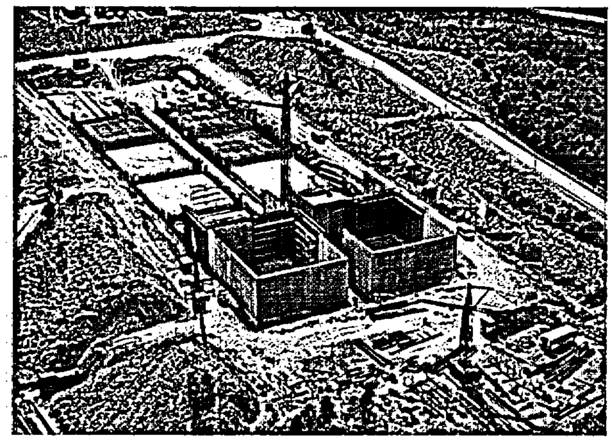
El Cabril Low and Intermediate Level Waste Disposal Facility (Córdoba)

One of ENRESA's first activities was to begin work on designing and constructing the new installations at the El Cabril Disposal Facility. The objective was to make available modern, safe installations covering the needs of the country. In 1992, this effort placed Spain in a leading position at international level in this area.

In addition to the disposal of low and intermediate level wastes, the El Cabril Facility undertakes other complementary activities. Radioactive wastes are treated and conditioned, concrete containers are manufactured for their disposal, the quality of waste conditioning is controlled and verified and research is carried out on resources and systems for confinement and on waste volume reduction techniques.

El Cabril Disposal Facility.
Insertion of conditioned drums in a storage container.

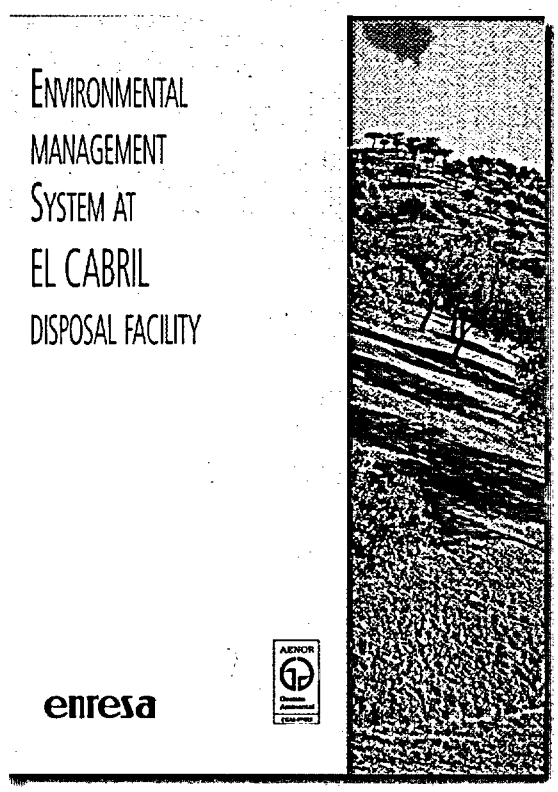
ENRESA's concern for environmental issues is one of the cornerstones of the activities performed at El Cabril, reflected in tasks such as care for the surroundings, minimisation of wastes by the facility itself, the optimisation of water resources and on-going improvement of processes. As a result of the above, the Environmental Management System received AENOR certification in 1997.

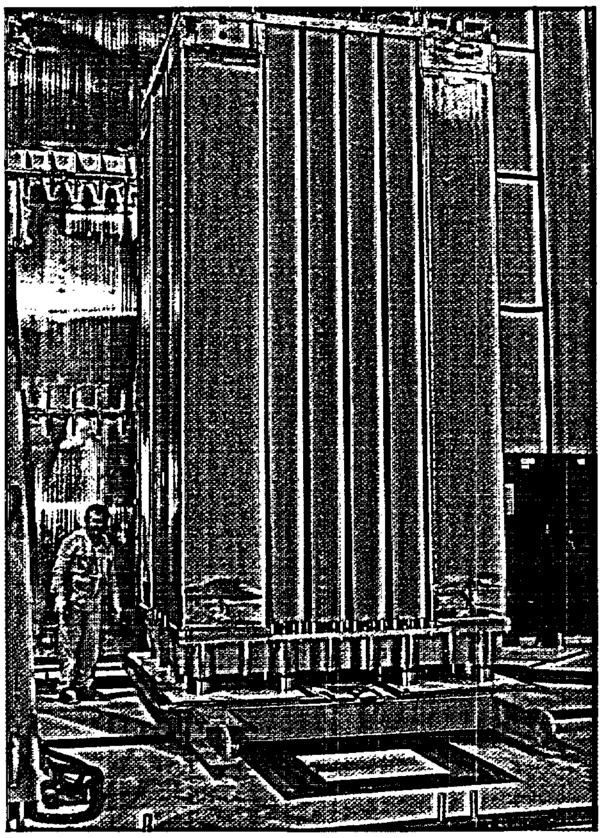


El Cabril Disposal Facility. Storage cell construction.

Once the disposal capacity of the facility has been depleted, and the operations for integration into the landscape have been completed, El Cabril will enter a surveillance phase and will become available for any use after 300 years.

The safety of the activities performed is checked through the Environmental Radiological Surveillance Plan (PVRA), which makes it possible to ensure, through systematic sampling of the air, water, soil, flora and fauna, that the El Cabril Disposal Facility does not affect the environmental radioactivity levels in the surrounding area.





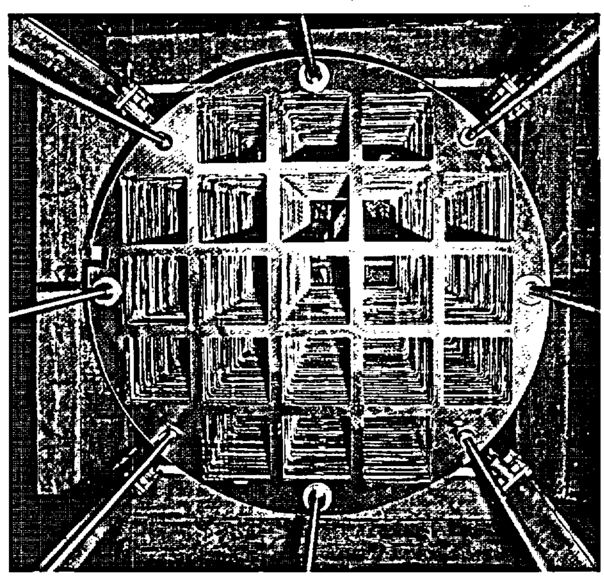
Reracking.

Temporary spent fuel management

At present, spent fuel is stored in the pools of the nuclear power plants themselves, for cooling and reduction of its activity (after the first ten years, the activity of the spent fuel has decreased by 99.5%).

In order to increase the capacity of the spent fuel storage pools, ENRESA, along with the nuclear plant owner companies, has replaced the conventional storage racks with other, more compact units of advanced design and made of special materials.

In order to guarantee the availability of an additional temporary storage system, ENRESA, in collaboration with North American and Spanish companies, has developed a metallic cask for dry storage. This cask, which will allow spent fuel to be stored for several decades, is also homologated for transport.



Storage cask for spent fuel.
Inner rack.

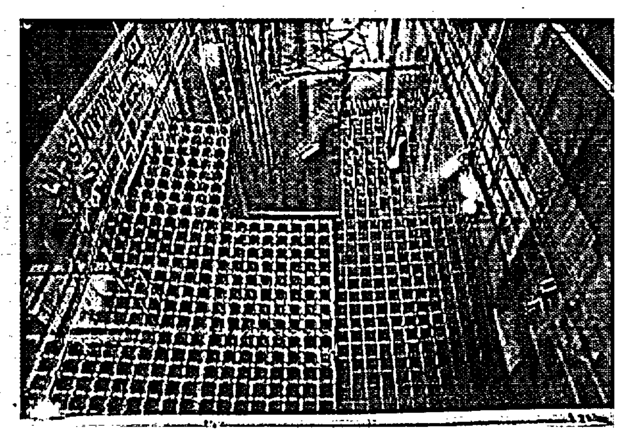
Removal of radioactive lightning rods

Royal Decrees 1428/86 and 903/87 established that the owners of radioactive lightning rods had to register them as radioactive installations, if they wished to keep them, or request their removal by a company authorised by the Government.

For this purpose, a census was drawn up of the radioactive lightning rods existing in Spain, and ENRESA began to disassemble and remove them, following an information campaign for owners and recycling tests on the isotopes that these rods contained.

The Plan undertaken by ENRESA meant the removal of more than 20,000 units.

Removal of radioactive lighting rods.



Racks at a NPP spent fuel storage pool.

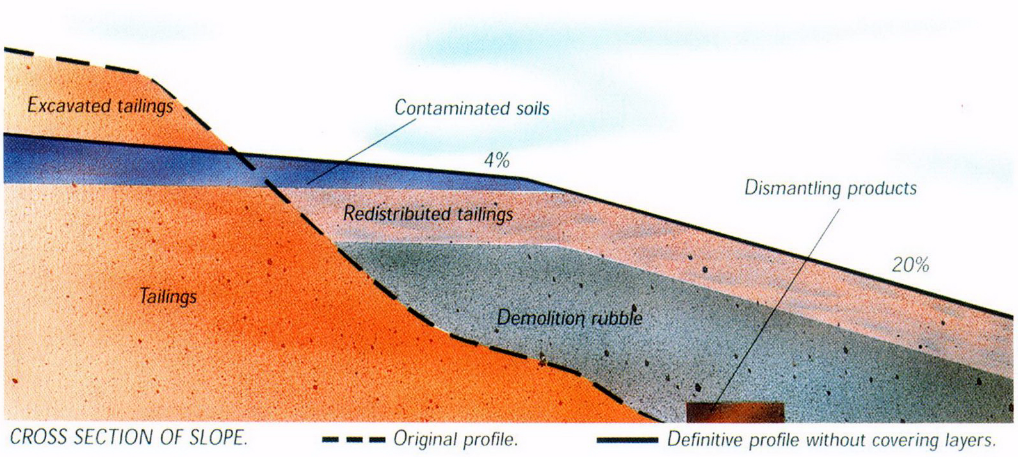
Andújar Uranium Mill.
Final state of the site after the remediation works.

Decommissioning and dismantling of the Andújar Uranium Mill (FUA)

The Uranium Mill in Andújar (Jaén) was used for the production of uranium concentrates from 1959 until 1981. When the facility completed its operating phase, there were 1,200,000 tons of mineral remains on the site, apart from the production installations, this material containing low concentrations of certain natural radionuclides from the original ore.

ENRESA dismantled all the facilities and conditioned the waste materials, confining them in the long term to prevent any interaction with the environment.

These operations required an important engineering and technical effort for the cutting and decontamination of the materials, as well as an Environmental Impact Statement, in accordance with the European legislation.



Andújar Uranium Mill remediation.
Cross section of slope.

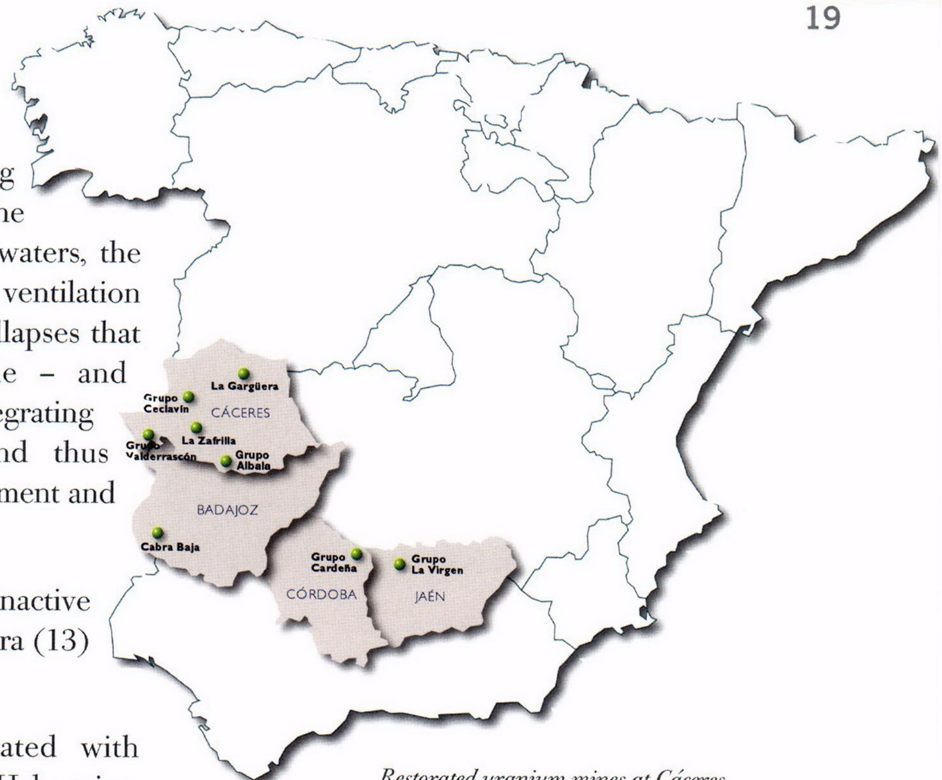
C03

Environmental restoration of disused uranium mines

In 1998, ENRESA started a programme for the recovery of land altered by uranium mining operations, which consisted of the protection of surface and groundwaters, the closure and sealing of shafts and ventilation conducts – in order to prevent collapses that might pose a threat for people – and replanting of the restored areas, integrating them into the surroundings and thus reducing the impact on the environment and the landscape.

Work was performed at nineteen inactive uranium mining sites in Extremadura (13) and Andalusia (6).

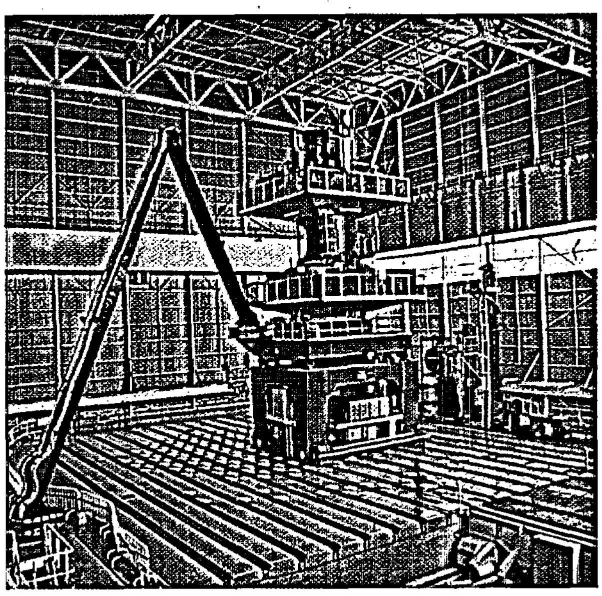
In addition, ENRESA collaborated with ENUSA in the restoration of the La Haba mine, in Badajoz.



Restorated uranium mines at Cáceres, Badajoz, Córdoba and Jaén .

"Ratones" mine. Groundwater monitoring equipment.

C04

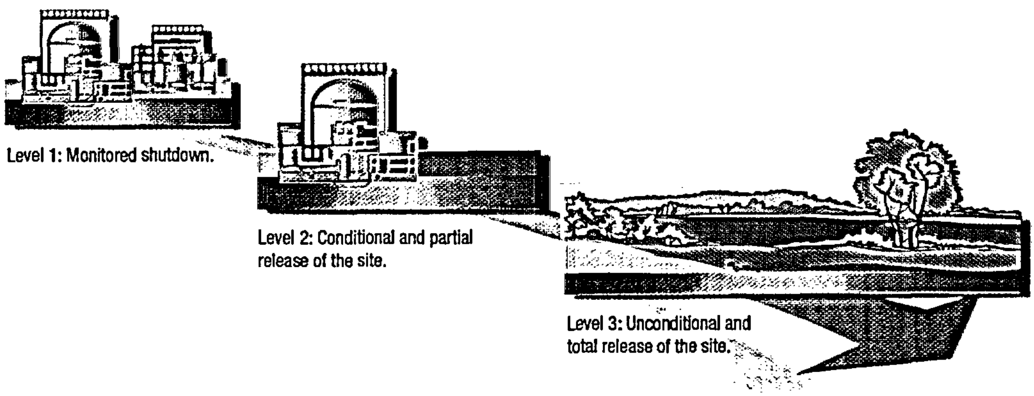


Vandellós I NPP. Reactor building.

Dismantling of the Vandellós I NPP

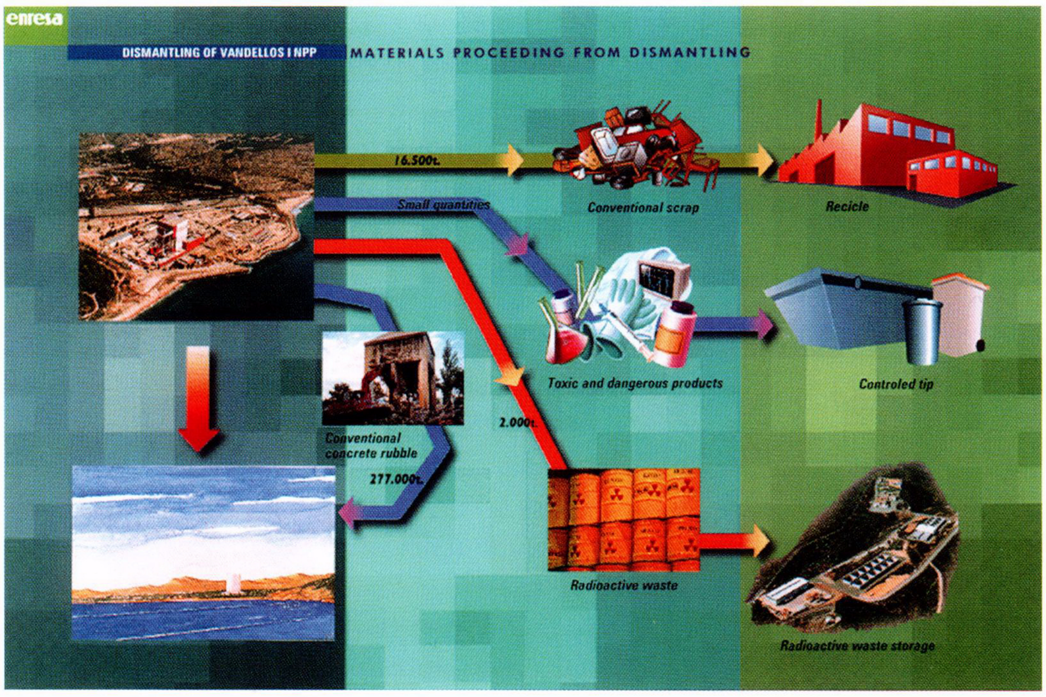
The Vandellós I nuclear power plant was shut down in 1989, entering the preliminary phase of decommissioning and dismantling.

In the wake of studies aimed at defining the technically and economically most appropriate strategy, the decision was taken in 1992 to initiate dismantling of the plant, except for the reactor pile (Level 2). Following approval of the Environmental Impact Statement and issuing of a favourable report by the Nuclear Safety Council, the Government authorised beginning of the works in 1998.



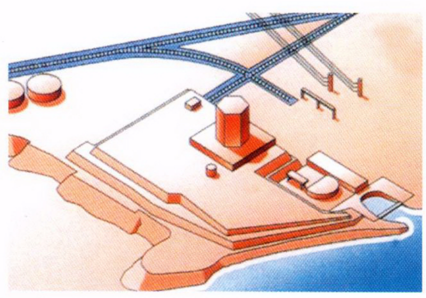
Dismantling levels.

The Level 2 dismantling of the Vandellós I nuclear power plant implies some five years of work, the key operating factors being the materials management process, the radiological controls and the Occupational Risk Prevention Plan.



When the works are completed, more than 80% of the site will be available for any use and available to the owner utility.

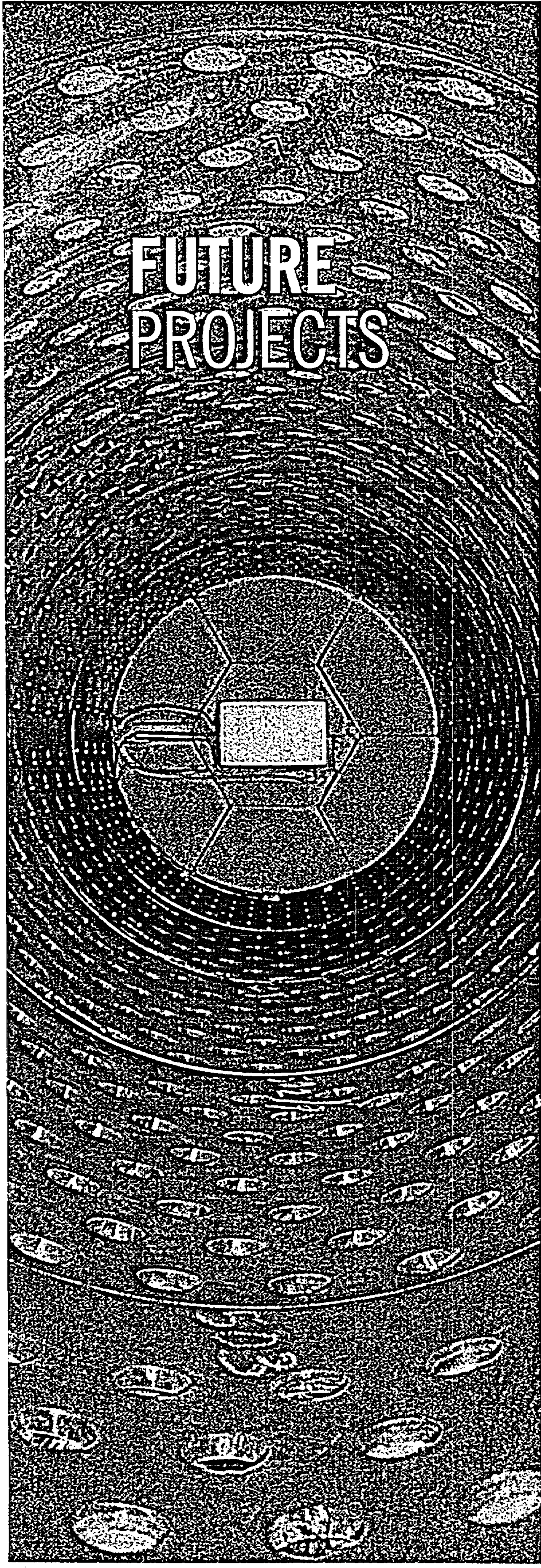
After 25 years the reactor pile will be dismantled, by which time the reactivity present will have decreased by 95%, with the corresponding reduction in radiological risk and, therefore, of costs.



Vandellós I NPP.
Latency period.

C05

FUTURE PROJECTS



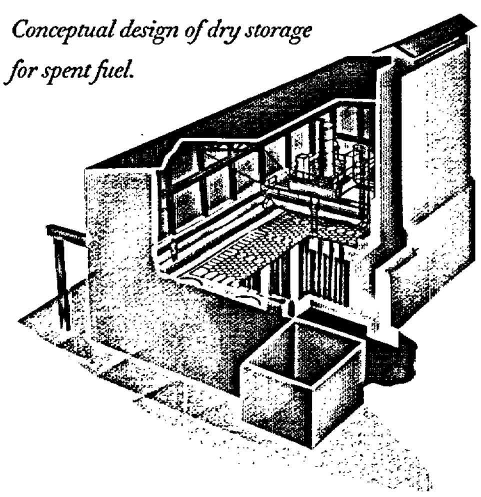
The future of radioactive waste management will be based on the implementation of increasingly safe and efficient systems, the main objective being to protect mankind and the environment and avoid the need for action by, and economic burdens for, the generations of the future.

Temporary spent fuel storage

Dry temporary storage is already a reality in the case of the Trillo nuclear power plant. This formula might be adopted by the other nuclear plants as the capacity of their storage pools becomes depleted. Nevertheless the General Radioactive Waste Plan establishes the advisability of having available a centralised temporary storage (ATC) facility allowing the fuel elements currently in the nuclear power plant pools and/or dry storage casks to be concentrated at one location.

This ATC facility would simplify the handling and surveillance of the spent fuel and would allow ENRESA to perform tests and studies on it.

Conceptual design of dry storage for spent fuel.



FEBEX project, Switzerland (Full scale experiment for a high level waste repository). Inside view of guide tube.

Definitive spent fuel management

Two lines of progress are currently being pursued by international research programmes. The first refers to the direct disposal of spent fuel in stable geological formations at great depth (AGP), in the case of the open fuel cycle, while the second relates to the separation and transmutation of long-lived radioactive elements, for the advanced closed cycle.

As a result, by the year 2010 it will be possible to provide the Government with the information required for decision-making in relation to the final spent fuel treatment system, as foreseen in the 5th General Radioactive Waste Plan.

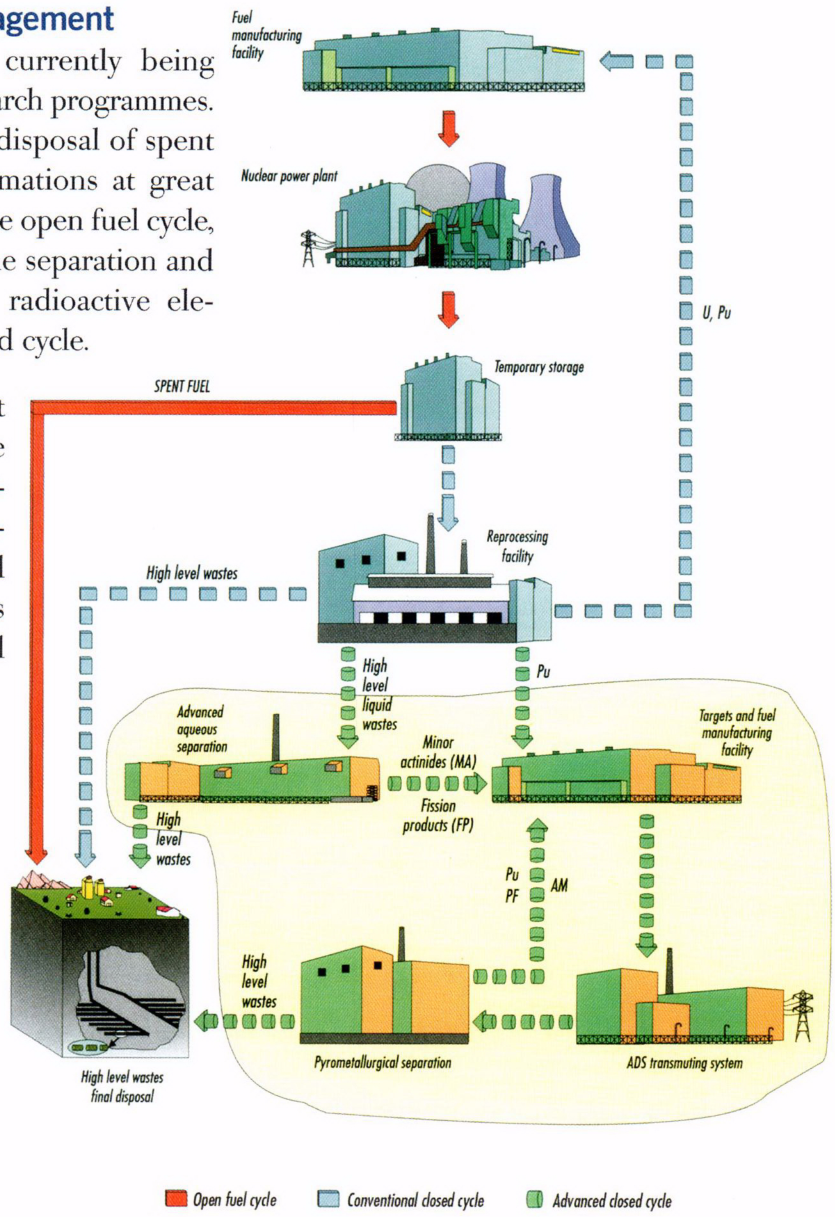
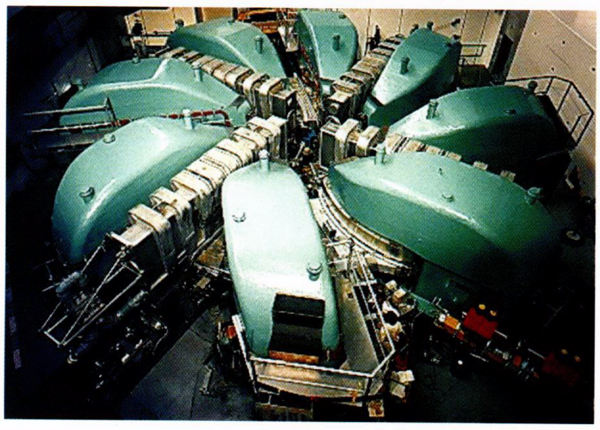


Diagram of open fuel cycle, conventional closed cycle and advanced closed cycle.

C06

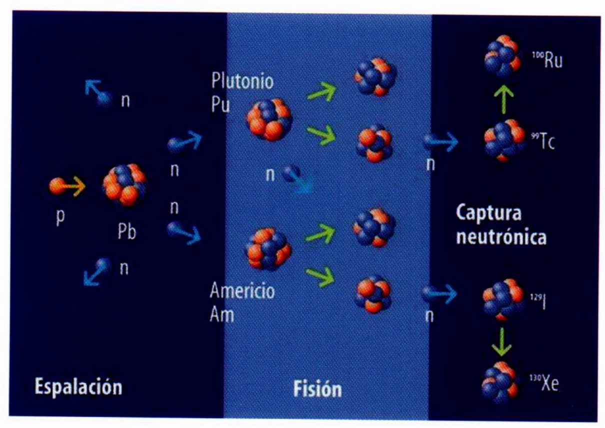


590 MeV Cyclotron for transmutation research.

Separation and transmutation

This consists of chemically separating the long-lived radioactive elements existing in spent fuel and of subsequently subjecting them to nuclear transformations in order to convert them into short-lived radioactive elements. Although this process might significantly reduce the high level wastes to be managed, it does not eliminate them completely, as a result of which there is still a need for a long-term storage system.

International research and development programmes are being performed in relation to these technologies, with the active participation of Spanish scientists.



Transmutation. Scheme.

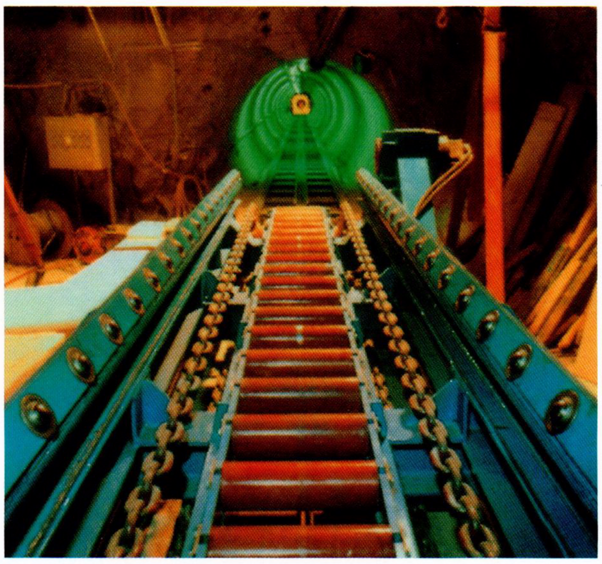
C07

Deep geological disposal (AGP)

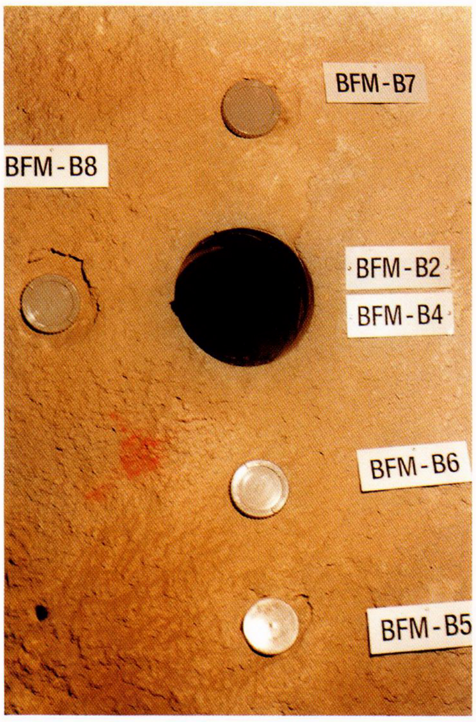
AGP consists of confining spent fuel or the high level wastes arising from its treatment (reprocessing and/or transmutation) in stable geological formations deep underground. This project contemplates three areas of work:

- Site selection studies: Spain has considerable potential as regards favourable geological formations. In any case, the designation of a future site will be determined by wide technical, political and social consensus.
- Basic design of the facility: this work has been performed in Spain on salt, clay and granite formations.
- Safety assessment: through profound knowledge of the behaviour of the materials to be confined and their interaction with natural barriers.

There is far-reaching international agreement as regards the safety and suitability of the AGP concept.

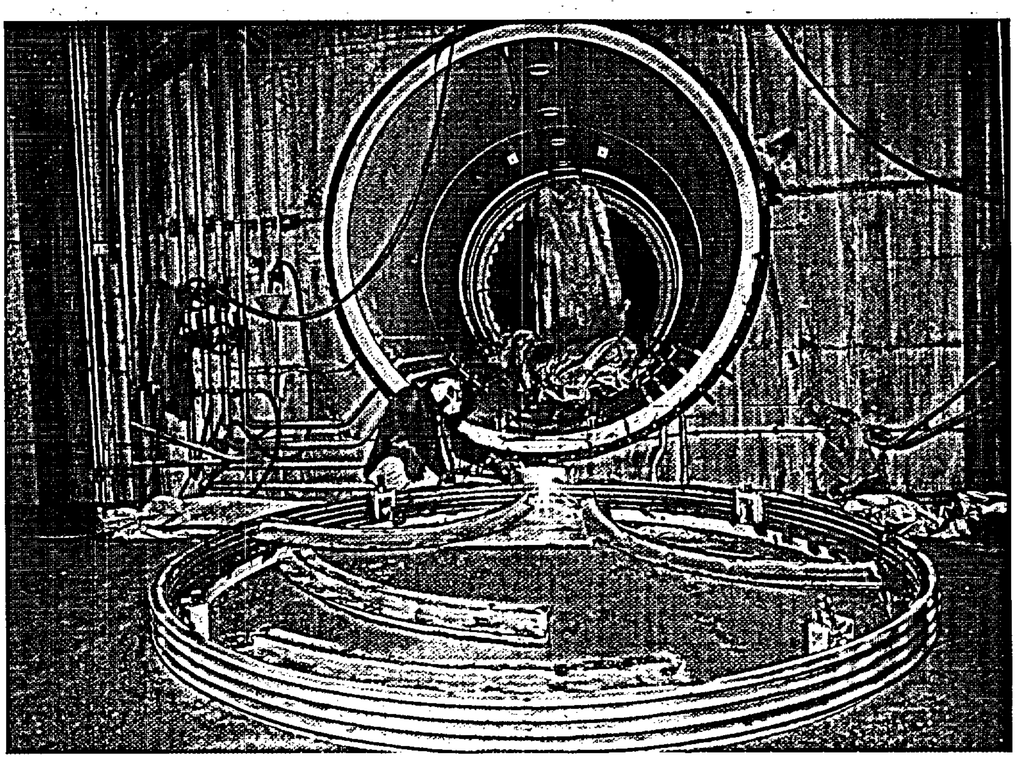


FEBEX project. Detail of drift.



MONT TERRI project. Detail of boreholes for studies of mechanical behaviour in clay formations.

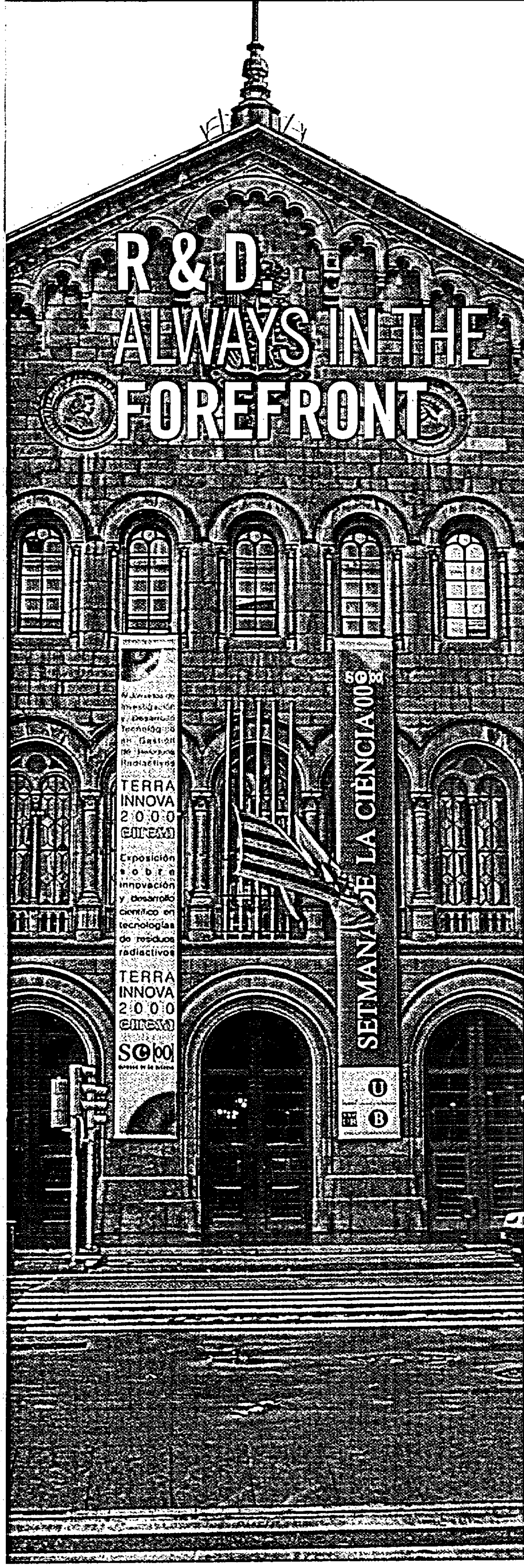
C08



Dismantling operations.

Dismantling of nuclear power plants

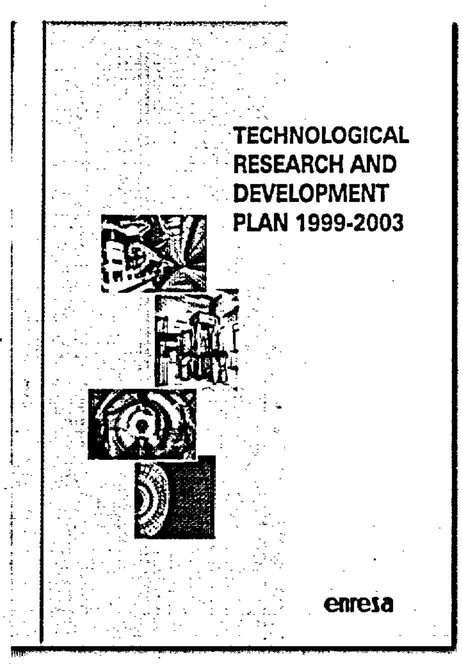
The experience acquired from the decommissioning of the Andújar Uranium Mill and the dismantling of the Vandellós I nuclear power plant will make it possible to address the complete dismantling of the Spanish plants at the end of their operating lifetime.



Research and Development (R&D) Plans relating to the management of radioactive wastes imply important economic and human resources investments. This effort overall amounts to 50,000 million pesetas. More than 600 scientists and experts from the most prestigious Spanish universities and research centres actively and regularly participate in this area.

The degree of technological development achieved in Spain has resulted in the availability of modern facilities for the treatment of LILW using the most up-to-date technologies, advanced dismantling techniques and versatile, modular temporary spent fuel storage systems.

At present, most of the research and development effort is made as part of the European Union's Framework Programmes, the main areas being safety assessment of deep geological disposal facilities and new radioactive element separation and transmutation technologies.



4th Technological Research and Development sessions on radioactive waste managemet. Terra-Innova 2000.

INTERNATIONAL COLLABORATION

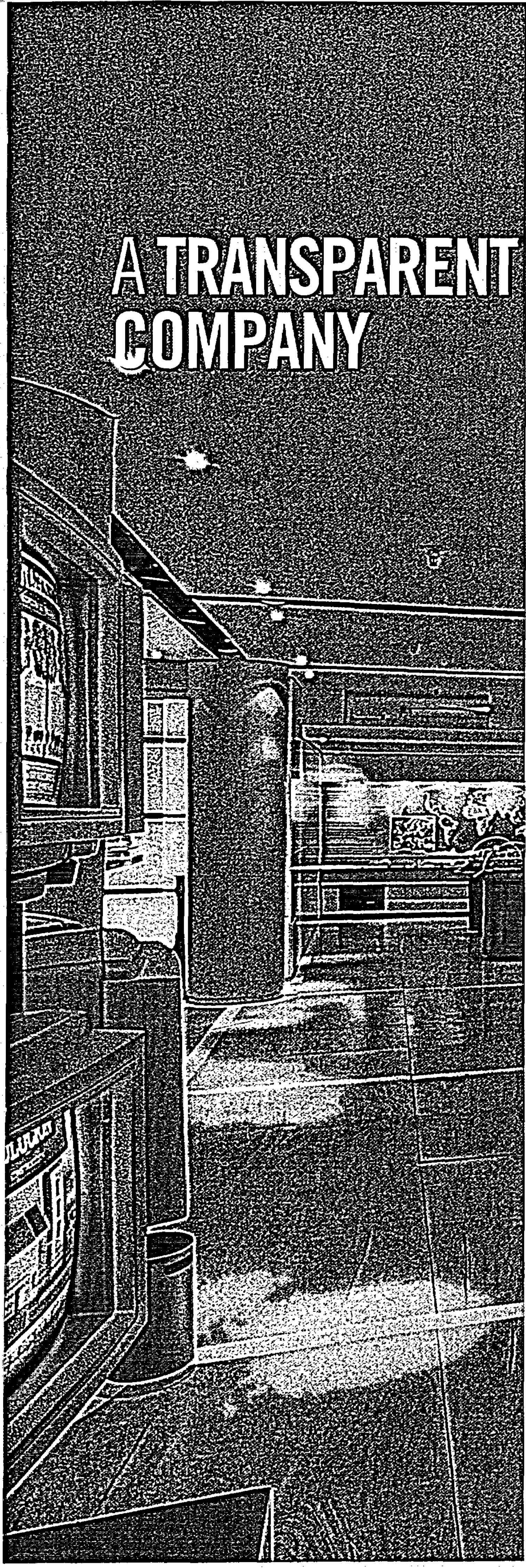
Far-reaching international collaboration exists within the European Union, the International Atomic Energy Agency and the Organisation for Economic Cooperation and Development, in both research programmes and the drawing up of directives and safety guides and technical assistance to other countries.

ENRESA also has numerous collaboration agreements with other technologically advanced countries, such as the United States, Germany, Sweden, Japan, etc., through which joint projects or programmes are carried out. This collaboration allows for the exchange of information on the technologies and systems that are being applied across the world, to adopt the best solutions in Spain.

The level of development reached in Spain allows technical support to be given to other countries, fundamentally through programmes established by the European Commission.

CD-ROM "Radioactive waste management in the European Union".

A TRANSPARENT COMPANY

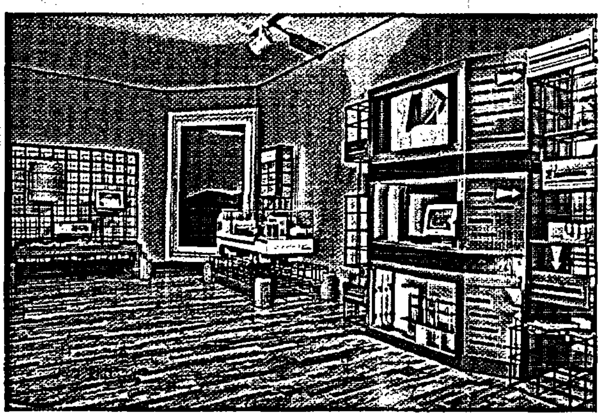


ENRESA's facilities are open to any member of the public who wishes to gain first-hand insight into radioactive waste management in Spain. The different Visitor Centres in El Cabril (Córdoba), Madrid, Andújar (Jaén), Vandellós (Tarragona) and Córdoba receive 25,000 visitors a year.

At these facilities the visitors encounter a series of supports (videos, interactive programmes, mock-ups) that provide them with an entertaining and easy insight into the different aspects of waste management.

But the provision of information does not stop at the physical limits of its installations and Visitor Centres. ENRESA has a website providing information on radioactive waste management in Spain.

There are also exit numerous booklets, videos and CD's describing the various projects and activities involved.



El Cabril visitors centre.

Madrid visitors centre.

ENRESA's magazines.

In addition, the company publishes various informative magazines destined for the general public:

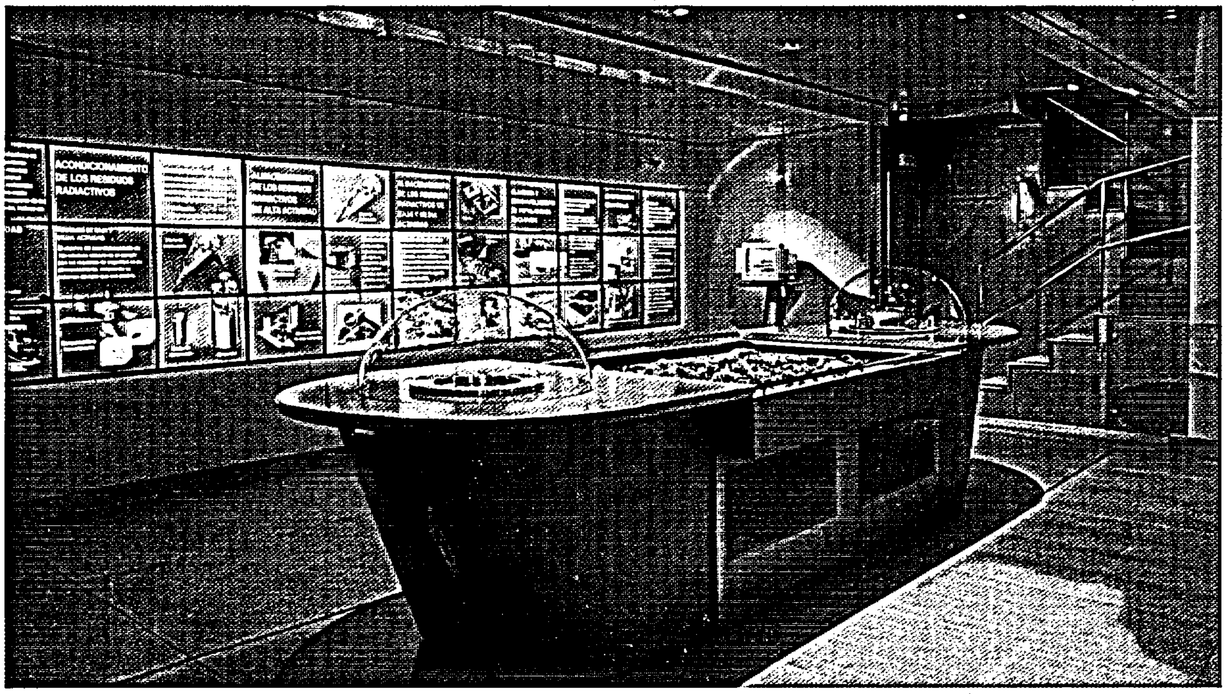
• ESTRATOS. The contents of this quarterly magazine relate mainly to environmental issues.

• SIERRA ALBARRANA. This publication contains information for the populations living around the El Cabril facility (Córdoba), including both local and more general news.

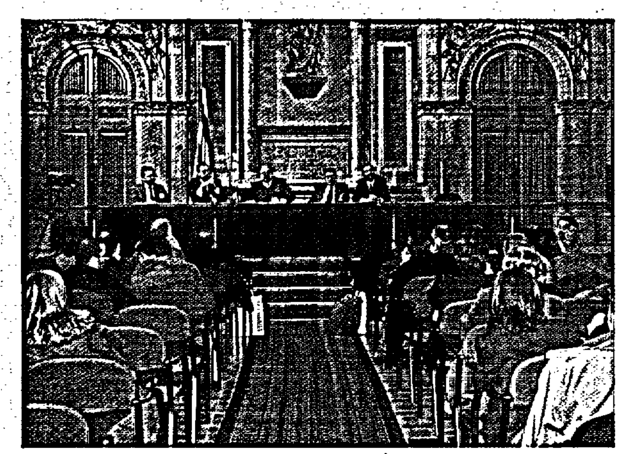
In parallel with this information for the general public, ENRESA has other information and educational channels for specific groups:

• ENRESA 3D. A journal aimed at the scientific community and reporting on research work.

Córdoba visitors centre.



Mobile visitors centre.



4th R & D sessions.

• TECHNICAL PUBLICATIONS. ENRESA has been publishing this set of books since 1991, with an average number of 12 per year. The books describe the different R&D projects undertaken.

• R&D WORKING SESSIONS. The objective of these sessions is to provide a meeting place and a venue for information exchange between the members of the scientific community involved in the Research and Development programmes, and the broadcasting to the general public of their work.

• SUMMER COURSES. These are aimed at university students and are organised within the educational programmes offered by the different universities.

• COLLABORATION AGREEMENTS. The creation of Environmental Courses at various universities: Córdoba, Complutense de Madrid, Politécnica de Madrid and Politécnica de Cataluña.

enresa

For further information contact:

enresa
Empresa Nacional de Residuos Radiactivos, S.A.

Dirección de Comunicación

Emilio Vargas, 7. 28043 Madrid
www. enresa.es

March 2001