Community Topics 16

The Euratom Joint Nuclear Research Centre

european community information service

The Euratom Joint Nuclear Research Centre

Ispra
Geel
Petten
Karlsruhe

The Euratom Joint Nuclear Research Centre
consists of four research establishments. Two are "general purpose" establishments, at Ispra (Italy) and Petten (the Netherlands). The other two are specialized, as their names indicate: the Central Nuclear Measurements Bureau, at Geel (Belgium) and the European Transuranium Institute at Karlsruhe (Federal Republic of Germany). By the end of the Community's second five-year program at the end of 1967, the research staff at work at the four establishments will number more than 2,500.

Contents

Euratom's role in Community nuclear research

The modern world needs more and more power. At the beginning of the nineteenth century, mankind was consuming only three times as much energy as two thousand years earlier; by 1850, consumption had risen six times; but by 1960, energy consumption was three hundred times higher than two thousand years ago.

The threatened exhaustion of known fossil-fuel reserves (coal, oil, natural gas, lignite) a few decades hence, and the irregular distribution of deposits, raise a special dilemma for the six Community countries: they must either abandon industrial expansion, for which power is the key, or else resort to ever-vaster imports of energy, at the risk of growing increasingly dependent on the supplying countries, a situation that might well give rise to both political and economic difficulties.

It is hardly twenty years since nuclear power's potential for peaceful uses was first appreciated. Now it is generally acknowledged that it is capable of providing a long-term or even permanent solution to the problem of the world energy deficiency.

The Euratom plan emerged from the resolve of Belgium, France, Federal Germany, Italy, Luxembourg and the Netherlands to pool their resources and efforts for peaceful nuclear research. The plan was of course onsistent with the policy of economic, and eventually political, unity which had been ursued since 1950 by these six countries.

Unlike other international organizations, Euratom does not confine itself to merely promoting atomic cooperation between the six Member States nor to aligning research activities. The Euratom Treaty signed at Rome on March 27, 1957, at the same time as the Common Market Treaty, gives Euratom a triple task:

- to promote a degree of coordination between national research programs with the aim of avoiding wasteful duplication of expenditure and effort;
- to stimulate activity in the national centres, private research units and industrial firms in the atomic sector;
- and to expand the scope of Community research, for instance, by investigating new types of power reactors.

General structure of the Joint Nuclear Research Centre

Origins

As there were already so many research centres on Community territory the Euratom Commission, rather than build yet another, preferred to form its Joint Centre by taking over national installations or setting up Community laboratories in close connection with national centres. Hence :

at Ispra (Northern Italy) an Italian centre was handed over outright to Euratom;

at Petten (Netherlands), the Dutch authorities transferred a reactor and several laboratories to the Community;

the Central Nuclear Measurements Bureau (CNMB) is in the vicinity of the Belgian Nuclear Study Centre at Geel;

similarly, the European Transuranium Institute stands in the grounds of the German Nuclear Research Centre at Karlsruhe.

Among the advantages of dispersal were :

- research could be begun on a Community basis
- research teams could be formed and set to work quickly
- Euratom was able to set up major laboratories without having to face the high expenditure involved in building a completely new centre.

Personnel

On January 1, 1965, the JRC's scientific and administrative staff numbered over 1,600, allocated as follows :

1,400 at Ispra,
140 at the CNMB Geel,
105 at Petten,
105 preparing to move into Karlsruhe; several of these, pending completion of the laboratories, were on training courses at various centres in Europe and the United States.

At the end of the Second Five-Year Program on December 31, 1967, Euratom plans that the JRC will be employing 2,530 research workers (out of a total payroll of 3,200 under the Euratom Research Budget), i.e. :

1,700 at Ispra
350 at Petten
180 at the CNMB, Geel
300 at the Transuranium Institute, Karlsruhe.

The research teams at the JRC of course consist of staff from all the six Community countries; this is also the case with the administrative personnel.

Program

The Joint Research Centre's work aims principally at developing or improving various types, or "strings" of reactors suitable for nuclear power stations.

Ispra's work is concentrated on the *ORGEL* project, i.e. an advanced version of the heavy water type of power reactor. Ispra is also the site of the Scientific Data Processing Centre (CETIS), which carries out research in such fields as automatic documentation.

Petten's main activity is the operation of a high flux materials-testing reactor, its principal item of research equipment. In addition, this establishment is responsible for the technical coordination of Euratom's work with its association contract partners on the high temperature gas reactor string.

At Geel, the Central Nuclear Measurements Bureau performs a valuable service to the whole field of nuclear research by establishing or perfecting measurements relevant to nuclear science.

At Karlsruhe, the European Transuranium Institute is mainly concerned with developing plutonium-based fuels for nuclear reactors.

Equipment

The equipment used by the JRC reflects the diversity of the six countries' industrial output. The JRC acquires its technical and scientific equipment, whatever its magnitude, by inviting tenders from all industrial firms, laboratories and experts in the European Community. For example, the nuclear portion of the *ECO* reactor (Ispra) was made by a Dutch company, while two firms, one German and one French, manufactured the fuel and an Italian firm carried out the civil engineering work.

Budget

Euratom is financed by contributions from the member states, each state contributing a percentage fixed by the Treaty. This is true of both the research and annual administrative budgets. The "slices" of the five-year research budget[1] are fixed each year by the Council of Ministers for the following year. Of the $425 million available for the Second Five-Year Research Program, $127 million, that is nearly 30 per cent of the total, has been allocated for setting up the JRC's four establishments. A further $30 million may be added to this total, representing the contributions of member states to the establishments located on their territories.

Another appreciable supplement to the JRC's own resources is provided by the credits allocated for individual research projects : thus Ispra enjoys substantial benefits, in the form of major installations, from the $57 million earmarked for the *ORGEL* project under the program.

Administration

The heads of the four establishments are responsible for their administration to the Euratom Commission, while scientific, technical and, where relevant, training activities at the establishments are subject to the authority of the Director-General for Research and Training, who bears sole responsibility to the Commission for the fulfilment of the research and training programs. This arrangement ensures that activities in the different establishments are, where necessary, coordinated, while allowing a degree of decentralization. If a certain administrative flexibility distinguishes the Joint Research Centre from other European Institutions, this is because it is the first great European Community "enterprise" in the technical-industrial sense of the word.

1 See appendix for details of the Euratom five-year research and training programs.

The Ispra Establishment

Site	400 acres in northern Italy, one mile from Lake Maggiore, 15 miles from Varese and 40 miles from Milan.
Origin	Nuclear research centre formerly belonging to the Comitato Nazionale Energia Nucleare and transferred to the Community on March 1, 1961.
Pers nnel	1,400 as at January 31, 1965, including 1,010 occupying scientific or technical posts. Estimate under Second Program: 1,700 by December 31, 1967.
Principal res arch facilities	2 reactors in operation (Ispra No. 1 and *ECO*), 1 reactor under construction (*ESSOR*), Electronic digital computers, 40 laboratories, workshops, etc.
Pr gram	Carrying out the *ORGEL* project (new power reactor string); Processing scientific data; Other research.
Budget	$76 million for the five-year period 1963-1967 (including balance brought forward from First Program but leaving out of account the addition of a substantial share of the *ORGEL* appropriations).

The ORGEL Project

Charact ristics

The chief activity at Ispra consists of studies and research on a reactor string using natural uranium as fuel, heavy water as neutron moderator, and an organic liquid as coolant; this is the *ORGEL* (*ORGANIQUE, EAU, LOURDE*) Project.

This formula was seen as offering particular advantages to the Community:

natural uranium is mined in large quantities in the Community and is now being fabricated in widely varying forms by European industry;

heavy water is a good neutron moderator, hence natural uranium can be used as fuel;

organic liquids can reach high temperatures (around 400°C) in low pressure circuits, and permit the use of conventional and therefore relatively cheap materials;

lastly, there had hitherto been little research in the member states on the organic/heavy water combination.

The *ORGEL* project promises to lead to the building of economic full-scale nuclear power stations operating on this system. The research needed to develop this string will also be useful for other natural uranium/heavy water reactors under design or construction in the Community countries.

Both large-scale research equipment and numerous laboratories and workshops are available at the Ispra Establishment for studying all the scientific and technical problems raised by the *ORGEL* string, and for other research[1].

[1] Complementary research in fields covered mainly by contracts or partnerships (proven type reactors, advanced gas reactors, fast reactors, irradiated-fuel processing, waste processing, biology, reactor physics, fuel chemistry, solid state physics, magnetic resonance, direct conversion, low-energy nuclear phenomena).

The main large-scale items of equipment are:

The Ispra No. 1 reactor, an American *Argonne CP-5* reactor. Commissioned in 1959, it has a thermal power of 5 MW and is fuelled with uranium enriched to 90 per cent with the isotope U235. It uses heavy water as coolant and moderator. At full power it consumes 6 grammes of uranium-235 daily.

The *ECO* reactor (*Essai Critique ORGEL* = *ORGEL* Critical Experiment): a critical assembly[2], the first large item of equipment for the *ORGEL* project. It will permit very high precision measurements to be made. It will also be used for studying the physics of any heavy water-moderated reactor, whatever the coolant employed. Its main features are a tank filled with heavy water in which rods containing fuel elements are immersed, a graphite reflector[3] and a biological shield[4]. The tank can take up to 245 rods corresponding to 28 tons of uranium.

Cost: $3·1 million. *ECO* went critical in 1964.

The *ESSOR* reactor (*Essai ORGEL* = *ORGEL* Test): a test reactor specially designed for studying the behaviour of nuclear fuel elements under the same conditions as would be found in an *ORGEL*-type power reactor, and in particular the same moderator (heavy water) and coolant (organic liquid). An important factor in a new reactor's success is the quality of the fuel elements which must, therefore, be very carefully designed. *ESSOR'S* originality lies in the fact that the *ORGEL* fuel elements to be tested will be surrounded by a ring of highly enriched uranium elements, which will subject them to the same radiation effects as would occur in a large *ORGEL* power reactor. *ESSOR* is housed in a leak-tight containment 35 m. high, and should come into operation not later than 1967.

Forty laboratories and workshops at Ispra are allocated to the Reactor Physics, Materials and Engineering departments which together have 17 sections. Most of them take a direct share, under the authority of the Project Head, in carrying out the *ORGEL* programs (mathematics, applied physics, neutron physics, critical tests, control and automation, technology, heat exchange, metallurgy and ceramics, chemistry, etc.).

Processing Scientific Data

G n ral

Nuclear research calls for quantities of coded information which have to be dealt with by electronic computers. The Scientific Data Processing Centre (CETIS = Centre de Traitement de l'Information Scientifique) works out processing methods and handles the computer work at Ispra.

Program

Alongside its regular work (scientific and statistical calculations, etc.), CETIS is carrying out a program of original research on the automation of the calculations demanded for reactor design, and the handling of scientific texts, documentation and automatic translation.

Faciliti s

CETIS has six electronic computers, one of which is capable of 229,000 additions, or 39,000 multiplications of 8 figures each in one second.

2 Name given to a test reactor that generates little or no power during operation.
3 The "reflector" stops the neutrons and sends them back into the reactor core.
4 The biological shield protects the operators of the reactor.

The Petten Establishment

Site	62 acres (option on a further 50 acres) in the Netherlands, on the North Sea coast 40 miles north of Amsterdam.
Origin	Plant constructed by Reactor Centrum Nederland, and transferred to the Community on November 1, 1962. The Dutch centre has been adjacent to the Establishment since that time.
Pers nnel	Present: 105, including 85 engaged on scientific or technical work as at January 31, 1965. Planned: 350 by end-1967.
Principal research facilities	1 materials-testing high-flux (HFR) reactor
Program	Operation of the HFR reactor; Technical coordination of research on high-temperature gas reactor carried out by Euratom in association with various countries; Research on certain nuclear materials (graphite, molten salts).
Budget	$27 million for the five-year period 1963-1967, including balance brought forward from the first program.

The materials-testing high-flux reactor

After a nuclear reactor has been in operation for some months or years, the materials used in its construction are sometimes found to have altered radically, to such an extent that they have lost the physical qualities for which they were chosen. It is therefore essential for engineers designing and constructing nuclear power plants to have a sound knowledge of all the changes that radiation may provoke in the materials they intend to use.

Owing to the high intensity of the radiation produced by the materials-testing reactors, such information can be obtained extremely quickly; whereas in ordinary reactors grave structural damage would only become observable after some years, it can be shown up on samples in the intense neutron flux of a high-flux materials-testing reactor.

The Petten reactor designed for this purpose is a remarkable tool for atomic scientists seeking to build reactors with the maximum resistance to atomic wear. Transferred to the Community in 1962, it has since then been run jointly by Dutch researchers and their Euratom colleagues. Responsibility for its functioning still lies with the Netherlands for a transitional period of four years from the date of transfer.

This plant supplements the materials-testing facilities already available to the six Community countries in the big BR2 test reactor at Mol which, operated by Euratom in cooperation with the Belgian Nuclear Energy Centre (CEN), came into operation in 1961.

Euratom will shortly be adding two laboratories to the Petten HFR reactor, one for preparing irradiation experiments and the other for examining irradiated samples.

Technical coordination of high-temperature gas reactors work

General

In order to choose and develop as early as possible a power reactor type that will produce electricity cheaply, several possible combinations or "strings" have to be considered. With its own resources Euratom is already investigating the *ORGEL* string. But, to increase the range of knowledge available to member countries and industrialists, Euratom has also joined forces with national or international bodies exploring other systems such as the high-temperature gas reactors, representing the latest development in the gas-graphite string, at present the mainstay of both the British and French power reactor programs.

Characteristics

Initial experiments on the high-temperature gas reactor string suggest the feasibility of a combination of uranium and thorium as fuel. Large deposits of thorium are known to exist in the world, but although it is a potential reactor fuel (for it can be transformed into the fissile material U233), its full potential has yet to be assessed. A second advantage is the high temperature of the gas coolant – around 700°C gas outlet. This will enable a much higher yield to be obtained from the fuel than is possible with earlier types of gas-cooled reactor which operate at lower temperatures.

Program

Since 1959 Euratom has been a partner in the *Dragon* high temperature, gas-cooled reactor project. *Dragon* was inspired by the British authorities and taken up by the European Atomic Energy Agency of the OECD. The *Dragon* reactor recently went into operation at the UK Atomic Energy Authority's centre at Winfrith, Dorset, England. Euratom is contributing $32 million over the eight-year period to 1967.

Euratom is also associated with a German project for the operation of a high-temperature reactor of original design (known as a "pebble-bed" reactor from the shape of its fuel elements) at Jülich, Germany, and to study a power reactor based on this system.

The Petten establishment will be responsible for the technical coordination of the research under these two projects.

At the same time experiments will be carried out on liquid fissile substances, to find out how the circuits (pipe-systems) behave when highly radioactivated, and on the properties of molten salts and their interaction with graphite at high temperature.

New facilities

The laboratories and workshops which Euratom is going to build near the HFR reactor (technology hall, cell for distributing experimental devices after they are removed from the reactor, low and medium radio-activity laboratories) will be suitably equipped for certain studies relating to high-temperature gas reactors.

Furthermore, the high-flux test reactor will play a major part in research on fuels and materials for advanced gas reactors.

The Central Nuclear Measurements Bureau (Geel)

Sit	90 acres a few miles from the Belgian Nuclear Study Centre (CEN) at Mol, 45 miles north-east of Brussels. Thus the Bureau is in the immediate neighbourhood of the Belgian installations, which include the BR2 high-flux materials-testing reactor, in the operation of which Euratom participates.
Origin	The CNMB – the Joint Research Centre's oldest establishment – started work in 1960 on a site handed over by the Belgian State, which also supplied laboratories and a certain amount of infrastructure.
Personnel	Present: 140 as at January 1, 1965. Planned: 180 by January 1, 1968.
Principal research facilities	1 van de Graaff accelerator, 1 linear accelerator, Physics, chemistry and electronic laboratories.
Pr gram	Research in nuclear metrology.
Budget	\$11·5 million for the five-year period 1963-1967, including balance brought forward from the First Five-Year Program.

The science of nuclear measurements

Gen ral

The purpose of the CNMB is to advance the science of physical measurements by carrying out precise measurement of nuclear data, especially of the "effective cross sections"[1] of interactions between atomic nuclei and neutrons. The CNMB also undertakes the absolute counting[2] of radioactive sources and prepares standards.

The establishment represents the Euratom member states and Commission on the European-American Nuclear Constants Committee which, set up on the initiative of Euratom and the former OEEC (now OECD), is the first example of specific collaboration combining, in a limited but essential field, all the resources of the western world.

Program

The immediate tasks of the CNMB are:

holding the primary standards[3] and comparing the standards of similar laboratories with them;

1 Apparent surface of an atomic nucleus subjected to bombardment by a neutron.
2 Counting, the purpose of which is to determine the absolute number of disintegration of a radioactive source.
3 A radioactive substance which, after being subjected to absolute counting, defines a constant which can be used as a reference for all radioactive measurements and is held for this purpose.

distribution and periodic checking of secondary standards[4] and standard-samples for science, industry, commerce and medicine;

improvement of standards and measuring instruments and methods;

fundamental research in connection with precision measurements;

calibrations, measurements and physical analyses for outside clients;

relations with the Standards Bureaux on the establishment of nuclear specifications.

Faciliti s

The CNMB is equipped with two large-scale experimental instruments :

a van de Graaff accelerator will be used mainly for energy calibration of fast neutrons and for certain measurements required for reactor design;

a high-energy linear accelerator can be used to obtain extremely short "bursts" (from a hundred-millionth to two millionths of a second) and a very high instantaneous average intensity. 10·3 m. long, it will be capable of attaining considerable energies, in the region of 100 MeV, when at full power. The neutron flux at high density will be capable of reaching 26,000 milliard (US billion) neutrons per second;

in addition, Geel has laboratories for physics, analytic chemistry, mass spectrometry, preparation of samples, electronics and radioactivity (for studying stable isotopes, radioisotopes, etc.).

[4] A standard supplied by the holder of the corresponding primary standard.

The European Transuranium Institute (Karlsruhe)

Sit and Origin

In course of construction on terrain handed over by the Land Baden-Würtemberg, adjacent to the nuclear research centre at Karlsruhe, in Germany, under an agreement signed with the Federal German Government on December 21, 1960.

Personnel

Present: 105, including 90 scientific and technical agents as at January 1, 1965.
Planned: 300 by December 31, 1967.

Principal research facilities

Extensive laboratories, fully equipped for handling highly radioactive substances.

Program

Basic research on transuranium elements, especially plutonium, and research into their industrial uses.

Budg t

$28 million for the five-year period 1963-1967, including balance brought forward from first program.

Domesticating Plutonium

G n ral

So far ten transuranium elements are known (i.e. elements above uranium in the periodic table): in order, they are neptunium, plutonium, americanium, curium, berkelium, californium, einsteinium, fermium, mendelevium and nobelium.

The most important of the transuranium elements is plutonium, a substance which does not occur in nature. Plutonium is a by-product of nuclear fission and is thus produced in all power reactors. Like uranium it is fissile and can release considerable energy on disintegrating. Its extreme chemical toxicity and the intense radiation it emits, however, make it a difficult substance to handle.

Program

The Karlsruhe European Institute will be mainly engaged on the problem of domesticating plutonium so that it can be used as a reactor fuel for electricity generation. It will therefore aim at developing plutonium-based prototype fuel elements for both thermal (slow) neutron and fast neutron reactors. The accent will be placed on the second type of fuel, in view of the considerable future advantages promised by the fast neutron breeder reactor string ("fast reactors"), the special feature of which is that they produce more nuclear fuel than they consume, thus multiplying the present yield of uranium some 50 or even 100-fold.

A small percentage of the Institute's work will be devoted to the transplutonium elements, which, like plutonium, do not occur in nature and are produced by nuclear reactions, though only in very small quantities. These elements are probably destined to play an important role in space propulsion and research.

The Second Five-Year Research Program allocates $25 million to Karlsruhe, to which should be added $3 million from the first program. The initial construction and equipment costs are put at $15 million.

Pending completion of the laboratories, certain of the tasks for the Karlsruhe program are being carried out under contract in the Community (plutonium "recycling" in thermal reactors, production of transplutonium elements and studies of their properties).

Facilities

A large group of laboratories, occupying some 45,000 sq. yds., is under construction. It will consist of:

"hot" cells (highly radioactive),

a technology hall,

physics, chemistry, metallurgy and ceramics laboratories.

The Joint Research Centre

instrument of progress in the service of Europe

At the end of the First Five-Year Program in 1962 it was the Ispra establishment that showed up predominantly in the balance sheet of the Euratom Joint Research Centre's activities; the others were not yet sufficiently advanced to achieve major scientific and technical results. From the first months of 1963, however, a growing number of contracts were placed by the various JRC establishments with public bodies, private firms and universities :

of the 428 contracts concluded by Euratom up to January 1, 1964, 54 had been placed by the JRC, including 42 by the Ispra establishments;

of the 272 technical or scientific reports published by Euratom in 1962, 97 emanated directly from Ispra;

of the 214 applications for patents for inventions, filed in at least one Community country by the Euratom Commission during the period 1958-1963, 61 came from Ispra and the *ORGEL* program, which has itself attracted interest in both Canada and the United States.

In addition, by taking on numerous trainees in its laboratories and workshops, who share in its task at the same time as they improve their practical knowledge of nuclear science and techniques, the Euratom Joint Research Centre is amply fulfilling its role as an instrument of progress in the service of the Six countries.

Euratom's five-year programs

Euratom's research activities are laid down in five-year programs prepared with the approval of the chief responsible officials as well as national experts. The Commission's proposals are put before the Council which, acting in unanimity, must take a decision to adopt them. The First Five-Year Program (1958-1962) put $215 million at Euratom's disposal. The program was in fact, carried out in the three years 1960-1962.

The second program, covering the years 1963-1967 has $425 million allotted to it. The breakdown by item is shown in the accompanying table.

The second program is in logical sequence to the first and is similarly based on three principal lines of research laid down in 1959:

1 the use of atomic fission for power; the development of power reactor technique (reactors and allied research). This is a major item since, in addition to the $232 million specifically allocated, it also claims a part of the Joint Research Centre appropriations (e.g. at Ispra);

2 the study of nuclear fusion (controlled thermonuclear reactions);

3 the use of radioisotopes and radiation.

The Joint Research Centre installations receive $127 million for equipment (under the first program the JRC had received more than $60 million), but a considerable share of the appropriations for reactors and allied research should be added to this figure: for instance, the *ORGEL* project is mainly carried out at the JRC's Ispra establishment.

Budget items	Amounts ($ million)		Total
Joint Research Centre	Ispra	72	127
	Petten	19	
	Geel (CNMB)	11	
	Karlsruhe (Transuranium Institute)	25	
Reactors and Allied Research	Proven-type reactors	29·5	232
	Advanced gas reactors	25	
	ORGEL project	57	
	Fast reactors	73	
	New types of reactors	9	
	Marine propulsion	7·5	
	Operation of BR2 materials testing reactor	12	
	Irradiated-fuel reprocessing	14	
	Processing of radioactive waste	5	
Fusion	Thermonuclear reactions and plasma physics	31	31
Radiation	Isotopes	5	22·5
	Health and Safety and biological research	17·5	
Training		3	3
Diss mination of Information		9·5	9·5
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