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Evolution of Organizations and Programs in the Field of Atomic Energy in the Federal Republic of Germany

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Karlsruhe Nuclear Research Center

1. Evolution of Organizations

1.1 The Federal Ministry of Scientific Research (formerly Federal Ministry of Atomic Energy)

The Ministry came into being in 1955. Presently, the staff comprises some 60 higher-ranking officials. The Ministry is responsible for federal legislation and for the promotion of scientific research on a federal level (the responsibilities of the "Länder", i.e. the states, among other fields of activitiy comprise the edition of local licenses, and the participation in financing research centers. However, they take no active part in the execution of the Atomic Program).

1.2 The German Atomic Energy Commission (DAK)

is an advisory body for the Federal Ministry of Scientific Research. It is made up of 5 expert committees:

I Atomic legislation
II Research and training
III Technical and scientific questions pertaining to reactors
IV Radiation protection
V Economic, financial and social problems.

The expert committees have formed 16 working groups, among others handling reactors, nuclear physics, nuclear chemistry, engineering, ore deposits, radiation protection, etc.

Experts coming from science, engineering, and industry cooperate in the Atomic Energy Commission as honorary members. Although the Commission has advisory functions only, its influence on the development of nuclear energy in the Federal Republic must not be underrated. The Atomic Energy Program, too, was drawn up by committees of the Atomic Energy Commission.

1.3 Research Centers

Since 1957 the Federal Republic has founded three major research centers in the nuclear field: Jülich, Karlsruhe, and Geesthacht. Moreover, the Institute of Plasma Physics at Garching was created within the framework of the Max-Planck-Gesellschaft.

In addition, there are several chairs of nuclear engineering at universities and technical colleges which are partly equipped with reactors. Let me mention just the institute headed by Professor Maier-Leibnitz in Munich-Garching which has a swimming-pool reactor used for purposes of training and research.

The personnel development in the research centers of Jülich, Karlsruhe, Geesthacht, and at the Institute of Plasma Physics in Garching can be seen from the table enclosed.

1.4 Atomic Energy Program and Budget

The Atomic Energy Program was drawn up by the German Atomic Energy Commission. The Program is included in the appendix. All steps of its realization are individually discussed by committees of the Commission and recommended to the Ministry of Scientific Research for execution and promotion, respectively. In each case execution and promotion may turn out to be quite different.

Development of Personnel in the Research Centers

	Scientists	Technicians	Others	Total
1. Jülich				
1960	243	218	381	842
1961	310	377	738	1425
1962	393	479	840	1712
1963	438	621	1072	2131
1964	562	659	1391	2612
2. Karlsruhe				
1960	229	276	537	1042
1961	258	434	712	1404
1962	339	539	895	1773
1963	411	674	1060	2145
1964	457	788	1258	2503
3. Geesthacht				
1960	33	34	51	118
1961	33	52	67	152
1962	37	69	89	195
1963	46	96	117	259
1964	52	114	133	299
4. Institute for Plasma Physics				
1960				90
1961				220
1962				320
1963				450
1964	107	291	142	540

In the sphere of fundamental research the funds may be given to the interested research institutes and colleges directly. In the case of nuclear installations, nuclear power stations in particular, fitting the program of the Commission, promotion as a rule is based upon the cooperation of utilities, reactor industry and, perhaps, public bodies. Construction of the facilities is regarded as a task of industry. As a rule, neither federal authorities nor research centers build any large-size installations on their own. In this way industry is linked with the responsibility for such a plant right from the outset and thus can familiarize itself with the progress of engineering. This is regarded as being one of the predominant aims of the German Atomic Energy Program.

Based on the suggestions by the German Atomic Energy Program the Ministry draws up a budget which has to be discussed with the Minister of Finance and approved by the Federal Diet within the framework of the national budget every year. The development of the budget is shown in the following table.

Expenditures of the Federal Government
1956 - 1964

1956	DM 18 428,3 t	0,05 %
1957	44 095,6	0,12
1958	101 792,9	0,26
1959	173 087,6	0,44
1960	141 369,6	0,34
1961	249 069,9	0,52
1962	333 932,8	0,63
1963	439 252,0	0,74
1964	485 300,0	

These figures include expenditures for science and research, the development of engineering including experimental and power reactors, for training, radiation protection as well as for administration including contributions to international organizations. Moreover, the table shows the percentage of these sums as against the national budget.

The work of the institutes of universities and technical colleges is coordinated in itself and with that of the research centers primarily by the German Atomic Energy Commission. In addition, there are many direct contacts and advisory contacts between college institutes and research centers.

No power reactor has been built so far in the Federal Republic which is not run by a utility. Even in the case of prototypes created at research centers a utility is charged with operations as soon as electricity is generated. This is true, e.g. of the multi-purpose research reactor at Karlsruhe.

2. Development of the Programs

2.1 Nuclear Fusion, Plasma Physics

2.1.1 Institute of Plasma Physics at Garching

Preparatory work done by a working group of the Max-Planck-Institut für Physik und Astrophysik (since 1956) and a working group of the Technical Physics Laboratory of the Munich Technical College (since 1957) resulted in the foundation of the Institute of Plasma Physics at Garching in 1960 between the Max-Planck-Gesellschaft and Professor Heisenberg. In the meantime, the institute has become the most important center of activities in plasma physics in Germany.

Under its statute the institute has these tasks: research in plasma physics and allied fields as well as the development of the methods and means this requires.

Some DM 60 million investment costs have been provided for the complete setup of the institute in three phases (two of them are finished, the third one has been started).
Since 1961 a contract of association has been existing between the institute and EURATOM forming the basis for common research in plasma physics.
At present, the institute has three experimental divisions, one engineering division, one theoretical division and the necessary supply facilities.
In the present state of development work in the field of plasma physics is directed towards the treatment and solution of fundamental problems. The "ultimate goal", i.e. generating useful energy out of fusion processes, is still in the stars. However, some practical applications of plasma physics have become apparent meanwhile, out of which three problems may be mentioned here:

a) The conversion of chemical or thermal energies to electric energy by means of the magneto-hydrodynamic generator.
b) the possibility of plasma drive for rockets.
c) The problem of re-entry into the atmosphere of the earth of spacecraft and rocket heads.

These are the main topics treated in the individual divisions:
Division I: Investigation of the phenomena occurring in the fast discharge in the theta-pinch.

a) Determination of the course of the magnetic field
b) Measurement of partcile densities.

Investigations of the linear Z-pinch and the tubular-pinch.
Development of methods of measuring investigations of pinch discharges.

Division II: Studies of the diffusion processes in plasma.
Interaction of particle beam and plasma.
Plasma investigations with the stellorator configuration.
General fundamentals of plasma physics (spectroscopy, microwave measuring techniques.

Division III: Investigations aiming at a reduction of thermal conductivity of the plasma.
Heat-up and acceleration of the plasma.

Engineering Division: Technical development of special experimental equipment (e.g. planning and design of a 1.5 MJoule battery for Division I).

Maintenance of technical equipment of the experimental divisions.

Theoretical Division: Theoretical treatment of the theta-pinch.

Calculations concerning thermal conductivity of the plasma.

Theory of the statistical equilibrium between neutral gas and plasma.

Laser investigations.

2.1.2 Plasma Physics Institute of the Jülich Nuclear Research Establishment

This institute originated froma working group founded at the Aachen Technical College in 1956. The institute, too, has entered into a contract of association with EURATOM in 1962. This safeguards a very intensive cooperation with the rest of the European centers associated with EURATOM. The institute mainly works on these topics:

a) Experiments using fast magnetic compression.

b) Development of a plasma accelerator.

In addition, a pulsed high-current device has been built over the past few years using a capacitor battery of 600 kJoule energy content.

2.1.3 Institute of High-Temperature Research, Technical College of Stuttgart

The working group "High-Temperature Research" was founded in 1956 and incorporated as an independent institute into the Technical College of Stuttgart in 1961. For the time being, the investigations are restricted to dense plasms (investigations in the field of the stationary arc column). Special interest is devoted to the plasma beams emerging at the two electrodes. The experimental work is supplemented by work on the theory of flowing plasms.

2.1.4 Physical Institute of the University of Kiel

First, the work centered around spectroscopic investigations of plasms in thermal equilibrium. In this connection, also the stationary arc columns were investigated as plasma formations. With the technical utilization in mind problems have been tackled lately which are connected with the construction of a magneto-hydrodynamic energy converter.

2.1,5 Siemens Research Laboratory, Erlangen

Here, too, the physics of the arc column are the focus of all investigations. A current impulse installation was built for investigations of the linear Z-pinch. Other work is devoted to the development of so-called plasma guns.

2.1.6 Plasma Physics Institute of the Hanover Technical College

Plasms of high and very high densities are investigated in this institute. The work is intended to permit an insight into the conditions and events within plasms by measurement.
Other work, among other topics, centers around the phenomena occurring with magnetic compression in gases of higher density.

2.2 Large Accelerators - DESY

By far the most important and most expensive plant in the field of large-scale accelerators in Germany is the German Electron Synchrotron (DESY) in Hamburg.which was started up early in 1964. DESY is capable of accelerating electrons up to 6000 mev; after a projected extension of the accelerator it will be able to accelerate electrons to 7500 mev. This will make DESY the world's largest electron accelerator for many years to come.
In DESY the electrons are accelerated on a closed circular path of 100 m diameter equipped with 48 electromagnets. 16 cavity resonators serve as the acceleration path. The electrons are pre-accelerated to 40 mev in a linear accelerator and attain their ultimate energy after some 10.000 revolutions within 10 milliseconds.
In 1956 German physicists first thought about building a high-energy accelerator in Germany. Hamburg was selected as the site. In 1958 the decision was made in favor of an electron synchrotron. Late in 1959 the foundation "Deutsches Elektronen-Synchrotron" was initiated to assume construction and operation of the plant. DESY started operation in 1964. For special experiments a hydrogen bubble chamber of 80 cm length has been built in cooperation with engineers and scientists of the Saclay Nuclear Research Center; it has started operation early in 1965.

The German Electron Synchrotron is available to all research institutions in Germany. At present, the first five experiments are being prepared.

a) Experiments using the elastic electron proton scattering to permit more exact conclusions about proton structure.

b) Generation of π -mesons by a photon beam.

c) Spark chamber experiments.

d) Bubble chamber experiments.

e) Investigation of the π^0-production (prepared by the University of Bonn).

The capital cost of DESY amounted to DM 85 million for construction of the synchrotron and another DM 25 million for the constructional and technical preconditions of experimental activities. The cost was borne by the Federal Government, the city of Hamburg, and the Volkswagen Foundation. Current operational expenses will be some DM 30 million per annum.

At the end of 1964 DESY employed some 460 persons, 75 of them university or college graduates.

2.3 Biology and Medicine

It is impossible to list in detail all activities carried out in this field in Germany. The instructions will be confined to the enumeration of subjects which form the main points of activities in the particular fields:

2.3.1 Medicine

a) Mode of acting of alkylating cytostatica
Institute for Biochemistry, Freiburg

b) Development of applicators for the irradiation of tumors with isotopes
Med. Academy, Düsseldorf

c) Sterilization of medical necessaries by radiation
Braun, Melsungen

d) Permeability examination of the effect of drugs.

2.3.2 Biology

a) Primary processes of radiation effects
Institute for Radiation Biology, Hanover

b) Radiation influence upon genes (induced mutation)
Max-Planck-Institute for Breeding Research, Cologne

c) Biological indicator procedures - neutron activation analysis
Institute for Radiation Biology, Hanover.

2.3.3 Biochemistry

a) Regulation, structure, metabolism and effects of nucleic acids
Institute for Biochemistry, Freiburg,
Institute for Genetics, Cologne

b) Regulation of protein-biosynthesis
Institute for Biochemistry, Marburg,
Institute for Genetics, Cologne

c) Primary reactions of photosynthesis
Institute for Organic Chemistry, Brunswick,
Institute for Botanic, Frankfurt

d) Synthesis of labelled biochemicals
Bö hringer, Mannheim

2.3.4 Pedology, Agriculture and Forestry. Food Technology

a) Soil structure and transformation of organic substance in the soil
FAL, Brunswick

b) Examination of residue in the field of pest control (herbicide, insecticide)
Institute for Organic Chemistry, Bonn

c) Food preservation by radiation
Federal Institute for Food Preservation Technology, Karlsruhe

d) Toxic environmental influences on the biosphere.

2.4 Development of Reactors

The Federal Republic has initiated two programs for the development of nuclear power reactors, one for immediate realization, the other for realization in the remote future. The program set up for immediate realization is comprizing several construction principles selected according to criterions which are partly listed below. The reactor type

is to secure economical energy for the near future and, in addition competitive ability should be expected for a longer term. Internationally available experience should be included in the projects. Moreover, the development and construction of reactors by efficient groups must be safeguarded. In the case of cooperation with a foreign group it must be secured that the German group will assume an essential part of the plant, even in respect of the nuclear part. Those reactor types which are promising the possibility of a single important contribution in the development because of their novelty, may require favored promotion during the first stages of their development. The same applies to types with good conversion properties and especially high coolant temperatures.

The program set up for realization in the remote future comprises in the first line breeders.

Considering these criterions the activities and promotion in the Federal Republic are being directed towards the development of boiling reactors and pressurized water reactors (including pressurized heavy water reactors) and sodium-cooled as well as gas-cooled reactors.

The activities of the Nuclear Research Center Karlsruhe are devoted to the development of fast breeders, whilst the Nuclear Research Center Jülich is concerned with the development of thermal breeders.

The following table (p.12) gives the nuclear power plants in operation, under construction or completed in the Federal Republic.

3. International Relations

3.1 International Organizations

The Federal Republic is a member of the following atomic organizations:

a) International Atomic Energy Agency - IAEA - in Vienna
b) European Nuclear Energy Agency of OECD
c) European Atomic Community (EURATOM)
d) European Organization for Nuclear Research (CERN)
e) European Atomic Energy Society - EAES

Nuclear Power Stations in Germany

(in operation, under construction and construction completed)

Nr.	Name	Location	Put into operation	Electr.net power, MW	Type of Reactor	Installation cost ₰ / kW
1	Experimental Nuclear Power Station Kahl (VAK)	Kahl/Main	1961	15	Boiling Water Reactor	600
2	Multi-purpose Research Reactor (MZFR)	Karlsruhe	1965	50	D_2O Pressure Vessel Reactor	625
3	Experimental Nuclear Reactor (AVR)	Jülich	1965	15	Gas-Graphite High-temperature Reactor	1000
4	Nuclear Power Station RWE-Bayernwerk (KRB)	Gundremmingen Donau	1966	237	Boiling Water Reactor	300
5	Nuclear Power Station Lingen (KWL)	Lingen/ Ems	1968	240	Boiling Water Reactor	235
6	Nuclear Power Station Baden-Württemberg (KBWP)	Neckar Obrigheim/	1968	282	Pressure Vessel Reactor	240
7	Superheat Reactor (HDR)	Kahl/Main	1968	25	Boiling Superheat Reactor	600
8	Compact Sodium Nuclear Power Station (KNK)	Karlsruhe	1968/69	20	Sodium-Zirconium-Hydride Reactor	800
9	Nuclear Power Station Bayern (KKN)		1968/69	100	CO_2-D_2O Pressure-Tube Reactor	450

Federal Republic of Germany, including Berlin (West), Population 56,5 million; Gross national product ₰ 94 mrd.
Gross power consumption 150 mrd. kW

3.2 Bilateral Agreements

In addition, the Federal Republic has concluded the following bilateral agreements:

a) on July 3, 1957 with the USA an agreement regulating primarily the direct acquisition of enriched uranium from the United States;

b) on July 31, 1956 with UKAEA, England;

c) on July 11, 1957 with Canada.

The last two contracts also provide for the supplying of uranium and uranium concentrates, but they are equally allowing for the purchase of other nuclear material.

3.3 Direct Contacts

Besides, there is a series of direct contacts, particularly with France and the USA, in the field of breeders and in other fields of activity. An official exchange of experience with the USA, the UKAEA and the other EURATOM-members in the field of fast breeders is arranged by EURATOM for the European Atomic Community. An extensive description of the total international cooperation of the Federal Republic is contained in the "Taschenbuch für Atomfragen 1964" (Festlandverlag GmbH, Bonn), p. 303.

The following details should be added with respect to the international relations:

3.3.1 Relationship between the Fast Breeder Development Groups in Karlsruhe and Cadarache

The exchange of experience is carried out to a large extent by direct contacts. At the time being this exchange concerns above all the comparison of results from reactor calculations, nuclear data, group constants as well as aspects which are important for the construction of the critical assemblies SNEAK and MAZURCA. The exchange of knowledge also concerns the preliminary drafts for power breeders cooled with sodium.

3.3.2 Relationship between Karlsruhe and Fast Breeder Groups in the USA

The Nuclear Research Center Karlsruhe has participated with $ 5 million in the construction of the SEFOR-reactor near Fayetteville, Arkansas. At the Geneva Conference 1964 W. Schnurr exposed in paper No. 533 in detail this set of agreements underlying the common construction and operation of the SEFOR-reactor. It comprises agreements between the following parties:

a) SAEA and USAEC
b) SAEA and General Electric
c) SAEA and Karlsruhe.

3.3.3 NSPE/EVESR Program (NSPE = Nuclear Superheat Project / EVESR)

On the part of Germany several branches of industry and nuclear research centers take part in this project. The contribution of the Federal Republic amounts to DM 14 million. The Allgemeine Electricitäts-Gesellschaft (AEG) speaks on behalf of Germany. The subject are experiences in EVESR (Esada Vallecitos Experimental Superheat Reactor) in the field of nuclear superheat. The reactor is sited in the Vallecitos Laboratory of General Electric Company. The contract provides for a base development, superheat fuel development, and Nuclear Superheat Performance Evaluation Program. The program covers 36 months, part of which has already expired. The German parties in the contract are: RWE, Bayernwerk AG, NUKEM and Mannesmann, and the Nuclear Research Centers Jülich and Karlsruhe. The exchange of experience is carried out by the exchange of reports and by the stay of German experts in Vallecitos; just now their number is about a dozen.

3.3.4 Relationships between industries

On industrial level, too, there exists a series of relations between the Federal Republic and the USA, the most well-known being those between Siemens-Schuckertwerke AG and Westinghouse, AEG and General Electric, INTERATOM and Atomics International. The German Babcock and Wilcox maintains close relationship with the American company. The same applies to Gutehoffnungshütte AG (GHH) and General Atomic. These are only the most important contacts out of a great number which are existing in this field between German and American industries.