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## THE GERMAN COMPETENCE NETWORK ON NUCLEAR TECHNOLOGY

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**Abstract.** The present German energy policy is based on the phase-out of nuclear electricity generation, which means that the last of the 19 German nuclear power plants will run until about the year 2022. While the plants will be shut down one after the other, decommissioning will start together with interim storage of the radioactive waste. The safe waste disposal in a final repository is planned to start around 2030 and may take another two decades, i.e., in Germany nuclear competence is further needed, at least until the mid of this century. Against this background, a high-ranking commission under the chairmanship of the Federal Ministry of Economy and Technology evaluated the publicly funded nuclear safety related research and development (R&D) activities in Germany. One of the recommendations made by the commission was the foundation of a Competence Network on Nuclear Technology (in the sense of an Alliance for Competence in Nuclear Technology) for an optimum coordination of the remaining nuclear activities including aspects of future human resources in this area. This Network was established in March 2000. Its objectives, actual problems and first approaches are described in more detail.

### 1. Introduction

One of the energy policy objectives of the present German federal government is to phase out of the use of nuclear energy. The corresponding “Act on the Proper Termination of the Use of Nuclear Energy for the Production of Electricity” of July 25, 2002, legally hedges the previous “atomic consensus” reached by the red-green government and the utilities on June 14, 2000. According to this agreement, standard operation time of each of the 19 nuclear power plants (NPPs) operated in Germany shall be limited to a total of 32 years (calculated from the beginning of operation). The resulting nuclear power perspective is illustrated in Figure 1.

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Fig. 1: Operation times of the 19 German nuclear power plants in accordance with the agreement achieved on June 14, 2000

According to this figure and from today’s point of view, eight NPPs will stop operation until the year 2010, and the last plants will run until about 2022. While the plants will be shut down one after the other, decommissioning will start together with interim storage of the radioactive waste. The safe waste disposal in a final repository is planned to start around 2030 and may take another two decades, i.e., in Germany nuclear competence is further needed, at least until the mid of this century (see also Figure 2).

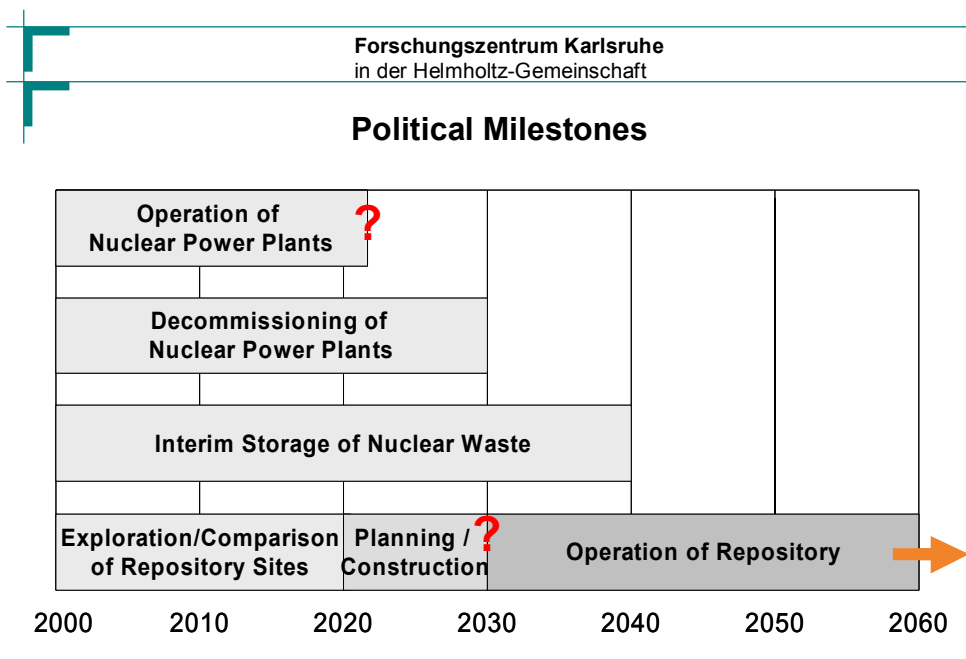


Fig. 2: Time horizon of nuclear activities remaining in Germany after the shutdown of nuclear power plants

Against this background, a high-ranking commission under the chairmanship of the Federal Ministry of Economy and Technology evaluated the publicly funded nuclear safety related research and development (R&D) activities in Germany. In its final report of January 21, 2000 [1], the commission pointed out that:

*“Irrespective of the requirements resulting from the political decision to opt out of the use of nuclear energy in Germany, competence in nuclear safety needs to be maintained for the next decades. Only then can the state’s obligations to protect and take precautions be fulfilled and the safety of nuclear facilities and disposal paths be ensured in accordance with the international state of the art of science and technology”.*

## 2. Competence Network on Nuclear Technology

To ensure the necessary maintenance of competence, the Commission recommended to establish a Competence Network with the aim to further intensify cooperation among the research institutions and with their respective neighboring universities. In this sense, the German Competence Network on Nuclear Technology (or the Alliance for Competence in Nuclear Technology) was founded on March 16, 2000. Today, we have six Network member institutions which are:

- the Research Centre Juelich (FZJ),
- the Research Centre Karlsruhe (FZK)
- the Research Centre Rossendorf (FZR),
- the Gesellschaft fuer Anlagen- und Reaktorsicherheit (GRS) in Munich,
- the Bundesanstalt fuer Geowissenschaften und Rohstoffe (BGR), and
- the Materialprüfungsanstalt (MPA) University of Stuttgart

with their respective neighboring universities. The resulting Network structure is outlined in Figure 3.

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### Fig. 3: The Structure of the Competence Network

The neighborhood relationship of the various institutions is as follows: In the eastern part of Germany we have the Research Centre Rossendorf with the Universities in Dresden and

Zittau, in the south GRS and the TU Munich, in south-west are located the Karlsruhe Centre and the three Universities in Karlsruhe, Stuttgart und Heidelberg, in the western part the Juelich Centre and the Aachen Universities and, in the north, the federal institution BGR, the University Hannover and TU Berlin.

The Network meets twice a year. The participants comprise

- permanent members: Representatives of the six member institutions;
- permanent participants in the session: Representatives of the BMWA project management for reactor safety and waste management as well as representatives of the utilities, the European Institute for Transuranium Elements (ITU), and of the International Atomic Energy Agency (IAEA);
- permanent guests: Representatives of the federal ministries BMWA, BMBF, and BMU; and as
- ad-hoc guests: Representatives of other research institutions, the utilities, and the nuclear industry.

The strategic goals of the Competence Network on Nuclear Technology were derived from the recommendations made by the evaluation commission. They include:

- Survey of the trends of job development and training capacities in the nuclear technology area;
- Enhanced cooperation of the research institutions with universities and support of international initiatives for offering training in the nuclear sector (e.g. ENEN, WNU);
- Coordination and bundling of the publicly funded R&D activities in nuclear safety and radioactive waste management and disposal;
- Support of qualified young scientists and engineers (post-graduate and pre-doctoral students) – also by third-party funds, and
- Participation in international activities and projects for the maintenance and further development of international nuclear safety standards.

These individual goals and the status of activities are outlined in more detail below.

### 2.1. Job Development and Training Capacities

As a first step, the Competence Network on Nuclear Technology determined the actual situation prevailing in Germany in summer 2000. According to the survey made, competence in nuclear technology in Germany was represented by some 16,500 qualified employees and experts [2].

A need-oriented perspective for the year 2010 revealed a decrease in jobs for nuclear expert staff from 16,500 to about 13,000. This total number included some 7,000 jobs for university (universities, technical universities, higher technical colleges) graduates in nuclear technology, which were expected to be reduced to 6,200 by 2010. Figure 4 shows the trends of job development for university graduates in several branches which are results of the 2000 survey.

Forschungszentrum Karlsruhe  
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## Germany: Competence in Nuclear Technology

Job Development for **University Graduates\*** 2000 ⇨ 2010

Employer	Jobs 2000		Jobs 2010 (of these, new employments)
NPP utilities	1,250	- 20 %	1,000 (none**) ?
NPP manufacturing and service industry	3,500	- 6 %	3,300 (1,000)
Supervisory and expert institutions	1,350	- 19 %	1,000 (300)
R&D institutions: Reactor safety	370		370 (160)
Nucl. waste disposal	350	+ 8 %	380 (110)
Participation in international bodies	100		100 (100)
<b>Total</b>	<b>6,920</b>	<b>- 10 %</b>	<b>6,250 (1,670)</b>

\*) Universities, technical universities, higher technical colleges  
\*\*) in case of unchanged fluctuation

Fig. 4

It is obvious that by 2010, about 1,700 qualified young graduated employees will be required due to age-related loss of personnel. About 300 vacancies will have to be refilled in supervisory and expert institutions and about 270 new employments are expected to be required at the R&D centers of the Competence Network. And current prospects of the utilities are again more optimistic as they also indicate new job vacancies for young engineers.

But how can this need for the alternation of generations be met? According to the survey made in 2000, in the course of which 17 universities and 11 higher technical colleges responded to the questionnaire, the number of university graduates participating in nuclear technology studies in addition to main natural science and engineering lectures amounted to about 50 per year. Due to this small demand by students and the political environment, studies offered in nuclear technology were strongly reduced by the universities. As a trend, the survey revealed that studies offered in 2010 will no longer cover 22, but only 10 nuclear technology subjects, i.e. they will be cut by more than half, compared to 1995. Later surveys made in June 2002 and January 2004 demonstrated that this trend has become even more pronounced (see Fig. 5) [3].

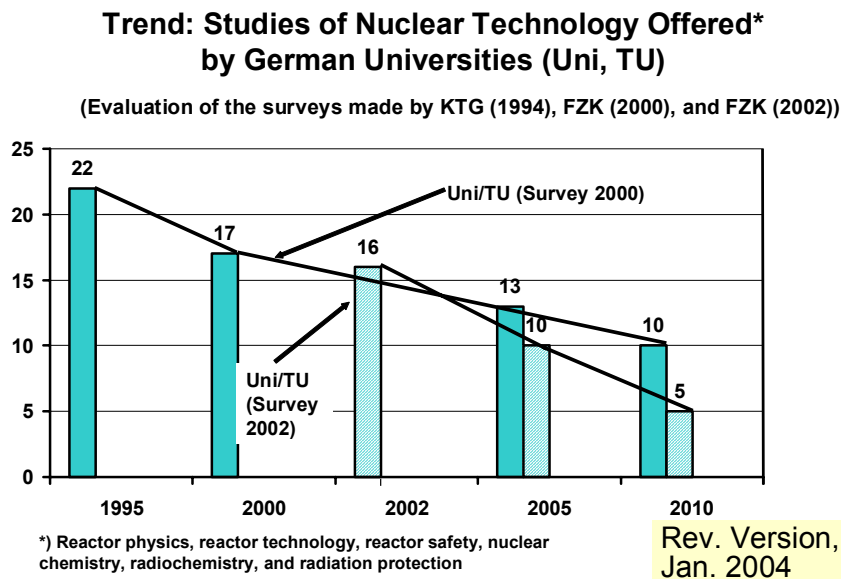


Fig. 5

## 2.2. Enhanced Cooperation between the Research Centers and Universities

To counteract this negative trend, the Alliance for Competence in Nuclear Technology promotes an intensification of cooperation between the research centers and their neighboring universities. In this respect, the Alliance already has achieved first successes:

- The University of Heidelberg and FZK have succeeded in jointly appointing a professor for the chair of nuclear waste management and intend to refill the vacant chair for radiochemistry by funding a C3 professorship.
- The University of Stuttgart and FZK plan to maintain the chair of nuclear energy technology and energy systems (IKE) by establishing a joint appointment procedure.
- The Technical University (RWTH) of Aachen and FZJ try to positively solve the matters related to the succession of Professor Kugeler by the joint funding of a professorship.
- The Technical University (TU) of Dresden, the University of Applied Sciences (FH) of Zittau, and FZR make joint appointments. To increase the efficiency of their R&D activities, the three institutions have established the “Competence Center East” within the Network.

## 2.3. Coordination and Bundling of R&D Activities

Another recommendation made by the evaluation commission in 2000 was:

*“Technical cooperation in Germany in the field of reactor safety and nuclear waste disposal research and sharing of the pertinent work should be aimed at further increasing its efficiency. The Competence Network should contribute to reaching this aim by coordinating the respective tasks in terms of contents.”*

This recommendation was given priority by the Competence Network and the task was assigned to the project management agencies for reactor safety and nuclear waste management of the BMWA for implementation, in cooperation with the research institutions. For the period from 2002 to 2006, the publicly funded R&D projects focus on reactor safety and radioactive waste disposal. The corresponding summary reports do not only give a detailed overview of the current status of activities, but also represent a valuable orientation aid for the medium-term conception of the research institutions’ R&D programs and complementary project funding by the federal government.

As an example, the meanwhile accomplished programmatic coordination of work in the Helmholtz Association of Research Centers (HGF) can be mentioned. Here, the Helmholtz centers Juelich and Karlsruhe have drawn up a joint R&D program on nuclear safety research, the time horizon of which extends to the year 2030. In Fig. 6, the safety program structure in the partial fields of “nuclear reactors” and “nuclear waste disposal” as well as the main issues covered are sketched. The current program “nuclear safety research” for the years 2004 to 2008 was reviewed by a commission of internationally acknowledged external experts in 2003. In their report, the experts underlined the “high” scientific quality of reactor safety research and considered the quality of nuclear waste disposal research to be “very high on an international scale”. In view of the already started alternation of generations, the commission deemed a specific advertising initiative to be necessary to attract top students for nuclear safety research and recommended to accordingly improve the research policy boundary conditions.

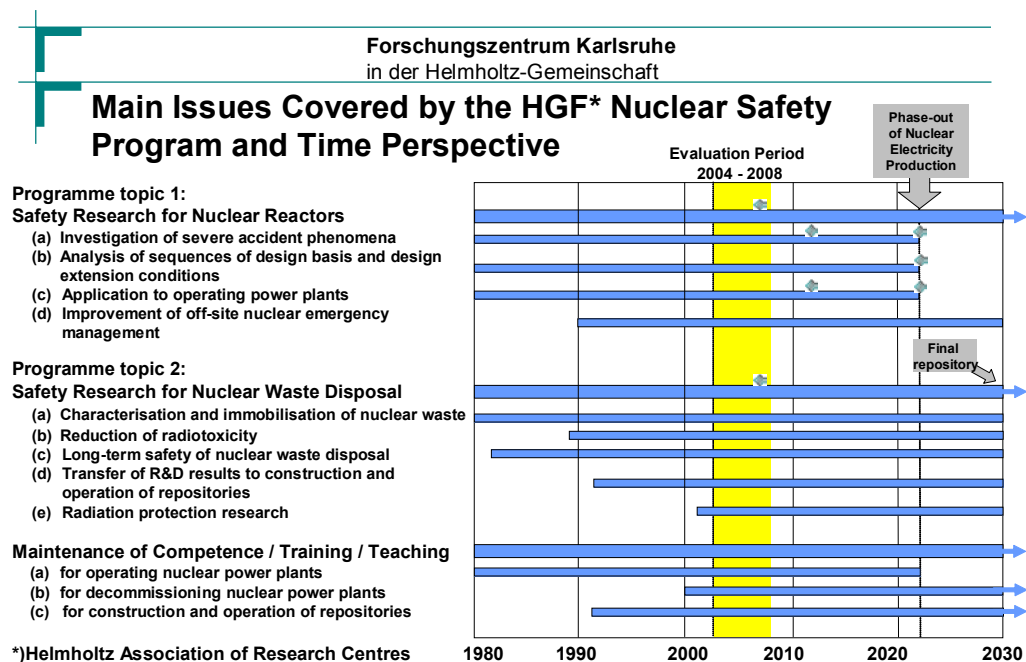


Fig. 6

In another initiative, the Competence Network annually organizes special workshops to present and discuss the current state of knowledge with respect to selected issues of reactor safety among experts of the member institutions. In addition, further R&D needs and activities are agreed upon. The last workshop was held in June 2004 in Dresden and was focused on the “development, validation, and use of CFD tools in reactor safety research”.

#### 2.4. Support of Qualified Young Scientists and Engineers in the Nuclear Technology Sector

Maintenance of competence in nuclear technology is a central issue of the strategic program of the Alliance for Competence. In this context, the international “Convention on Nuclear Safety” has to be considered. By the adoption of its Article 11 the member states have committed themselves in a legally binding manner to undertaking appropriate steps to ensure the availability of sufficient adequately qualified and experienced staff for all safety-relevant activities in and for each nuclear facility. In this respect, the Alliance supports the government in the supply of the necessary technical competence by appropriate initiatives for students, the procurement and supply of jobs for pre-doctoral students at the research institutions, and by

the research centers offering nuclear technology courses for the qualification and advanced training of technical and scientific personnel.

For instance, students are addressed specifically in close cooperation with the Deutsches Atomforum (DAtF, German Atomic Forum) that regularly (two times a year at changing places) organizes a colloquium on the “perspectives in nuclear technology”. These colloquia provide the students with adequate fora for contacts to the nuclear technology branch and the latter with the opportunity of offering their safe and attractive jobs to future university graduates. Moreover, current trends at the universities are pointed out, such as the new extraordinary chair in nuclear technology founded at the Technical University of Munich. From the winter semester 2004/2005 on, a one-year in-depth studies course in nuclear technology will be offered to graduates. Or on the European level: The foundation of the European Nuclear Education Network (ENEN) Association in September 2003 (with its office in Saclay, France). The ENEN Association has the defined objective of establishing a virtual European nuclear university that offers studies for a European master of science (M.Sc.) in nuclear engineering as an additional diploma. In Germany, the Technical University of Munich and the University of Stuttgart participate in this initiative [4].

Moreover, on these colloquia it is also reported about global initiatives for the maintenance of competence and the promotion of young scientists in nuclear engineering. In this respect, the activities of the International Atomic Energy Agency (IAEA, Vienna) for “Managing Nuclear Knowledge” [5] and the “World Nuclear University” [6] founded on September 4, 2003, in London have to be mentioned. Both initiatives are supported cooperatively by the Competence Network and perceived by the students with considerable interest.

As a whole, the number of participants in these colloquia is constantly increasing, such that meanwhile it is not even possible to admit all students interested. For this reason, the student oriented programs shall be further extended.

Young engineers and scientists may also be supported by the research institutions via the scheme for the promotion of pre-doctoral students. As an example, the situation at the Research Centre Karlsruhe may be addressed: Under the internal Pre-doctoral Students Program, 17 jobs (3/4 BAT II, employment contracts limited to 3 years) have already been offered in the nuclear sector. Another 3 pre-doctoral students are financed from third-party funds of so-called “Virtual Institutes” of the Helmholtz Association.

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Fig. 7

In addition, the close cooperation of the Competence Network with the nuclear industry has enhanced the development of a regional concept for a special sponsorship of nuclear technology training and research institutions by German utilities. The concept illustrated in Fig. 7 marks certain preferences of the four utilities (EnBW, E.ON, RWE, Vattenfall) which operate NPPs for research institutions in their neighborhood [7]. Under this meanwhile multiply practiced model, individual utilities and NPP manufacturer companies (Framatome ANP, WTI/GNS) finance qualified university graduates as pre-doctoral students working at a research institution. For this purpose, they employ qualified graduates and delegate them directly to a research institution. Upon successful dissertation, these persons will return to the delegating company. Such measures represent an attractive option for university graduates. They contribute to potentially strengthening the management level at the industrial companies and complement the institutions’ R&D capacity (as they are funded from third-party funds) and, thus, represent an interesting variant of maintaining nuclear competence for all parties involved. Additional possibilities for the research centres associated with this option in terms of topics to be covered shall be outlined in further detail in section 2.5.

This issue was also addressed at a special meeting of professors and university lecturers that was organized by the DATF in close cooperation with the Competence Network on January 26, 2004, in Bonn. On this occasion, these initiatives for the promotion of young scientists were expressly welcome by all participants. The resultant constructive exchange of ideas and information between industry, research, and teaching shall be continued at future meetings of the university lecturers (on the day before the annual DATF winter meetings).

For an early placement of contacts to the nuclear technology branch, the Kerntechnische Gesellschaft (KTG, German Nuclear Society) has established a special workshop on “maintenance of competence in nuclear technology” at its annual meetings for several years already. Here, committed pre-doctoral students report about the progress of their dissertation work and, in this way, introduce themselves to potential employers. The Competence Network on Nuclear Technology undertakes all efforts to support this successful series of meetings that is garnished with a “best paper award”.

Parallel to the alternation of generations in the technical and scientific staff sector, utilities and nuclear service industries show an increasing interest in practical exercises and training courses on nuclear technology and radiation protection. Such courses are offered for years by the Centre for Advanced Technological and Environmental Training (FTU) of the Research Centre Karlsruhe, the only one of its type in the Helmholtz Association. Since 1998, the number of these courses and lectures has increased from 80 to 130, with the number of participants rising from 1,400 to 2,100. Furthermore, FTU also gains international recognition due to its organization of relevant courses of the European Union and of major workshops on the peaceful use of nuclear energy on behalf of the IAEA. The Competence Network expressly supports these activities.

#### 2.5. Active Participation in International Nuclear Projects

In the course of the evaluation commission’s discussion, participation in international projects was identified to be the most interesting possibility of arousing interest among university graduates.

In this connection, the following recommendation was unanimously agreed upon by the evaluation commission [1]:

*“Continued active participation of Germany in major international activities and projects for the maintenance and further development of reactor safety and nuclear waste disposal research should be ensured”.*

In the meantime, this recommendation has been restricted by the red-green coalition agreement of October 16, 2002. There, it is pointed out that: *“Research to increase the safety of existing reactors shall be supported”.* And a little later: *“Support by the federal government of the development of nuclear technologies for electricity production shall be terminated”.*

As a consequence, active participation of German scientists from publicly funded research institutions in international projects is no longer possible. This relates, for instance, to the “Generation IV International Forum (GIF)” based on an initiative of the US DoE [8] and to the “International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)” of the IAEA [9].

In its statement addressed to the BMWA on July 16, 2003, the Competence Network on Nuclear Technology has deemed the participation of German scientists from publicly funded research institutions in Generation IV and comparable international projects necessary to keep up with the state of the art of science and technology and to analyze transferability of innovative safety approaches for future reactors and other “spin-offs” to NPPs operating in Germany.

As the above restriction only refers to employees financed from public means, external funding options have been examined. As a result, only those pre-doctoral students who are funded by the utilities and manufacturer companies may well study the attractive international issues listed above.

Meanwhile, also German participation in Generation IV has become possible via the membership of the European Union (EU) in GIF (since July 30, 2003) and by financing German contributions to Generation IV from third-party funds granted by the EU and industry. Management staff from FZK and FZJ is present in the steering committees for the Supercritical Water-Cooled Reactor System (SCWR) and the Very-High-Temperature Reactor System (VHTR) with EU funding and prepares valuable contributions to the projects with industry support under the 6<sup>th</sup> Framework Programme (FP6) of the EU. In this way, potential pre-doctoral students are admitted to the front of science and technology and given access to the international nuclear community. As a consequence, it is possible to influence, at least partly, safety concepts of future nuclear facilities abroad and to check new findings for potential applicability in Germany – even though scientists are forced to go a long way around.

### 3. Interim Results 2000 – 2004

Interim results of the work of the Competence Network on Nuclear Technology achieved so far may be summarized as follows:

- In spite of the limited operation times of nuclear power plants, long-term maintenance of nuclear competence will be required until far in the middle of the present century. In this context, it is underlined by the Competence Network that due to the current alternation of generations and the decreasing number of students studying nuclear technology, a lack of expert personnel may develop and even increase in the years to come.
- To counteract this development, the research centres that have joined the Alliance for Competence in Nuclear Technology are intensifying cooperation with neighboring universities so as to provide adequate training and dissertation possibilities in the nuclear area. First successes have already been achieved by the new establishment of chairs in nuclear technology and reappointments of their holders. To sustainably maintain this research sector, stable funding by the federal government as well as by the federal states is required.
- By coordination and bundling of the corresponding R&D programs in the Competence Network on Nuclear Technology, efficiency of the use of public funds to promote nuclear safety and waste disposal research has been increased sustainably.
- Together with the German Atomic Forum and the German Nuclear Society, research centres and universities regularly organize special colloquia and information meetings for students with a view to attract young scientists and engineers in nuclear technology. The centres and universities offer attractive pre-doctoral student employments to qualified university graduates, which – with increasing tendency – are financed from third-party funds of industry.
- In line with the research policy requirements, participation of German R&D institutions in international projects aiming at an innovative further development of nuclear energy systems is possible via third-party funds that are increasing considerably at the moment. In the opinion of the Competence Network, this second-best solution needs improvement, as the guaranteed operation of nuclear facilities according to the current international state of the art of science and technology first of all is a task of the federal state.

### 4. Concluding Remark

At the moment, nuclear energy assumes the largest share in electricity supply in Germany with 28% (see Fig. 8), in base load operation and free of CO<sub>2</sub> emissions. For the future, the red-green federal government has defined political guidelines for science and industry by

adopting its Act on the Phase-out of Nuclear Energy Use. As a result, the scopes of action of science and industry are restricted considerably. Nevertheless, nuclear safety and waste disposal R&D work remains, also in Germany, a necessary constituent of the responsible handling of the risk associated with the civil use of nuclear energy. Thus, it is an indispensable part of the society's provident research. The Competence Network on Nuclear Technology will continue to provide constructive contributions.

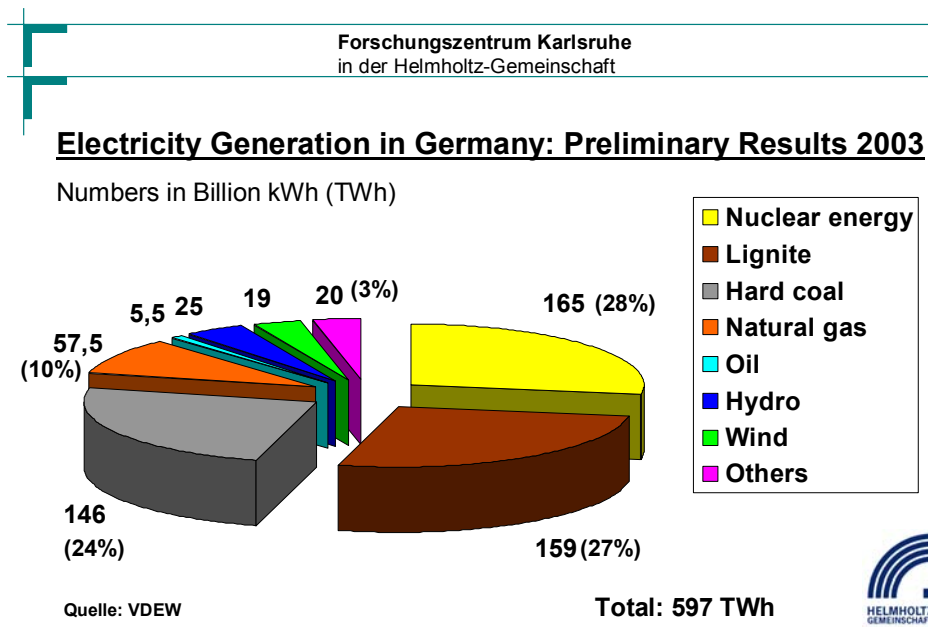


Fig. 8

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