

ANNUAL REPORT

1 JULY 2016 TO 30 JUNE 2017





The digital German and the English edition of the VGB Annual Report 2016|2017 are available for download at: http://www.vgb.org/en/annual_report.html.

VGB PowerTech

Annual Report

1 July 2016 to 30 June 2017

Contents

1 VGB PowerTech

VGB PowerTech: Partner for Electricity Generation

Tasks and Structure of the VGB Secretariat 4

2 Results of VGB's Activities

Nuclear Power Plants 7

Power Plant Technologies 18

Renewables and Distributed Generation 36

Environmental Technology, Chemistry,
Safety and Health 47

Technical Services 54

R&D Activities and VGB RESEARCH FOUNDATION 56

KRAFTWERKSSCHULE e.V. 59

VGB: Events and Publications 60

Co-operation in Associations and Organisations 63

3 Power Plant Statistics

Power Plant Statistics 64

4 Association Structure

VGB Membership 68

Structure of Members 68

List of VGB Members 69

Board of Directors 75

Technical Advisory Board 76

Scientific Advisory Board 77

VGB RESEARCH FOUNDATION 78

Imprint 79

Preface

Ladies and Gentlemen,

This Annual Report summarises the results of the work and activities of VGB PowerTech in the 2016|2017 reporting year. In its nearly one hundred year old history, the international association for generation and storage of power and heat, VGB PowerTech, has developed to a technical competence centre of the generation sector. Our members are at the centre of our attention. We support our members in operational and strategic matters, and are a contact and link for international relationships and the exchange of experiences and know-how related to generation and storage of power and heat. The main focus in this respect is on economic efficiency, technical efficiency, safety and environmental compatibility as also health and safety at work in construction, operation and decommissioning of the plants.

The topics and issues addressed by VGB PowerTech e.V. and its associated institutions Kraftwerksschule e.V., VGB Forschungsstiftung and VGB PowerTech Service GmbH are presented in detail in this report.

Generation in competition

The developments on the electricity markets in Europe and worldwide shift the weighting of generation technologies and investments in the individual types of generation. This is causing fundamental changes in the traditional structures. The significantly broader energy mix of conventional fuels and renewables is associated with various challenges, some familiar but becoming more acute, and some new, which will have to be overcome. In that context, it is expected that power supply will continue to be safe, secure and climate-friendly, in the spirit of a balanced triangle of cost-effectiveness, security of supply and environmental soundness in the energy sector.

Technology will play a major role in solving the problems of the future. It is the basis of business operations in generation and storage. Closely adaptations and innovations are leading to greater cost-effectiveness. This represents a challenge for VGB too, and increasingly so. We focus on the technical and economical challenges in the changing market environment, to support our members in achiev-

ing the stated goals – independently of proprietary systems or particular technologies, for the entire spectrum of generation from small, distributed facilities to large power plants, from renewables to classical thermal generation systems.

VGB members – in 33 countries across the globe

The stable membership structure is certainly an indicator of the recognition earned for the competence, expertise and work of VGB. Our 452 member companies are based in 33 countries worldwide. With 429 members, the European Union continues to be the most strongly represented region. Another 23 members come from 3 further European countries or are based in 10 countries outside Europe. In total, then, the association represents a power generation capacity of 433,000 MW.

VGB working for its members – the focus on the future

In response to the challenges to the industry and the association, VGB has initiated the structural project «Future VGB». In a step by step process, measures are being identified and taken to bring the association's range of services even more in line with the changing needs of the members. As a result, VGB will have suitable structures and an optimum portfolio to support its members.

The restructured VGB Head Office with its streamlined organisation provides synergies in the four major competence areas of «Nuclear Power Plants», «Power Plant Technologies», «Renewables and Distributed Generation» and «Environmental Technology, Chemistry, Safety and Health». In addition, «Technical Services» provide services in the fields of engineering consultancy, construction and installation supervision, the materials laboratory and water chemistry, and databases such as the power plant information system KISSY round off the association's portfolio of services. The exchange of experience, one of VGB's core functions, was successfully continued in the committees in the year under review, and also at the 27 VGB events in, which were attended by 2,100 participants.

In international contacts and activities, Eurelectric and the VGB are expanding their cooperation in the field of hydro power to strengthen the profile of that sustainable form of energy in Brussels

and the EU member states. Further cooperation arrangements with the Chinese Electric Power Planning & Engineering Institute (EPPEI), the EEC Excellence Enhancement Centre for the Indian Power Sector, the Japanese Thermal and Nuclear Power Engineering Society and the Turkish-German Energy Forum (TGEF) have been successfully continued.

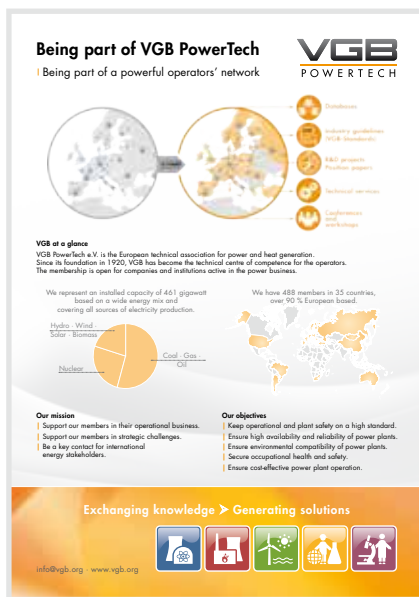
Together with the PowerTech training centre KWS and the simulator centre KSG|GfS, the Deilbachtal Energy Campus in Essen-Kupferdreh is a central venue for power generation topics. Initial training and continued professional development, technical training, simulator training and an exchange of information on services on engineering consultancy, construction and installation supervision, laboratory services and water chemistry are provided in close cooperation on the basis of a common infrastructure.

We wish you an interesting read of the VGB Annual Report 2016|2017.



Dr Hans Bunting
Chairman of the VGB Board of Directors

Erland Christensen
VGB Executive Managing Director



Tasks and Structure of the VGB Secretariat

The VGB Essen-based Secretariat covers the Competence Areas (Figure 2):

- Nuclear Power Plants,
- Power Plant Technologies,
- Renewables and Distributed Generation,
- Environmental Technology, Chemistry, Safety and Health and
- Technical Services.

The three Departments and the Technical Services work through all issues concerning heat and power generation and associated environmental protection issues – in close collaboration with EURELECTRIC on European and e.g. BDEW (Bundesverband der Energie und Wasserwirtschaft, Germany) on national level.

In order to fulfil the statutory tasks, honorary committees were set up by the VGB Board of Directors. The VGB Technical Advisory Board is responsible for allocating the committee members and determination of tasks. Currently committees are active in four fields with a large number of technical committees, technical groups and strategic forums. Three striking projects were realised during the reporting period:

- Re-organisation of the committee structure,
- Optimised working procedures to increase VGB's efficiency and
- Reorganisation of VGB Department organisation.

VGB PowerTech e.V. is the international technical association for generation and storage of power and heat. VGB's 452 members from 33 countries represent a power plant capacity of 433,000 MW thus in 2016/2017 VGB achieved again a good result in terms of «members», «countries», and «power plant capacity». (Figure 1)



Fossil-fired power plants	238,500 MW
Nuclear power plants	117,500 MW
Hydro-power plants and other renewables	77,000 MW
Total:	433,000 MW

EU-28: 429 Members in 20 Countries

Austria, Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Luxembourg, The Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden

Other Europe: 11 in 3 Countries
Russia, Switzerland, Turkey

Outside Europe: 12 in 10 Countries
Argentina, Australia, China, Japan, Malaysia, Mongolia, Morocco, Saudi Arabia, South Africa, USA

Total: 452 in 33 Countries

VGB represents a worldwide power plant capacity of 433,000 MW

Fig. 1: VGB memberships according to European countries. Outside of Europe, another 11 companies in 9 countries are VGB members.

During the year under review, the committees, groups and forums of VGB convened at over 180 meetings. All VGB members are informed about the results of these meetings through the bimonthly «VGB Newsletter» by e-mail, through the VGB Home Page, and via internet (closed user groups). Other interested parties can also obtain the VGB Newsletter free of charge by e-mail. Interested parties can register at www.vgb.org | Publications.

Apart from overseeing the activities of the committees, the VGB Secretariat also performs other tasks. In addition to working on the rules and regulations in form of VGB-Standards, VGB is also responsible for organisational support and coordination of joint research of power plant operators in the VGB-Forschungsstiftung (Research Foundation). The joint research supplements the company-specific research objectives. Furthermore, the VGB Offices organise seminars, symposia, conferences, and the annual VGB Congress «Generation in Competition». These meetings are further platforms for the international exchange of experience within VGB PowerTech.

Against the background of the current challenges and the restructuring of European heat and electricity supply, VGB's missions are:

- ...to support our members in their operational business,
- ...to support our members in strategic challenges,
- ...to be a key contact for international energy stakeholders.

VGB's objectives are:

- ...to keep a high standard of operational and plant safety,
- ...to ensure environmental compatibility of power plants,
- ...to secure occupational health and safety, power plant concepts,
- ...to ensure high availability and reliability of power plants,
- ...to implement modern energy technologies,
- ...to ensure a cost-effective power plant life cycle.

VGB's Technical Services offer services in the fields of:

- engineers' consulting,
- damage analysis and material test laboratory,
- monitoring of construction and assembly/quality monitoring,
- external chemical investigations.
- Creation of technical Standards (no-official standards), in detail:
 - since August 2011 VGB Guidelines and VGB Instruction Sheets have been published as VGB-Standards,
 - since 2017 Ordinary Members of VGB have free access to VGB Standards (eBooks).
- data bases and technical information in all fields of generation,
- coordination of projects and R&D,
- networking with associations like IEA, EURELECTRIC, EUTurbines, and others.
- training and further vocational training of power plant personnel (at KWS and KSG | GfS).

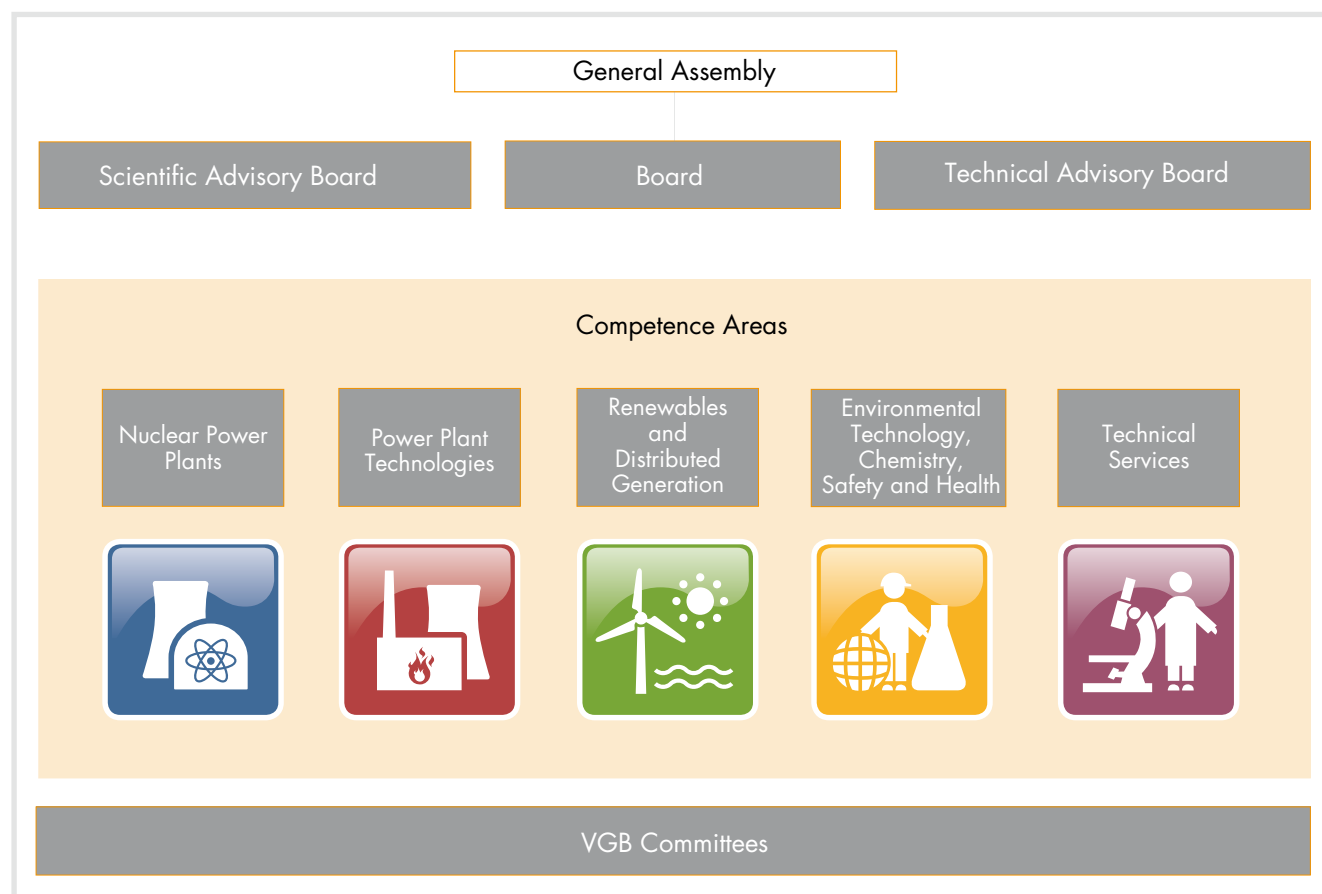


Fig. 2: Structure of VGB PowerTech e.V., the international technical association for generation and storage of power and heat.



Fig. 4: The Training Centre of the KRAFTWERKSSCHULE E.V./PowerTech Training Centre Association in Essen-Kupferdreh with the new building at the «Deilbachtal Energie Campus».



Fig. 5: The Simulator Centre of the KSG|GfS in Essen-Kupferdreh at the «Deilbachtal Energie Campus».

Partner Companies of VGB

The VGB Executive Managing Director is also the Managing Director of VGB-Forschungsförderung e.V., and VGB PowerTech Service GmbH (Figure 3). He also has a close association with the KRAFTWERKSSCHULE E.V., the Kraftwerks-Simulator-Gesellschaft (KSG) and the Gesellschaft für Simulatorschulung (GfS), which are responsible for training concerning conventional, renewable and nuclear technology. Furthermore, he coordinates the distribution of tasks amongst other sector associations.

KRAFTWERKSSCHULE and KSG|GfS

The competence of operating staff is, to a great extent, a determining factor in the security, cost-effectiveness and environmentally-friendliness of power plants. Even in the current times of liberalisation, the contribution of personnel to the value of a company is decisive for its competitiveness.

The VGB members have long since realised the importance of training and further vocational training for their employees. Drawing up guidelines for the training of operating staff set the course for the qualification of power plant operators and shift supervisors, in particular, at an early stage. The Kraftwerksschule e.V. (KWS, PowerTech Training Center) was founded in 1957 and since then has trained and updated training for employees in member companies (Figure 4).

The personnel at nuclear power plants are trained in The Simulator-Centre KSG|GfS in Essen-Kupferdreh/Germany. Simulator training for reactor operators began on Klinkestraße in Essen in the VGB Offices as early as 1977. In 1987, the KSG (Kraftwerks-Simulator-Gesellschaft mbH) and GfS (Gesellschaft für Simulatorschulung mbH) companies were founded by 11 German and two international energy

supply companies. KSG provides the simulators in the new Simulator Centre and the appropriate infrastructure which GfS uses to carry out its training (Figure 5).

VGB PowerTech Service GmbH

VGB PowerTech Service GmbH (PTS) is essentially responsible for collecting and distributing the existing know-how at VGB. It publishes the VGB PowerTech international journal as well as VGB-Standards guidelines, instruction sheets, conference proceedings, technical scientific reports, VGB books and brochures.

VGB FORSCHUNGSSTIFTUNG

The tasks of the VGB Forschungsförderung (VGB Research Foundation), founded in 1970, and the results achieved in the financial year concerned are described in chapter 2 of this report.

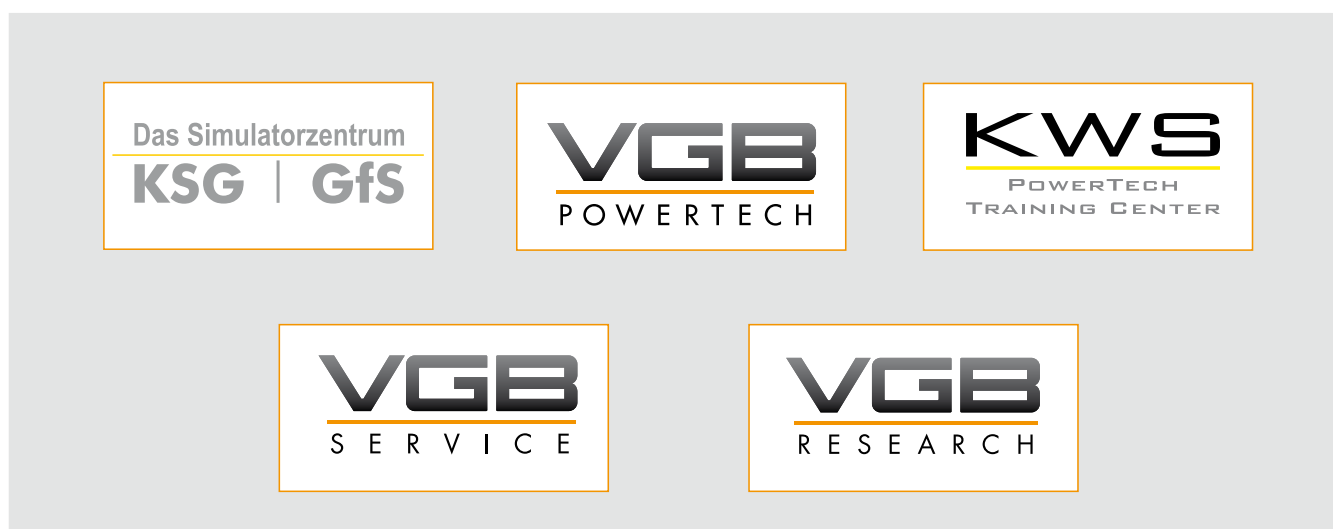


Fig. 3: The VGB Group, KWS KRAFTWERKSSCHULE and KSG|GfS – Das Simulatorzentrum.

Competence Area Nuclear Power Plants

GC Nuclear Power Plants	C: Dr. H. Pamme A: T. Linnemann
TC Engineered Safety	C: Dr. M. Fuchs A: Dr. L. Mohrbach
WP Safety Assessments	C: T. Hanisch A: T. Linnemann
WP Plant Security	C: M. Meyer A: Dr. L. Mohrbach
WP Component Integrity	C: Dr. G. König A: J. Ganswind
WP Reactor Core	C: W. Schäfer A: G. Vallana
WP Impacts on Civil Structures	C: K. Borowski A: J. Ganswind
TC Nuclear Power Plant Operation	C: M. Bongartz A: Dr. L. Mohrbach
WP Mechanical and Process Engineering	C: L. Schoppe A: H. Grimmelt
WP Electrical and I&C Engineering	C: M. Bresler A: J. Kaiser
WP Practical Radiation Protection	C: Dr. R. Wink A: Dr. L. Jentjens
WP NPP Management Systems	C: J. Schwarzin A: J. Ganswind
WP Event Analyses	C: A. Hums A: G. Vallana
TC Decommissioning and Disposal	C: U. Rieger A: K. van Bevern
WP Decommissioning	C: Dr. R. Versemann A: K. van Bevern
WP Interim Storage	C: Dr. F. Guterthuth A: A. Seidel
WP Safeguards	C: M. Hahn A: K. van Bevern

GC General Committee
SC Special Committee
TC Technical Committee
WP Working Panel

The tasks and results of the Technical Group «Chemistry of Light Water Reactors» are described in Chapter 2 «Environmental Technology, Chemistry, Safety and Health».

Competence Area Nuclear Power Plants

Ludger Mohrbach

In the period under review, the VGB department «N» (Nuclear) continued to be organised under its General Committee «Nuclear Power Plants» in three Technical Committees (TC) and 13 Working Panels (WP) (Figure 1).

In addition, (part-time) department staff also managed other panels like e.g. the WP «LWR (Light water reactor) Chemistry» (see «Environmental Technology, Chemistry, Safety and Health»), the WP «Electric and I&C Technology in Nuclear Power Plants» (see department «T»), other panels on health and safety, turbines, transformers or the Technical Committee «Nuclear Power» («Fachausschuss Kernenergie») on behalf of the nuclear power plant operators.

TC Nuclear Power

Thomas Linnemann

The Technical Committee (Fachausschuss «Kernenergie»), formerly organised by BDEW (Bundesverband der Deutschen Energie- und Wasserwirtschaft (Federal Association of the German Energy and Water Industries)), provides a forum for the exchange of experience on the level of the associations BDEW, DAfF (Deutsches Atomforum (German Atomic Forum)), VGB PowerTech and Swiss-nuclear. Together with questions on the political situation of the industry, the exchange of operating experience covered issues related especially to the «back end» of the nuclear fuel cycle.

In the period under review, the legal position of the nuclear power plant operators in Germany improved further with the landmark decision of the Federal Constitutional Court on December 6, 2016, confirming the non-compliance of the federal government's 2011 post-Fukushima legislation ordering the premature shutdown of all operational 17 units until 2022. Therefore, the government will have to indemnify the operators. No decision on the final amount of compensation has yet been taken.

Implementation of the KFK findings

On 27 April 2016, the so-called «KFK Commission» (Kommission zur Überprüfung der Finanzierung des Kernenergieausstiegs (Commission for Review of the Financing of the Phase-out of Nuclear Energy)), convened by the Federal Government, submitted its final report with recommendations on the financing of decommissioning, dismantling and disposal of the nuclear power plants, and on the redistribution of responsibility between the state and the operators.

The responsibility for interim storage and final disposal is in future to be transferred to the state, while activities such as dismantling, processing of residues and packaging of waste shall remain within the responsibility of the operators.

With the state taking over the complete responsibility for interim storage and final disposal, the KFK Commission called for an additional risk premium of approx. 35% on top of the reserves of around 17G€ already earmarked for that purpose (i.e. one G€ per nuclear power plant unit). This results in a once-and-for-all payment of 23.3 G€, to be covered from the reserve funds accrued during operation. In relation to the total of over 5,200 TWh the nuclear power plants have produced in Germany until today, the resulting final disposal costs of less than 0.45 €/kWh electricity from nuclear energy are manageable.

Put differently, one annual instalment of the present EEG differential costs (Remuneration paid out throughout Germany under the terms of the Renewable Energy Act (EEG) minus market revenue for the electricity fed in from plants receiving EEG subsidies.) of approx. 23.5G€ is sufficient to settle all interim storage and final disposal obligations from what in the year 2022 will have been more than 60 years of commercial nuclear power plant operation. In addition, it remains remarkable that cost estimates in other countries regularly arrive at significantly lower final

disposal costs in a range of 10% to 50% of the German figures (for example the USA: 40G\$ for 143 nuclear power plant units, corresponding to approx. 25 % of the German figure).

Provisions for storing high-level nuclear waste in e.g. Gorleben are thus four times higher than e.g. for Yucca Mountain.

A report by auditors Warth & Klein indicates that the German operators have fundamentally taken all the necessary cost items into account in their reserves. Furthermore, the reserves, totalling € 38 bn (as of 2014) for the 24 units of the private power industry are, according to the report, adequate to fulfil all back-end requirements. The report admittedly drew attention to sensitivities on interest rates and anticipated price increases, but still assessed the actions of the operators as appropriate in general.

With regard to the implementation of the KFK recommendations, procedure details and responsibilities, questions on the transfers of the on-site interim storage facilities and the definition of requirements for the packaging of waste have not yet been finalised (as of 1 June 2017).

The «Act on Reorganisation of Responsibility for Nuclear Disposal» has been adopted, but not yet put into effect, as there is a need for substantive arrangements on payment terms. The results of the review by the EU Commission on its compliance with EU subsidy laws are also pending. As a safeguard against political changes, the act is additionally to be backed up by a public law contract. The interim storage facilities for heat-generating waste are prospectively to be transferred to the state on 1 January 2019, and those for medium and low level radioactive waste on 1 January 2020.

Unconstitutionality of the Fuel Assembly Tax

Over and above this, the Federal Constitutional Court found on 7 June 2017 in a final and non-appealable verdict that the Federal Government had no competencies to legislate on the fuel assembly tax levied from 2011 to 2016, and that the total of that tax of 6.3 G€ (including interest) is to be repaid to the nuclear power plant operators immediately.

Developments on EU level

The regulations of the new EU Nuclear Safety Directive must be implemented into each member state's national legislation by 15 August 2017. In Germany, this will take place within the framework of the «15th Amendment to the Atomic Energy Act», in which – for the first time – radiation protection will also be given a status as a federal law.

The directive presents Germany with two tasks: Firstly, the organisation of the Topical Peer Reviews required under six-year intervals from 2017 onwards, and secondly, new arrangements on the independence of the authorities. From the point of view of the German operators, there is no need for any further implementation measures, as corresponding national regulations are already in place to cover these issues.

The EU regulator's advisory body ENSREG (European Nuclear Safety Regulators Group) will (in consultation with WENRA (Western European Nuclear Regulators Association)) have to stipulate an individual topic for each topical peer review. For 2017 it chose «Ageing Management» and related issues of ageing effects of electrical components and I&C cables, non-accessible pipework and concrete structures (especially reactor containments).

Developments in Switzerland

The referendum in Switzerland on 27 November 2016 on a phase-out of nuclear energy, under the motto «45 years are enough» resulted in a clear majority of 54 % for the rejection of the petition. The winning «Contra» application called for nuclear as a «transitional technology for as long as base load supplies» will be required. The objective of the «Pro»-application had been to have all five Swiss nuclear power plant units shut down within one year of reaching 45 years of operation.

There was a further referendum in Switzerland on 21 May 2017: A majority of the population approved the 2050 energy strategy and the aims of reducing energy consumption, increasing energy efficiency, promoting renewables and prohibiting the construction of new nuclear power plants.

Final Disposal in Germany: Back to Square One

After multi-annual work, the «Final Repository Commission» (appointed by the Federal German Government) submitted its final report on the «socially compatible» selection of a new final repository site for heat-generating nuclear waste to the Bundestag on 5 July 2016.

One of the fundamental findings was that the final disposal in deep geological formations continues to be the solution to be aimed at. As a further result, it is to be noted that the Gorleben site, which has already been extensively explored, will remain in the selection process.

With the exception of the criterion of recoverability, the criteria for the search for a final repository are the same as those applied by the governmental working group on «Selection Procedure for Final Repository Locations» (Calendar years from the date of official commissioning). The search is to be backed up by extensive measures to involve the public. A site is to be selected by 2031, and the repository constructed by 2050.

The conversion of the former iron ore mine «Schacht Konrad» near Salzgitter, approved as a final repository for non-heat-generating radioactive residues, has encountered further delays, and commissioning is now scheduled for 2022/2023 at the earliest. «Konrad wastes», accumulating up to that date (especially from the dismantling of decommissioned plants) will have to be temporarily stored at the respective power plant site (at considerable cost).

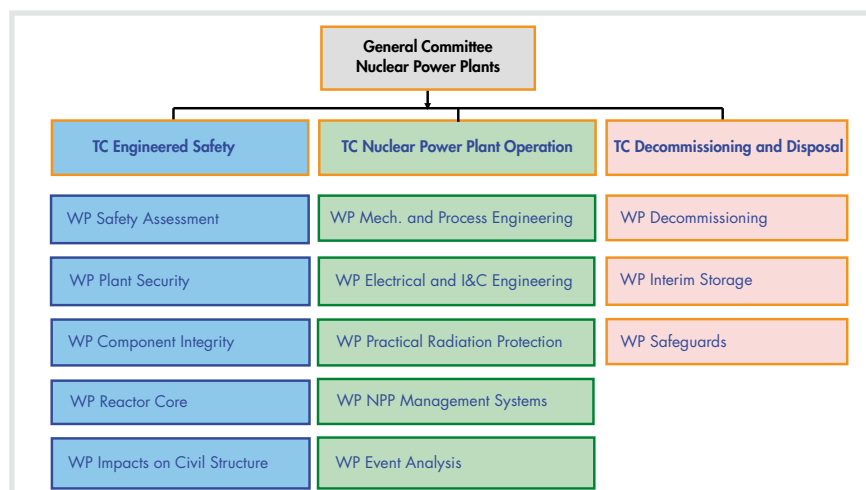


Fig. 1: Organisation chart of VGB Department «N» (Nuclear).

Nuclear Power Plants of International VGB Members

Ludger Mohrbach

Members from Argentina, Belgium, Finland, the Netherlands, Spain and Switzerland continue to work on various committees and panels of department «N». Eletronuclear (Brazil) has suspended its membership for one year as a result of financial constraints following the bribery scandal connected with the construction of Angra-3.

Global Expansion of Nuclear Energy

While Germany was the only country in the world to shut down operating nuclear power plants after Fukushima and decided to exit completely from nuclear energy in around ten years, the expansion of nuclear energy continues in many countries around the world (Figure 2).

Since 2011 in particular, new-build projects have commenced in five newcomer countries (United Arab Emirates, Belarus, Bangladesh, Turkey and Egypt), while especially the most important CO₂ emitting countries apart from the USA, i.e. India and China, are planning significant expansions of nuclear capacity (Figure 3).

Project Management

Thomas Linnemann

The subcommittees of the General Committee «Nuclear Power Plants» promote operation-related research and development projects for nuclear power plants. These are financed by the participating nuclear power plant operators on a cost-sharing base. In 2016, 42 projects were awarded, with a total funding volume of 2,328,499 € (Table 1).

In 2016, a total of 42 projects (previous year: 47) were started, with a total funding volume of around 2.3 M€ (previous year: 3.6 M€). Two projects with a funding volume totalling 0.26 M€ were initiated by the General Committee (previous year: 1 project with 65,000 €), 35 projects with 1.6 M€ by the TC «Nuclear Power Plant Operation» (previous year: 27 projects with 1.9 M€), five projects with 0.5 M€ by the TC «Engineered Safety» (previous year: 18 projects with 1.7 M€).

Medium-term Budgeting

All nuclear VGB committees communicate their expectations for the medium-term development of their expenditure on operation-related VGB joint projects once each

Conclusions	Country
Start of nuclear programme	UAE, BY, BD, TR, EG, SA, JO, PO
New build	AR, CN, FI, HU, IN, IR, PK, RU, UK, US
No change	BG, BR, CZ, HR, MX, RO, SE, SK, UA
Moratorium	CA, FR, LT, NL, SK, TW, ZA
Turn back of phase-out	JP
Extended operation licenses	BE, ES
Withdrawal of new nuclear programme	IT, CH
Phase-out with shut-down of plants in operation	GER

Fig. 2: National nuclear power strategies after Fukushima.

year to the VGB secretariat, which draws up a five-year (2018 to 2022) budget plan on this basis.

VGB regularly assesses the status of all projects by assigning traffic light colours to each project, reflecting delays and/or cost overruns.

At the end of April 2017, a total of 69 projects was under way. None of the projects was rated «red» at that time, whereas 31 projects whose timing deviated from the original scheduling for justifiable reasons were classified as «yellow», and 38 projects as «green».

In the year 2016, 49 projects were completed commercially, while the technical work on a further eight projects was also completed. In the first four months of 2017, 16 commercially and 3 technically completed projects were added.

The reasons for the «yellow» classifications included primarily delays resulting from coordination processes among the involved operators, delays in the final invoicing process, or, in individual cases, delays due to the necessity of involving external experts. These individual cases, unpredictable as a rule, lead to the deferral of planned payments into the fol-

lowing year because project scheduling usually leaves no room for back loops. For budgeting purposes, this effect can at best be estimated only on a cross-project basis (statistically averaged empirical values from the previous years), and from a competition law point of view only for the individual operator.

Whereas for the year 2015 budget deferrals to the following year totalling around 3.1 M€ were reported, those for the year 2016 were significantly lower at around 1.9 M€. These budget deferrals always concern contractual liabilities from joint projects applied for, reviewed, approved and assigned in conformity with VGB rules.

In each of the past three years, around 60% of the expected total costs were received by the VGB Secretariat in the form of invoices. In the previous year, the forecast costs were 11.9 M€, of which 6.8 M€ was actually invoiced.

In early May 2016, the General Committee received the new VGB medium-term budget plan (2018 to 2022, Figure 5), agreed bottom-up with all committees dealing with nuclear technology, for information. According to this budget, only total costs of 5.6 M€ are expected for

No.	Committee	Quantity	Euros
1	GC «Nuclear Power Plants»	2	259,000
2	TC «Nuclear Power Plant Operation»	35	1,570,566
3	TC «Engineered Safety»	5	498,333
4	TC «Decommissioning and Disposal»	0	0
Total		42	2,328,499

Tab. 1: Nuclear projects commissioned in 2016.

- Damage analysis and identification of remedies.
- Public relations and committee work (publications, presentations and work on German and European standards).

Assessment of Damage Cases

The general procedure in cases of damage consists of determining the damage mechanism, the causes of the damage, identification of repair and remedial actions to prevent repetition, and of assessing transferability potential to other plants. There is also an evaluation of «Lessons Learned» potential. An example of a damage case examined by the WP is presented below:

- Slot Wedges of Generator Rotors

Based on a damage event involving a slot wedge inside a 60 Hz generator reported from a US nuclear power plant, the WP launched a test programme to assess the transferability to rotors of 50 Hz generators of the same type. The programme focused on damage analysis, NDT findings and integrity assessment. The results of the project make improved assessment of NDT indications with regard to component integrity possible and in that way improve the basis of decision-making on continued operation or repair (Figure 5).

WP Reactor Core

Guido Vallana

Current projects deal with safety case issues of neutronic and thermohydraulic core design as well as the layout and operating behaviour of fuel assemblies and fuel rods for the required safety assessments. As a result of the general nuclear energy situation in Germany, it is to be noted that the range of activities of the WP is increasingly shifting in the direction of interim storage.

In the period under review, the WP conducted an intensive exchange of experience on the following focal topics in a total of nine meetings:

- Operational performance of fuel assemblies, fuel assembly bending and the resulting reactivity behaviour.
- Assessment of the effects of water gaps on normal operation and during incidents.
- Revision of nuclear standard «Design of Reactor Cores in Pressurised and Boiling Water Reactors».

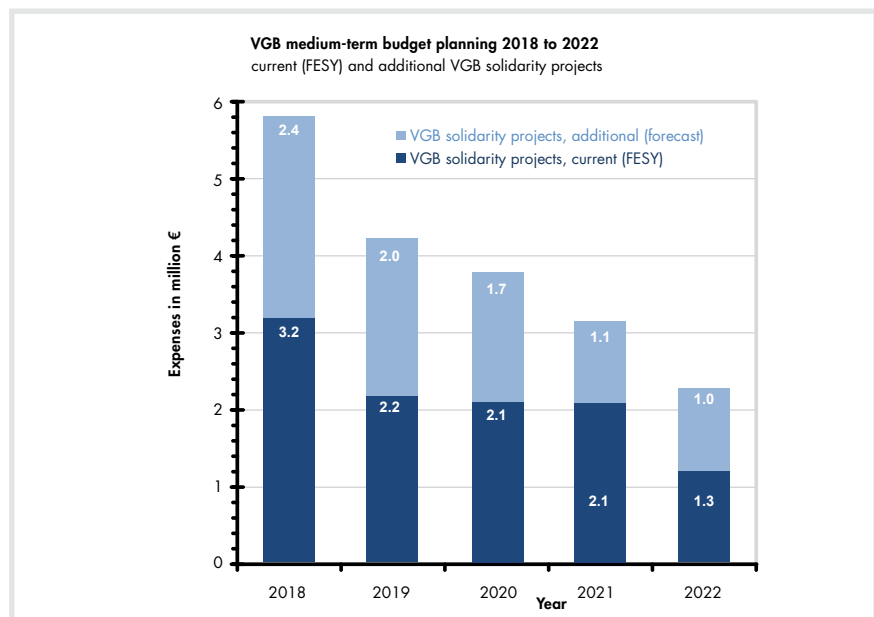


Fig. 4: VGB medium-term budget planning 2018 to 2022.

- Continued and new participation in international research projects, e.g. the OECD-HALDEN reactor project.
- Assessment of findings from plant inspections.
- initiation and supervision of study programmes on safety assessments and the development of fuel assemblies or fuel rods within the framework of national and international research projects.

Further activities included

- technical consultation on general enquiries from authorities and independent experts,
- monitoring of the state of the art, and

On a higher level and in accordance with its remit, the WP has devoted attention to identifying nuclear issues which could come into question as projects in the coming four years. This part of the project management was accompanied by corresponding budget planning.

RSK-Committee	Subject of discussion	Date	VGB WP
EE	Status of implementation and practice on the ageing management requirements of KTA 1403 for electrical and I&C components	06.06.2016	EL
RRSK	Robustness analyses: VGB robustness concept for BWRs (written statement without presentation)	14.02.2017	NWV
AST	Status of fuel assembly deformation in PWR plants (follow-up presentation)	18.01.2016	R
RB	Recurrent training for non-routine tasks	02.02.2015	KKWB
RB	Operating experience with PWR neutron flux noise, queries (written feedback without presentation)	09.06.2016	R
EE	One- or two- phase faults of the main, back-up or emergency power network connections: Handover of the VGB report (written feed-back without presentation)	05.07.2016	EL
RRSK	Robustness analyses: Plant-related information on flood protection (written feedback without presentation)	15.03.2016	NWV

Tab. 2: Operator presentations and submissions to the RSK committees «Plant and System Technology» (AST), «Electrical Equipment» (EE) and «Reactor Operation» (RB) organised by the WP «Safety Assessments».

«EL» = Electrical and I&C Engineering; «KKWB» = Nuclear Power Plant Operation; «KOM» = Component Integrity; «NWV» = Safety Assessments; «R» = Reactor Core.

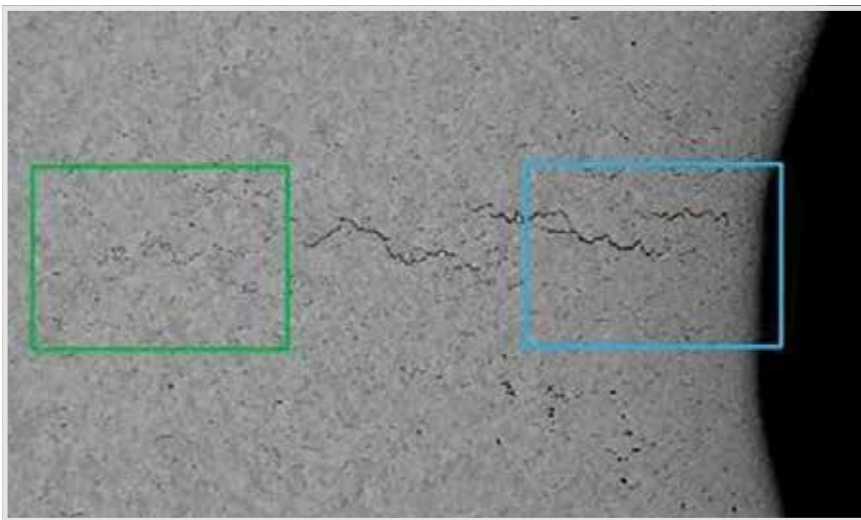


Fig. 5: Grain structure damage in a generator slot wedge.

WP Impacts on Civil Structures

Jens Ganswind

The focus of the WP is mainly on civil engineering issues relevant to safety in the fields of seismic design, flooding, extreme weather, explosions, fire protection and ageing management, and on safety assessments on civil structures in operation and during dismantling.

The state of the art is monitored by an exchange of experience among all operators and by the involvement of experts from science and industry.

In the course of the project «Technical Review of the Need for Revision of KTA 2207 on Protection of Nuclear Power Plants from Flooding», for example, a contribution was made to the argumentation of the KTA subcommittee. In general, the expert assistance of the operators in standardisation work is prepared in the Working Panel, for instance in relation to a statement on ageing management and on examination of the need for revision of relevant KTA standards under the terms of section 5.2 of the KTA rules of procedure.

The WP compiled recommendations for action, independent of particular manufacturers, in response to the verdict of the European Court of Justice (ECJ) on unregulated construction products, e.g. wall anchors in nuclear power plants.

New tasks result from the end-of-duty operation and the dismantling of the nuclear power plants. In cooperation with a specialist contractor, application requirements for modified safety assessments have been discussed for that scenario. The working group «Civil Structures during Dismantling» is also being monitored.

The preservation of know-how and the necessary further training of operator personnel in the field of civil structures for nuclear applications are also ensured by the WP.

TC Nuclear Power Plant Operation

Ludger Mohrbach

In three meetings lasting two days each, the nuclear plant managers reported on operational events and common projects (including project management and medium-term planning). For «Best Practice» recommendations and «Lessons Learned» see the individual meeting minutes.

Change in WANO Membership

The German nuclear power plant operators PreussenElektra, RWE Power and EnBW Kernkraft had decided to reorganise their memberships within the «World Association of Nuclear Operators» (WANO) through a joint VGB representation for cost reasons. With the retirement of the VGB-WANO Interface Officer in mid-2016, the associated functions were outsourced to three newly nominated employees of those companies.

German versions of the WANO documents continue to be made available at the power plants, and translation is still performed at very low cost via a VGB project (with additional involvement of the Swiss nuclear power plant operators).

Contractor Assessment

With the retirement of the responsible VGB officer in mid-2016, the contractor assessment functions were transferred to the

working group of the same name, which has compiled a detailed work plan for the temporary and permanent tasks which are now pending.

Exchange of experience

The safety indicators for the year 2016 were on the same excellent level as in the previous years. In the period under review, all VGB plants reported only events on level 0 of the International Nuclear Event Scale (INES).

The release of radioactive nuclides with waste air and waste water was very low in all the plants monitored, and well below the approved limits in all cases. As in past years, no impairment to the environment and no incidents occurred. The exposure of the plant personnel to radiation continued to be pleasingly low at all the plants, and therefore the favourable trend in radiation protection was successfully continued.

In the course of the exchange of experience, the plant managers presented situation reports on selected operational events and current topics:

- Decommissioning strategies (KWB, KKB, KKK, GKN-1, KKI-1, KKP-1, KKK, KKG, KKM).
- Primary system decontamination (KKK, KWB, KKK, KKG).
- Erection of interim storage buildings for non-heat-generating waste (KWB, GKN, KKI, KKK).
- Spontaneous ignition of drum contents (KKE, KRB), drum corrosion (KKB, KKK).
- Special features of handling procedures on the reactor floor (KRB-B, KBR).
- Industrial accidents (KKU, KBR, KKE, Doel-4).
- Water hammer (KWG).
- Cask inspection reports, CASTOR loading (all).
- Minor leakages (KRB-B, KKP-2, OL-2, KWG, KKE, GKN-2, KBR).
- Location of malware in a loading machine display unit (KRB).
- Fuel rod damage and disposal (KRB-C, GKN-1, KKP-1, OL-1, KKM).
- Fuel assembly bending (KKGg), dryout discoloration (KKL), new cladding oxidation (KBR).
- Diesel radiator/gearbox findings (KKP-2, KKGg).

- CASTOR transport between KWO and GKN by water.
- Disposal options for boric acid (GKN, KKG, KKB) and non-radioactive wastes qualified for normal disposal (KKB, KKI, KKU, KKK).
- Preposition of grid services (minimum load, load gradients) (GKN-2, KBR, KKE, KRB).
- Installation of roof protection facilities as defence against helicopter actions (GKN-2).
- Erection of additional interim storage facility protection walls (KKI, KKU, KKK).
- Modification of grid connections (KKI, KKP-1, KKK, KBR).
- Personnel planning (KKU, KKG).
- Incorrect declaration of inspection and overhaul work (KKP).
- Reaction to RENEGADE (Unidentified flying object) alarms (all).
- Results of VGB-SBS (Safety culture assessment) (KKG).
- Reporting of findings in reactor pressure vessels (Beznau-1, Doel-3, Tihange-2).
- Status of manufacturing documentation for pressure vessels from Chalon (Switzerland, France, Belgium).
- Pump damages (KCB, KWG, Tihange-1, GKN-2, KKGg, KKE, Tihange-2).
- Failed disengagement of a fuel assembly during lifting of the reactor vessel head (KBR).
- Detection of phase imbalances in the high voltage network (KBR).
- I&C system modernisation (KKGg, Doel-1, Doel-2, KKI-2, KWG, Doel-3).
- Prolongation of service life by 10 years (Doel-1, Doel-2).
- Reactor scram after control rod failure (Doel-1).
- Introduction of neutron radiography for condition assessment of control rods (KRB).
- Drift of measured data on incore temperature gauges (KRB-B).
- Phase shifter operation of the generator (KWB-A).
- Licensing of MOSAIK and TN24 casks (KWB, GKN, KKI).
- Faults in electronics (KKB, KKE, Doel-2).



Fig. 6: Use of a pipe milling machine by workshop personnel.

- Sheared and/or deformed bolts on ventilation duct trays (KKP, GKN, KWG).
- Filtered containment venting; design faults and retrofitting (GKN-2, CNT).

Revitalisation of National Peer Reviews

In response to a number of plant events with health-damaging potential, the TC re-constituted the proven instrument of «National Peer Reviews» and initiated a new review on the subject of workplace hazard assessments.

«QP»-Database for Lubricants and other Consumables now Available

For rapid access to all necessary documentation for lubricants, cleaning agents and other consumables, the newly established VGB «Quality Products Database» is now available for use by operators of nuclear power plants and also by interested parties from other types of power plants.

New Standards/Recommendations/Presentations

The TC adopted new standards, compiled by various working panels and groups, for example (Figure 7) on

- fuel assembly storage basin cooling,
- professional management behaviour, and
- preservation of expertise for interim storage facilities.

WP Mechanical and Process Engineering

Heinrich Grimmelt

A total of four meetings took place in the period under review. The WP discussed reportable events and near incidents with relevance to occupational health and safety and plant safety, such as

- irregularities and damage to fuel assemblies,
- events during loading of fuel assembly transport and storage casks,
- malfunctions of valves and pumps,
- consequential damage from inadequate screw locking on a pump impeller,
- sheared and/or deformed bolts on ventilation duct trays, especially on mechanical properties of the L-shaped gap bridging profiles and corresponding wall/ceiling gap distances,
- leakages in secondary cooling water systems,
- replacement of flange supports on emergency power motors,
- procedures for lifting gear operations with jacks and hoists.

The discussions focused on root causes analysis and future precautionary measures to prevent repetition.

As a result of several incidents (some of which led to serious personal injury) in the context of isolation switching and normali-

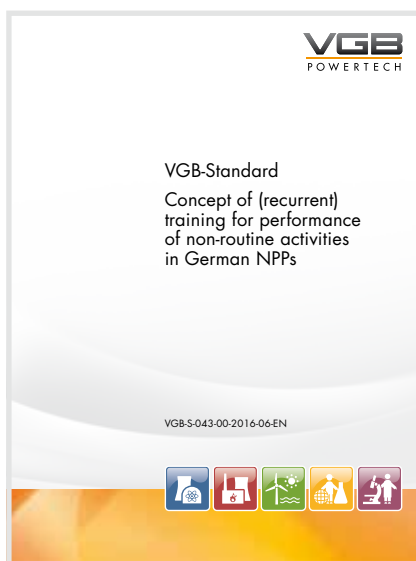


Fig. 7: VGB-Standard «Concept of (recurrent) training or performance of non-routine activities in German NPPs VGB-S-043-00-2016-06-EN.

sation, the WP decided to intensify its exchange of experience and to concentrate on the subject of monitoring of depressurisation and isolation. For that purpose, the WP established a core team which has compiled a guideline on this topic.

Furthermore, it has been found in several plants that ventilation ducts were contaminated with fluff from the laundry, which leads on the one hand to an additional fire load, and on the other hand to possible harm to the health of the personnel. The WP responded to these findings by organising an exchange of experience on assistant manager level on the subject of heating and ventilation systems. It became apparent that preparation and organisation of extraction procedures take up a large amount of work both during plant operation and during dismantling.

A closer consideration of health and safety at work aspects has revealed that the probability of industrial accidents during dismantling work is disproportionately greater than during maintenance work in normal operation, which includes more recurrent tasks (see Figure 6).

General hazard assessments are therefore an insufficient basis to draw upon, and rather specific hazard assessments related to the particular application should be compiled.

With contracted work, too, there are points of contact in terms of safety between the operator and the contractor. The operator must provide support staff to deliver safety instructions at site, taking account of

the specific background conditions of the workplace. The hazard assessments and the qualifications of the contractor's staff have to be checked. Furthermore, it must be ensured that the contractor complies with the safety measures required.

WP Electrical and I&C Engineering in Nuclear Power Plants

Jörg Kaiser

The WP coordinates the electrical and I&C issues of various committees within and outside VGB, and evaluates events of generic importance. This also includes findings from the committees on electrical, I&C and information technology in conventional power plants, for instance for large electrical components such as generators and transformers, on feedback effects from power electronics in the transmission system, and also on IT security.

The intensive experience exchange on unusual conditions during operation, inspection, maintenance and retrofitting, and on research projects ensures a coordinated proceeding and creates the opportunity to organise operation and projects in a cost-effective manner.

Within the WP, projects are essentially handled directly by the VGB WG «Qualification of I&C Components» (42 projects, 21 of which are by now technically complete) and the VGB WG «Qualification of I&C components for LOCA conditions» (24 projects, 8 of which are now technically completed).

Effects of Single-phase Grid Connection Failures

As a result of «events with asymmetrical power supply after failure of individual phases» in foreign nuclear power plants, GRS compiled Information Notice 2013/05. At the request of the German nuclear power plant operators, the project group (PG) «Grid Issues» addressed the analysis, the effects and the measures to detect phase failures and the associated asymmetries in auxiliary service supply systems of nuclear power plants.

The PG «Grid Issues» successfully brought its work to an end, summarising all related issues and evaluating them. It specified the implementation of plant-related measures. It is therefore ensured that no adverse effects from these phenomena on nuclear power plant operation and their electrical components can occur.

Questions from the RSK Committee Electrical Installations

The WP «Electrical and I&C Engineering» also continuously exchanges information on the topics of the RSK committee «Electrical Installations». In response to concrete enquiries, it drafts operator comments (in co-operation with the VGB WP «Safety Assessments») and submits these to the RSK committee.

The actual issues concerned in the period under review were, for example, «Lightnings with parameters beyond the standardised lightning protection parameters», «Ageing management for electrical and I&C components» and «Systems with black-start capability for network restoration».

WP Practical Radiation Protection

Lena Jentjens

At the WP meetings, which take place twice a year (October 2016/March 2017), the emphasis is on the active exchange of experiences from plant operation and dismantling activities. In addition, the WP, mostly in the form of working groups, dealt with the following topics:

National/International Standards

Germany's new Radiation Protection Act was adopted in May 2017. It is a kind of «umbrella law», whose lower-level ordinances have not yet been published. According to the authoring Federal Ministry of the Environment, the relevant emergency protection regulations will come into force before the end of 2017, three months after promulgation of the act. The majority of the other new regulations will come into force at the end of 2018, at the same time as the detailed stipulations on the implementation of directives (which have yet to be compiled).

Cancellation of Radiation Protection Examinations in Switzerland

With effect from 1 August 2016, there will be no more routine radiation protection examinations for technical personnel in Switzerland. Up to that time, the examinations and fitness tests were performed and financed by the state accident insurer SUVA (Schweizerische Unfallversicherungs-Anstalt). A plan is currently under discussion, according to which the examinations will be cancelled and performance of fitness tests transferred to the plants.

Secondment of Contractor Employees

Since the start of 2017, any secondment of employees in Germany is restricted by law to 9 or 18 months. Consequently, any longer secondments will correspondingly require formal interruption of at least three months. This new regulation confronts a number of plants with organisational challenges, as annual contracts have been used in many cases up to now. Details are currently being clarified in the human resources and legal departments.

Data Transfer to GRS

Since 1990, GRS (Gesellschaft für Anlagen- und Reaktorsicherheit, Munich/Cologne) has been mandated by the Federal Ministry of the Environment in the context of research portfolio projects to perform detailed analyses and assessments of radiological safety at work for plants throughout Germany, and to benchmark these in relation to international findings. The base of this activity is formed by the radiation exposure data collected by ISOE from the dosimetry systems in the plants.

As GRS (in its function as expert organisation for the Federal Government) no longer receives any data from this source because of termination of ISOE membership by the German operators, the Federal Government has requested VGB to transfer the data now directly to GRS in the standard ISOE format. The WP is not, however, willing to agree, as there are already requests by the regional authorities in all federal states to report these data to RSK. Direct forwarding to GRS would require consent by the regional state authorities first.

Strategic Procedure for Releases

In the light of the fact that 95 % of the materials recovered from a nuclear power plant during dismantling is not contaminated and can be released for normal disposal, the respective DIN committee has proposed to develop a corresponding VGB Standard. A project group installed by the WP is currently working on a comparison of the release processes, so as to define a kind of standard requirement. The result is to be presented at the next meeting.

Measurement Instructions

For a large number of measuring processes in radiation protection, «Federal Measurement Instructions» exist. For others, discussions on individual background conditions and measuring methods have developed repeatedly. These include e.g.

stoker specimens, drilling dust specimens, insulating wool and non-homogeneous mixed waste. A small project group within the WP is currently working on descriptions of these measuring processes. The result will be discussed at the next meeting.

Incorporation

Both the RiPhyko and the federal Radiation Protection Register are currently due to be updated. For the latter (also valid for the staff at nuclear power plants), it would be useful to include the social security numbers of the persons concerned, which is however not permitted under data protection regulations.

A procedure has currently been proposed in which the Federal Office for Radiation Protection generates an ID number from the relevant social security number, and that ID number can then be used in the Radiation Protection Register. In this connection, it is suggested that the «VGB List Concept» be revised. A small project group within the WP is currently working on the revision and will present the result at the next meeting.

Comments

In the course of its work on standards, the WP has commented on the projects listed in Table 3.

Additionally, the WP is represented on further external committees, including the professional association «Fachverband für Strahlenschutz», the VGB WP «Medical Scientists in Nuclear Power Plants», at the German Commission on Radiological Protection on committees «A5 Emergency Management» and «A7 Radiological Protection in Nuclear Installations», and at the employers' liability insurance organisation BGEM.

WP Management Systems in Nuclear Power Plants

Jens Ganswind

The WP addresses cross-cutting issues on the subjects of management systems, product-related quality assurance, and safety culture.

The field of NPP Management Systems includes

- an exchange of experience on the practical implementation of the management systems already in place (the WP aims to have this regarded as a management tool, comprehensively supported by the managers, deviations should therefore not be accepted from the very start, but be corrected immediately);
- the adaptation of management systems for plants in a shutdown state (in the transition phase from the end of power operation to the start of dismantling work there are constant changes which result in modified operational processes and thus necessitate adjustments to the implemented management systems); and
- monitoring of international and national standards (the WP reviews the need for revisions and, where appropriate, compiles comments).

The tasks in the field of product-related Quality Assurance are addressed by the (non-VGB) WP «Contractor Assessment and Qualification» in accordance with KTA 1401, «General Requirements for Quality Assurance», include training courses and the «VGB Information System» software basis.

The tasks in the field of Safety Culture are addressed by the WP «Safety Culture» and comprise the topics of the VGB safety

	Submitted	Remarks
Ministerial draft bill of the 15th Act to amend the Atomic Energy Act	November 2016	
Draft of an Act to reorganise the right to protection from the harmful effects of ionising radiation	October 2016	
DIN ISO 11929 Parts 1-3	January 17, 2017	
DIN 25457 Part 7	May 5, 2016	
KTA 3604 Version/ Issue 2017-02	May 24, 2017	
Sample approval under section 15 of the Radiation Protection Ordinance	May 8, 2017 (repeat)	Coming into effect unknown, possibly as part of the Radiation Protection Act, or in 2018 on the Ordinance level

Tab. 3: Comments by the WP «Practical Radiation Protection».

culture assessment system SBS (only available until early 2018 as a result of VGB capacity restrictions), motivation and human performance tools.

WP Event Analyses

Guido Vallana

The WP focuses on topics such as «Holistic Event Analyses», «Specific Issues for Nuclear Safety Commissioners (kerntechnische Sicherheitsbeauftragte – kSb)», «Safety Culture Assessments and their Performance» (for details see WP «Management Systems»), «Human Factors» and related issues, and error avoidance techniques. Together with the German nuclear power plants, nuclear power plants from Switzerland and the Dutch Borssele nuclear power plant are represented in the WP.

Holistic Event Analysis

In the period under review, holistic event analyses were performed by suitably trained analysts at various nuclear power plants, and discussed in detail in the WP. Holistic event analysis is based on an approach which takes account of the factors of humans, technology and organisation (HTO) and their interactions. The method of performing HTO analyses was developed by the University of Berlin, and is termed «SOL» (Safety from Organisational Learning).

Human Factor (HF)-Related Topics

Based on various examples, the WP discussed the transferability of HF-related events and the implementation of countermeasures. A further focus of discussion was the exchange of information with authorities and independent experts on HF activities in the power plants.

Safety Culture and Workplace Safety

The WP emphasises that a strong safety culture and the systematic application of error avoidance techniques remain of great importance, even under long-term shutdown conditions or for plants during dismantling.

Nuclear Safety Commissioners

In this reporting period, as before, the WP maintained an intensive exchange of experience on reportable and other events. It discussed national and international reporting criteria, evaluated experience assessments and experience reports, and interpreted reports to be forwarded to the IRS (Incident Reporting System) of the In-

ternational Atomic Energy Agency IAEA and to the World Association of Nuclear Operators (WANO).

TC Decommissioning and Disposal

Katrin van Bevern

The TC held one meeting during the period under review. Its activities concentrated on the exchange of relevant experience from the field of decommissioning and disposal, and on the management of its WP structure.

WP Requirements for Interim Storage

As early as 2013, the TC «Decommissioning and Disposal» had founded a WP «Requirements for Storage of Radioactive Waste with Negligible Heat Development». It was tasked to analyse – based on the existing technical frame conditions – the corresponding regulatory regime (e.g. those of the Disposal Commission ESK).

At a number of sites with plants in the post-operational phase, new storage buildings for low-level-waste must currently be constructed, as the national final repository «Konrad» will not be operational before 2022. Storages are currently planned, applied for or (partially) approved at the GKN, KKB, KWB, KKP, KKK and KKG power plant sites.

In 2016 the TC has reconvened the WP in order to update its 2015 report, and the results are now available with a time stamp of October 2016.

It can be noted that the erection licenses issued to date fundamentally correspond with the contents of the application documents, renting the TC strategy principally successful.

A recent comparison with the relevant ESK guidelines revealed still no contradictions. Furthermore, the now available draft SEWD Directive for «Other Radioactive Substances» does not lead to any further implications on the concepts. The present planning basis for the interim storage facilities draws upon DIN 25422, «Storage and Keeping of Radioactive Materials – Requirements on Protection against Radiation, Fire and Theft for Storage Facilities».

Furthermore, the TC managed the activities of its WGs «Interim Storage», «Decommissioning» and «Fissile Material Monitoring» (the WP «Plutonium Recycling» had been terminated after fulfilling its tasks). The TC also reported regularly on the status of supply and disposal to the General

Committee, it also continued monitoring of the further development of partitioning and transmutation.

WP Decommissioning

Katrin van Bevern

Following the immediate withdrawal of the operation licence for eight German nuclear power plant units with the 13th Revision to the Atomic Energy Act (AtG) in 2011, and now that nine further decommissionings are to follow by 2023, a regular exchange of experience among both groups is ensured within the WP. This exchange also includes (future) decommissioning projects by VGB members in other European countries.

The WP experiences confirm that the technical issues of dismantling nuclear power plants – while ensuring the necessary level of safety – have been solved. A broad base of experience is available. Both the decommissioning projects of state-owned plants such as the AVR experimental high-temperature reactor in Jülich or the KKG nuclear power plant units in Greifswald as well as the utility projects like e.g. KMK Mülheim-Kärlich, KKS Stade, KWW Würsgassen and KWO Obrigheim are well advanced and provide valuable information on technical and organisational approaches.

By mid-2017, almost all plant owners have submitted decommissioning and dismantling applications under Section 7, §3 of the German Atomic Energy Act. Decommissioning and dismantling licenses are already available for KWB Biblis-A and Biblis-B, KKI Isar-1, GKN Neckarwestheim-1 and KKP Philippsburg-1 units. One Swiss nuclear power plant (Mühleberg 2019) and nine further German nuclear power plant units are in the decommissioning licensing process, with public hearings having already taken place in some cases.

Apart from the exchange of technical experience on the decommissioning projects, the WP intensified its communications in the field of health and safety at work during the decommissioning phase and in the monitoring of international decommissioning activities.

The employers' liability insurance organisation for Energy, Textiles, Electricals and Media Products (Berufsgenossenschaft ETEM) has published a guideline on «Health and Safety at Work during the Dismantling of Nuclear Power Plants», in which special workplace health standards are demanded. These requirements and



Fig. 8: VGB-Standard «Professional knowledge and knowledge of responsible persons in plants according to § 6 AtG (Fachkunde und Kenntnisse verantwortlicher Personen in Anlagen nach § 6 AtG)» VGB-S-48-00-2017-05-DE.

their practical implementation are just as much a WP topic as is the further exchange of information on precautionary measures for the machining of stainless steel and its effects on dismantling.

On the national level, the WP also monitors the activities on transfer of the EU basic standards on radiation protection into German law and their effects on decommissioning. In addition, the Federal Ministry for the Environment, Nature Conservation, Building and Reactor Safety (BMUB) published its decommissioning guidelines in the Federal Gazette in summer 2016.

WP Interim Storage

André Seidel

The WP deals with all generic issues relating to the loading, transport and storage of spent fuel in casks and the interim storage of spent fuel. In addition, the WP, through a specially convened working group, ensures the exchange of experience gained during cask loading. This work forms the basis for the definition of best practices, which is required by the interim storage guideline of the ESK Nuclear Waste Management Commission and by plant licences.

Apart from reporting on special issues during loading operations and operation of the storage facilities (including reportable events), the feedback from periodic safety checks at all interim storage facilities constitutes a central topic. A workshop was held on this topic in June 2017.

In cooperation with the (non-VGB) WG on Nuclear Training, the WP drafted the VGB Standard «Skills and Know-how of Persons in Charge in Facilities Covered by Section 6 of the Atomic Energy Act» (interim storages).

WP Safeguards

Katrin van Bevern

As part of the exchange of experience on current inspection practices, the WP especially keeps track of events in connection with the ongoing monitoring activities of EURATOM and IAEA.

In general, the WP work covers all aspects of monitoring of special regulations for interim storage facilities, both centralised and at power plant sites.

The regulator's official consultation with the operators on site-specific drafts of the special monitoring regulations for interim storage facilities at power plant sites start-

ed at the end of March 2017. Following an application-related review of the drafts, the WP compiled a generic VGB commentary paper, to which the Federal Ministry of Economic Affairs (BMWi) was invited to respond. Unresolved issues of material balance zones, key measuring points and accounting of nuclear material will be discussed and clarified at a WP meeting together with EURATOM – in its capacity as the safeguarding inspectorate – and the BMWi, in mid-June 2017.

The introduction of remote data transmission at the interim storage facilities is proceeding slowly. Pilot projects are currently in progress on the KKK Krümmel and GKN Neckarwestheim nuclear power plant sites. Most recently, at the end of April 2017, EURATOM reported successful data transmission from KKK to the EURATOM offices in Luxembourg. Which nuclear power plants will in future also be connected to the remote data transmission system is as yet unclear. An initial estimation will be possible at the end of 2017.

Further current activities of the WP include the following:

- Participation in the Federal working team on «Nuclear Materials, Safeguards» and in the programme council of the BMWi/ IAEA support programme.
- Modalities of accepting of the cask sealing function by the operators in combination with the use of digital Cerenkov viewing devices for fuel assembly verification.
- Nuclear material accounting for measurement devices and test specimens.
- Experience reporting on handling of safeguard equipment (both mobile and stationary).
- Model cases and applications on safeguards legislation.

Competence Area

Power Plant Technologies

TC Conventional Plants	C: Dr. M. Meierer A: W. Hartwig
TG Steam Generators	C: U. Gade A: W. Hartwig
TG Fuel Technology/ Firing Systems	C: Dr. T. Brunne A: C. Stolzenberger
TG Fluidized Bed Firing Systems	C: M. Nies A: C. Stolzenberger
TG Thermal Waste Utilization	C: Dr. M. Mineur A: Dr. A. Wecker
TG Industrial & Cogeneration Stations	C: J.-A. Czernitzky A: W. Hartwig
TG Flue Gas Cleaning Systems	C: Dr. R. Krüger A: Dr. A. Wecker
TC Mechanical & Civil Engineering	C: Dr. D. Keller A: P. Richter
TG Power Plant Concepts	C: C.E. Hendriksen A: Dr. O. Then
TG Steam Turbines	C: H. Strangfeld A: P. Richter
TG Gas Turbines	C: Dr. M. Freimark A: A. Böser
TG Cooling Systems	C: R. Gerber A: W. Czolkoss
TG Civil Concepts/Specific Civil Solutions	C: B. Titz A: T. Eck
TG Civil Structural Maintenance/ Condition Monitoring	C: A. Dorge A: T. Eck
TC Electrical Engineering and I&C	C: H.-D. Nehrhoff A: J. Kaiser
TG Electrical Equipment	C: M. Bagert A: J. Kaiser
TG Control & Instrumentation	C: P. Riedijk A: J. Kaiser
TG Acceptance and Control Tests	C: A. Knieschke A: W. Czolkoss
TG Interface Power Plant-Grid	C: S. Magais A: J. Kaiser
TC Operation and Maintenance	C: Dr. S. Laarmann A: J. Kaiser
TG Maintenance Management	C: B. Cramer A: H. Grimmelt
TG Power Generation Main- tenance Optimisation Network (PGMON)	C: H.C. Wels A: H. Grimmelt
TG Operational Management	C: M. Bieder A: K. Kofink
TG Plant Management Systems and Technical IT	C: J. Menauer A: J. Kaiser
TG Performance Indicators	C: J. Aydt A: S. Prost
TG Industrial Safety	C: Dr. E. Uhlig A: O. Baumann
TG Reference Designation and Plant Documentation	C: J. Richnow A: A. Böser
TC Materials and Quality Assurance	C: Dr. J.M. Bareiß A: O. Baumann
TG Supervision of Construction and Assembly/ Quality Assurance	C: T. Hauke A: C. Stolzenberger
TG Pipes & Valves	C: C. Koalick A: C. Stolzenberger
TG Online Monitoring and Testing	C: J. Hölbig A: O. Baumann

TC Technical Committee
TG Technical Group

Competence Area Power Plant Technologies

Oliver Then

The increasing share of volatile power generation from solar and wind energy plants in Germany and Europe, and in a constantly increasing number of countries worldwide, is necessitating increasing flexibility of supply from conventional power plants. The most important flexibility parameters include the stable minimum output, the load change gradients and the start-up times. Enquiries to VGB PowerTech concerning experience gained in Germany and its neighbouring countries in particular on the upgrading of existing power plants to increase their flexibility and the consequences of more flexible operation for availability, reliability and generation costs are constantly increasing.

As part of the Indo-German Energy Forum (IGEF), an expert task force on «Flexible Thermal Power Plants» chaired by the national Indian power supply utility NTPC was constituted at a meeting of Working Panel 1, «Conventional Power Plants» in New Delhi in June 2016. The activities, coordinated by VGB, included the performance of workshops and study trips in India and Germany, and the drafting of initial stages of a flexibility roadmap for the Indian power sector. This included evaluation of flexibilisation options for selected reference power plants and the design of a training programme for power plant personnel. Further stages will follow in co-operation with our Indian partner organisation EEC. A workshop series in three Indian cities on the subject of «Modern Flue Gas Treatment Methods» was also conducted with great success, involving several VGB member companies.

Further activities took place in the context of initiatives by the Federal Ministry of Economic Affairs and Energy and the German Foreign Ministry in Russia, China and Taiwan. Together with representatives of our member companies, we also supported our partner organisations TENPES in Japan and VTI in Russia.

A VGB presentation at the 8th International Conference on «Clean Coal Technologies» organised by the International Energy Agency (IEA) in Cagliari, Italy, and attended by over 250 participants from 31 countries, focused on the results of a current survey in the power plant information system KISSY. This database, managed by VGB, contains availability data and performance indicators of power plants owned by international power plant operators with a total gross capacity of currently around 270 GW. The basis is formed by performance indicators for power plants, which were established and developed by a VGB Working Panel which has been active for over 40 years now. KISSY covers analysis of operating data from thermal power plants, storage and pumped storage power plants and from wind farms (Figure 1).

Cooperation with BDEW in the period under review focused on delivering comments by the industry on various proposed laws and regulations, and on the compilation of a background paper on flexibility options on the electricity market. On the European level, together with Eurelectric, the firming up and national implementation of the various Network Codes and the adoption of the BREF LCP were in particular supported; in the latter case in spite of support from the Federal Government, unfortunately without the desired success in adjusting the emission limits, for instance for mercury or nitrogen oxides, to reflect actual conditions. We continue to monitor the BREF process for waste incineration and for industrial cooling systems. Details on all these topics and the corresponding documents can be found at the VGB website.

The cross-cutting activities of the advisors between the Competence Areas of Renewables and Distributed Generation and Power Plant Technologies were successfully continued. The most recent example was the organisation of an oil workshop for hydro power, similar to those which have already been conducted with great success for steam and gas turbines and wind turbines. Over 10 new topics were

addressed for the first time in workshops and conferences, with good results. The activities on IT security met with great interest, and led, among other things, to the initiation of a joint service with KSG/GfS. On the committee front, two new Working Panels have been established following intensive discussions with interested member companies, on the topics of «Motor CHP Plants» and «Energy efficiency/Energy management to ISO 50001».

TC Conventional Plants

Werner Hartwig

Following the massive expansion of energy generation from renewable sources, the resulting decline in electricity prices and the associated dramatic effects on the profitability of conventional power plants, many plants have been registered for closure and an increasing number actually closed down when they were found not to be necessary for operation of the grid. Most of the plants with system relevance are located south of the river Main, in Baden-Württemberg or Bavaria.

All the major operators are devoting attention to the long-term phasing out of coal-based electricity generation. Various scenarios are currently being processed and assessed in terms of feasibility. In almost all cases, there is increasing reliance on gas. As this is not a matter of individual cases, questions of security of supply and independence can be raised. In this connection, there are echoes of Chancellor Helmut Schmidt demanding energy independence in the 1970s. In response, nuclear power plants and large lignite-fired plants were constructed.

Different situations prevail among the power plants which supply district heating or process heat in addition to electricity, depending on the specific local conditions. It is to be expected that the new combined heat and power legislation will only have favourable effects on combined cycle and unit type CHP plants in future.

New boiler materials

Following intensive discussions, and thanks to the VGB ad hoc working group, operators of newly constructed plants with boiler materials T24 and HR3C have developed plans for dealing with the outstanding material issues and remediation of the damage. Particular attention was paid to the different procedures for pickling and heat treatment of the new materials, enabling all the operators to devise measures appropriate to their specific

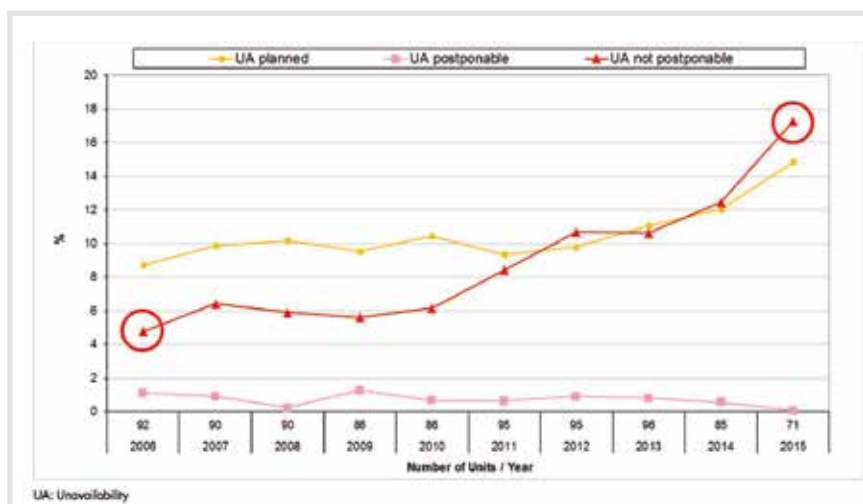


Fig. 1: KISSY analysis: Unavailability of hard coal fired power plants, > 200 MW worldwide (without German plants).

cases. All the new plants were then heat treated accordingly. After initial difficulties, the results achieved were impressive. The most recently erected plants were then also treated accordingly, with equally successful results.

Boiler circulating pumps

The reworking of the spherical calotts used in certain types of circulating pumps in once-through boilers is provisionally complete. There had been serious damage at one power plant and consequently considerable efforts on the part of the manufacturer, the operators and VGB. The findings, including the research results, were bundled by the manufacturer and used to integrate in the new production. The converted plants now therefore have circulating pumps which are state of the art in terms of flow mechanics, structural design and metrology.

The operator and the manufacturer reported on temperature measurements on a converted boiler circulating pump in parallel flow operation. The analysis with the «Areva Fatigue Concept» (AFC) system had already shown that with the pump at a standstill, in spite of preheating, a pool of cold water (ΔT up to 80 K) forms at the bottom of the casing. These findings are to be incorporated in the revision of VGB-Standard VGB-S-506. In a further VGB initiative, a new and highly interesting VGB-Standard dealing with the process development of preheating of the circulating pump in various plant states is to be created.

Mercury

The members of the Technical Committee discussed in great detail the topic of mercury emissions in recent meetings, with especial interest being expressed in the methods of measuring mercury.

As a result of the legal requirements for «measurement of total Hg», in-situ measurements without conversion of oxidised mercury are not possible. The latest equipment for continuous Hg measurement can cover a measuring range up to 10 $\mu\text{g}/\text{m}^3$. In consequence, only a limit of 4 $\mu\text{g}/\text{m}^3$ can be verified for power plants, approximately corresponding to the upper limit of BREF LCP range for hard coal fired furnaces. For waste incineration, the limit which can be monitored is even higher, at 6.6 $\mu\text{g}/\text{m}^3$. For limit values <5 $\mu\text{g}/\text{m}^3$, the standard reference method (SRM, continuous measurement calibration by TÜV) is no longer applicable, and a new method has to be established for such cases as a standard. A comparison of suitability tests in the USA and the EU shows that the EU provides for more extensive tests and quality assurance in advance. The verification of low limits around 2 $\mu\text{g}/\text{m}^3$ could only be performed at present by means of sorbent traps (see USA), which is not yet approved in Europe.

Further discussion took place with regard to Hg emissions into the waste water. At most plants, the analysis value is <1 $\mu\text{g}/\text{L}$ as yearly average (detection limit). The BREF LCP states a range of 0.2 $\mu\text{g}/\text{L}$ to 3 $\mu\text{g}/\text{L}$ as daily average. There should be no problems there if special attention is paid to the FGD waste water treatment system.

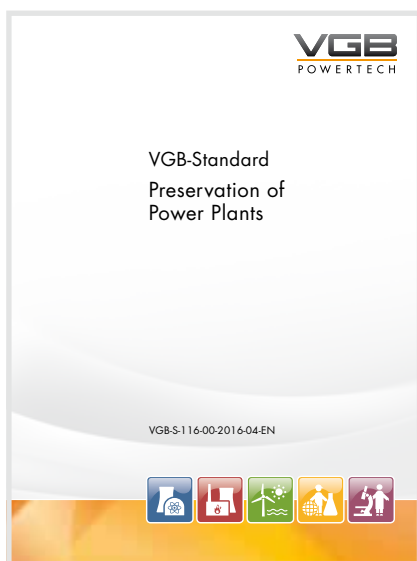


Fig. 2: VGB-Standard
«Preservation of Power Plants»
VGB-S-116-00-2016-04-EN.

Legionella

The contents of the ministerial draft of the 42nd Federal Pollution Control Ordinance (BImSchV) follow VDI 2047 Parts 2 and 3, the latter having been compiled in cooperation with VGB and published as a draft in February 2017. There, as a result of objections by VGB concerning the required hygienic monitoring and procedures, account was taken of the special features of cooling systems in large power plants >200 MW thermal capacity. The action levels for legionella are higher by a factor of 5 than those stipulated in Part 2 for smaller evaporation cooling systems.

TG Steam Generators

Werner Hartwig

General

In the exchange of experience to date, apart from the quality problems with materials (Super 304 H and HR3C), the topics predominantly addressed were flexibility and the thick-walled components in boiler systems.

Particular attention was paid to the different procedures for pickling and heat treatment of the new materials. All the operators have been able to deduce measures to be taken in their specific cases. All new plants were then heat treated accordingly. The results achieved were impressive.

The handling of and in particular the greater stress problems with thick-walled components occupied the Technical Group

«Steam Generators» in recent meetings. The initiatives by individual operators who started replacing these components well in advance are interesting. The components are in particular designed in such a way that they can be used in several systems on different heating surfaces. As a result, tenders are invited at the planning stage for components, which are then ordered and preserved. The operators are then ready for the conversion work and can install the relevant component for the specific case within a short overhaul time. This saves a considerable amount of planning time and costs.

A further approach was taken by TÜV Nord at the Rostock power plant with funds from the German confederation of industry BDI and the University of Rostock. The thick-walled components are examined and the potential fatigue crack propagation determined in a damage tolerance analysis. The maximum and minimum load values of the stress range are determined both by steady load cases (zero, partial and full load) and by transient start-up and shut-down processes and changes in output. This often results in stresses at areas which previously had been rarely subjected to recurrent testing or not considered at all.

This results in the stipulation of test intervals for thick-walled power plant components by means of damage tolerance analysis.

The present standard was compiled on the basis of the findings of the joint research project THERRI (Determination of indicators for assessment of thermal fatigue crack propagation in power plants), which was funded by the Federal Ministry of Economic Affairs and Energy (BMWi) in the period from 2013 to 2017.

Standards

A number of standards are currently being drafted or revised:

1. Revision of Standard VGB-R 116
«Preservation of Power Plant Systems».

The standard (Figure 2) is complete and will be presented for the first time at the workshop at Grosskraftwerk Mannheim on 20 and 21 September 2017. For the first time, there is a comprehensive work which deals not only with the boiler, but also with the fuel and flue gas systems.

2. Compilation of a new standard on
Insulation in Thermal Power Plants.

In order to produce a complete standard as rapidly as possible, VGB is cooperating

with the German industry working group AGI on its standard Q 101. In that form, there is already an extensive work, which is currently being brought up to date. With the addition of process data from the power plant operators and information on the latest insulating materials, a new standard will be created. It will be distributed on the same terms by both AGI and VGB.

3. In the same connection, an existing standard (VDI 4610) is to be revised jointly with AGI. In this case, the important topic of thermal bridges in insulation is concerned. The first revision meetings have already taken place.

TG Fuel Technology/ Firing Systems

Christian Stolzenberger

The focal topics of the Technical Group «Fuel Technology/Firing Systems» in the year under review were mercury reduction and detonation cleaning. On the first point, reports were delivered on the current status of the VGB initiative Hg^{capture}, and in particular on emission limits, reduction measures and measurement techniques. The following discussion drew upon experience at a hard coal fired power plant in which a DeNO_x layer in the catalytic converter is being replaced by a special layer for mercury oxidation, so as to achieve an Hg oxidation degree of at least 95 % upstream from the flue gas desulphurisation system. The gypsum continues to fulfil the requirements. At a lignite fired power plant, the mercury content of the lignite is being determined and will serve as a basis for decision-making on further action. Online measuring instruments for Hg are not as yet installed in all power plants.

On the subject of detonation cleaning, it can be noted that pasty deposit build-ups on the ash grate cannot be removed by this method. The reason for the deposits is the purchasing of lower cost coal which has a different content of volatile constituents than that provided for by the specification. It is recommended that this be mixed with different (more expensive) coal, or sootblowing performed more frequently, or «smart cannons» used. In general, however, the experience with detonation cleaning at the power plants has been favourable.

In the exchange of experience, reports were presented on coal fires which could be brought under control by applying nitrogen or light extinguishing foam. Three cases of mill damage were presented. In a beater wheel mill with preliminary

beaters, the shaft corroded as a result of inadequate cooling water quality. In a grinding roller basin, the grinding roller broke as a result of running on the nozzle ring, which was caused by misalignment. A beater wheel mill broke apart completely because corner reinforcement had become loose. It is suspected that the fastening screws supplied were not in accordance with the specification. The use of biomass as an alternative to coal is being examined as a means of maintaining the emission limits.

The KORINNA research project (online corrosion probe) at the Technical University of Darmstadt was supported on the technical level by the Technical Group. The aim is to develop the membrane wall sensor further, in order to achieve an improvement in measuring quality, and then, after laboratory testing, to make it ready for series production in a large-scale deployment in a power plant under varying conditions.

TG Fluidised Bed Firing Systems

Christian Stolzenberger

One of the focal topics addressed by the Technical Group «Fluidised Bed Firing Systems» was gaining an overview of the situation concerning legionella in large and small recooling systems. Legionella are ubiquitous bacteria with a lethality rate of 7 to 15 %. Together with the status of the draft of the 42nd Federal Pollution Control Ordinance (42. BImSchV) and Appendix 31 to the Waste Water Regulations, the laws and regulations to be observed in connection with evaporation cooling systems were explained and discussed.

The use of drones for inspection of boilers, other components and complex and poorly accessible spaces inside industrial plants is increasing. For this reason, a company presented the first drone to be protected by its design from collisions, and showed this impressively in a demonstration. The drone is protected by a cage, and can fly through interior spaces without problems.

Several power plants are reviewing the replacement of generators in 2017, so as to avoid a levy on station service electricity on implementation of generator replacement work in the coming year.

Various local authorities have resolved to cease coal firing, or intend to do so in the future, with the consequence that fluidised bed firing systems are either to be converted to use biogenic substitute fuels or closed down.

Operating difficulties with biogenic fuels were reported in the exchange of experience, together with the recurrent corrosion and erosion damage. Successful measures such as coatings or the replication of components for cost reasons were reported.

TG Thermal Waste Utilisation

Andreas Wecker

The first draft of the BAT (Best Available Techniques) reference document for waste to energy plants was published by the European IPPC (Integrated Pollution Prevention and Control) office in May 2017. BDEW and VGB are to draft their comments together and feed them into the process through EURELECTRIC.

The Technical Group is supporting the research project «Ammonia Masking», in which the effects of more stringent NO_x limits are to be examined. For that purpose, systematic measurements were taken at waste to energy plants and RDF power plants with various technologies, starting at the furnace chamber and proceeding along the flue gas treatment channels to the stack. Comparative assessments on plants of different technical design were made possible in this way. The values determined by this method provide a good stock of data for reactions to future issues of NO_x and NH₃ limit reductions. The findings, previously only available for individual plants, are put on a broader basis in this way.

A further reduction in the legally stipulated NO_x limit at the stack runs up against technical limits when the installed SNCR technology is retained. The project has shown that no influence of the type of grate, the type of gas routing, the boiler design and the SNCR technology can be discerned. The age and quality of the technical equipment may however have an impact on compliance with reduced limits.

The effectiveness of the reduction agent drops significantly with the increased stringency of the limit requirements, such that significantly more has to be used than would correspond to the stoichiometrically necessary quantity. The ammonium content in the residues then increases correspondingly strongly. The final report is currently being completed.

In the past year, there have been increasingly frequent accidents during unloading solid materials from silo vehicles. This circumstance led to the establishment of a Project Group which is to compile a VGB Instruction Sheet on safe unloading.

Experience gained by various plant operators has shown that shutdown of the plant is not a useful reaction to the release of mercury as a result of incorrect waste input. When the plant is shut down, storage effects and the lack of a reaction partner (HCl) on restarting cause a large quantity of mercury to be released abruptly with persistent hysteresis. Further operation of the plant with additional mercury reduction measures, by contrast, shortens the time during which mercury is released. Such measures should be agreed with the authorities in advance, so that appropriate reactions to mercury liberation can be implemented. As an aid to argumentation, a VGB Instruction Sheet on this subject is to be developed.

TG Industrial and Cogeneration Stations

Werner Hartwig

The economic position continues to be favourable, and industry is still enjoying increasing demand. In the light of this situation, new generation facilities are still being planned and constructed. That brings new members to the Technical Group on «Industrial and Cogeneration Stations», and produces a rising number of technical challenges and diverse professional topics.

One example is the formation of a further Project Group to address the issues of unit-type CHP plants and gas engines in greater depth. The PG on «Unit-type CHP Plants» will contribute to the professional consensus in the TC «Industrial and Cogeneration Stations». In February 2017, the members met for the constitutive meeting in Hanover. The 30 members, some new to VGB, elected Dr. Christian Behnke as Chairman. The members of the group are predominantly from operator companies. The manufacturers and engineering firms are also to be involved in explicitly selected topics. The technical issues under discussion concern the following:

- CHP tendering regulations
- Amendments to CHP legislation
- Operator experience in load changing operation
- Remote servicing
- Project experience in design and dimensioning
- Maintenance
- Provision of refrigeration services by CHP plants

- Requirements for operation and maintenance, and ratings
- Unit-type CHP plant operation with different fuels:

- Natural gas
- Biogas
- Mine gas
- Digester gas
- Landfill gas

As a result of the variety of plant types and the different technical issues, the members of the TG are primarily engaged in exchanging details of their experience. Following the CHP legislation, the members are currently dealing in particular with the optimisation of their generation plants. There are new plants in the areas of the petrochemicals, paper and automotive industries, and municipal utilities. One of the principal areas of attention is the plan for contaminants and residues to be incinerated together with the fuel in the plants to be constructed. In the petrochemicals industry, old plants are being modernised in order to preserve the existing approvals. VGB, together with professionally qualified planning firms, is advising the companies in various disciplines.

Standards

- Compilation of a new standard on grate firing systems in biomass plants. Following submission of the first draft by VGB, two ad hoc working groups met. At present, we expect the standard to be completed within the first quarter of 2018.
- Compilation of a new standard on finned tubes. An initial VGB draft has been produced and has been reviewed by a sponsoring member. We are looking for members who are interested in continuing the work on the standard. There would also be input from universities.
- Compilation of a new standard on insulation in thermal power plants. In

cooperation with the German industry working group AGI, its standard on «Insulation of Power Plant Components» is being revised.

TG Flue Gas Cleaning Systems

Andreas Wecker

The final draft of the BAT (Best Available Techniques) reference document for large combustion plants indicates that very low limits for mercury will be required in future. The Technical Group «Flue Gas Cleaning Systems» therefore embarked upon an intensive exchange of information with the measuring instrument manufacturers. The latest instrument for continuous Hg measurement can cover a measuring range up to $10 \mu\text{g}/\text{m}^3$. In consequence, only a limit of $4 \mu\text{g}/\text{m}^3$ can be verified measured for power plants at present. For waste incineration, the possible limit for monitoring is slightly higher, at $6.6 \mu\text{g}/\text{m}^3$. For limits $< 5 \mu\text{g}/\text{m}^3$, the calibration method for verified continuous measurement, the standard reference method, is no longer applicable, and a new procedure has to be established. A comparison of the suitability tests in the USA and the EU shows that the EU has more extensive tests and quality assurance in advance.

In the course of the exchange of experience, discussions increasingly focused on the selection of a suitable heavy metal precipitant which could in particular be used for precipitation of mercury in the scrubber. Several agents have already been used in most plants. It is not as yet possible to identify an optimum mercury precipitant which would suit all plants.

Several plants reported problems with heavy foaming in the scrubber. It is striking that this issue predominantly affects new plants. It remains however to be clarified whether the cause is the large number of load changes, new rubber linings in the scrubber, the quality of the added water or too low feed of anti-foaming agents.

Different analysis results on determination of the filterable substances in the flue gas desulphurisation waste water have led to

the conclusion that it is appropriate to precipitate the gypsum before sampling by cooling the waste water flow to 25°C .

TC Mechanical & Civil Engineering

Peter Richter

The Technical Committee «Mechanical & Civil Engineering» with its five Technical Groups deals with the issues of the day during a regular exchange of experience (Figure 3).

Due to the variety of the requirements this involves, the TC works together with other TCs. These are mainly the TC «Materials and Quality Assurance», the TC «Electrical Engineering, I&C, and IT», and the TG «Steam Generators».

Important issues addressed by the Technical Committee:

- Involvement in lobbying activities on the impending changes to regulatory requirements (emissions, grid connection conditions, etc.) to safeguard the interests of the operators.
- Identifying and addressing important areas of action, special topics and future issues, where necessary with involvement by the working groups.
- Exchange of experience and information between operators on conceptual planning, operation, maintenance, modernisation and damage, also involving the manufacturers of systems.
- New requirements for the plants resulting from a changing market and the stipulations of the law.
- Monitoring of manufacturers (scope of supply, technical developments, etc.).

One current topic is that of subsynchronous resonance in connection with the operation of an HVDC system and the associated stimulation of torsional vibrations (subharmonic oscillations) by network feedback, e.g. from converter stations. The TC «Mechanical & Civil Engineering», the TG «Steam Turbines» and the TC «Electrical Engineering and I&C» will form a core team to address this topic.



Fig. 3: Incipient crack in a generator rotor caused by torsional vibrations. Examined fragments.

The committees and groups assigned to the TC provided reports on past and future conferences and workshops, and on the status of the VGB Standards currently undergoing revision.

TG Steam Turbines

Peter Richter

Current topics are discussed in the Technical Group «Steam Turbines» in the course of a regular exchange of experience and documented in status reports (Figure 4).

As a result of the network created in this way, it has become possible for spare parts such as casing joint bolts, steam strainers and oil pumps, etc., to be lent out from operator to operator in order to avoid long downtimes while waiting for deliveries.

The problems occurring on USC steam turbines were an important topic within the TG. Joint meetings between operators and the manufacturer were organised in that connection. The aim of the talks was to establish a common level of information between the operators of the USC steam turbines concerned and the manufacturer on the various technical problems occurring at the different locations, and the methods of solving them. These included, for example, a complete identification of the issues, clarification of misunderstandings, establishing consensus on root cause analysis (RCA) and the existing or potential approaches to solutions, and stipulation of the next steps to be taken by the participants. The extensive remediation and conversion work performed on the portfolio was discussed with the manufacturer and reports on experience were exchanged.

More and more salt damage – with various causes – has been noted in recent times.

The VDMA/VGB Instruction Sheet «European Directive 2014/68EU – Pressure Equipment Directive, implemented in Germany by 14th GPSGV» has been revised.

Scope of application of the Pressure Equipment Directive with regard to steam turbines and their main components

With regard to the revision of the VGB Standard on «Internal Pipework of Turbine-Generator Sets», consultations with VDMA were conducted on the draft completed by VGB.

In addition, reports were delivered on past and future conferences and workshops, and on the status of the VGB-Standards currently undergoing revision.

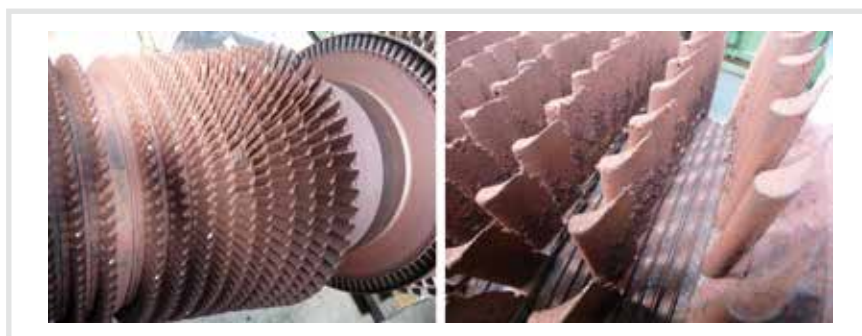


Fig. 4: Steam turbine rotor seriously damaged by poor feedwater quality.

Standards

- VGB-S-115-EN «Recommendations for the Inspection and Overhaul of Steam Turbines» has been published.
- The VGB-R 503 «Guideline for the Internal Pipework of Turbine-Generator Sets» is still undergoing revision.
- VGB-S-416-FR – The standard is now also available in French:

Partie A Surveillance des huiles de turbine usagées dans les turbines à vapeur et à gaz

Partie B Surveillance des fluides usagés difficilement inflammables dans les turbines à vapeur et à gaz

A PG was formed for compilation of a standard on the subject of gearbox maintenance.

TG Gas Turbines

Andreas Böser and Manfred Freimark

The work of the Technical Group «Gas Turbines» focuses on the exchange of experience and information related to the operation, maintenance, modernisation, lifetime extension including the implementation of upgrading measures and damage to gas turbine series and individual gas turbine models of different capacities (Figure 5).

As a result of changed market requirements, manufacturers, in close cooperation with operators, have achieved impressive results in extending the effective output range of existing combined cycle and CHP plants by measures such as graduated burner shut-downs and reduction of the compressor mass flow while complying with NO_x and CO-ELV levels. In combined cycle and CHP plants with gas turbines with gas turbines of the 200 and 300 MW class, minimum gas turbine outputs of around 25 % and of the 2+1 plant system of approx. 15 % have already been achieved.

As a result of increased numbers of start-ups and steeper output gradients of CCGT systems (combined cycle and CHP) with significantly reduced operating hours, an increased amount of premature damage on components – especially in the hot gas system of the gas turbine – has been noted. This is caused by the growing non-steady component of the thermo-mechanical stress collective. The experience gained with increasingly volatile operating modes has already caused a number of OEMs to implement upgrading strategies on heavy duty gas turbines by inserting inexpensive parts subject to wear in expensive components such as annular combustion chambers. Necessary improvements in the service life of components in the hot gas path with the problem of detachment of thermal barrier coatings have been achieved by operators rapidly and cost-effectively with innovative refurbishment strategies from non-OEMs.

Manufacture and refurbishment of expensive and complex components in the hot gas system of gas turbines is increasingly being performed with the aid of new processes such as AM (Additive Manufacturing) and SLM (Selective Laser Melting). Degrees of freedom in construction which are achievable with these new processes, using 3D printing technology, bring about significant improvements in component cooling and structure, coupled with reductions in weight. In initial practical trials with printed components, the cooperation between OEMs and operators has once again proved successful.

For additive manufacturing, laser deposition welding with powder or wire, and laser and electron beam melting, are used. A revolutionary process of change is already becoming apparent in spare parts stockage and the procurement of complex components for gas turbines on the basis of 3D prints which are integrated in the function.



Fig. 5: Damage to TULA1 from failure of the axial lockwire.

Renewal of I&C systems integrated in LTE measures has led, in cases where I&C interfaces received insufficient attention in advance, to increased fast trip malfunctions and increased time and fuel expended on restarting.

Increasingly noted gas turbine disturbances resulting from rapid changes to the natural gas composition within permissible parameter bandwidths have occasioned a number of operators to plan or implement the inclusion of the Wobbe index for gas in the control system of the gas turbine firing system.

Presentation of rational arguments from the VGB TG «Gas Turbines» has been made to BDEW and LAI, which are to be taken into account in the impending revision of the 13th Ordinance to the German Pollution Control Act (13. BImSchV) with more stringent NO_x and CO-ELV regulations for OCGTs and CCGTs in existing and new plants

With regard to CO-ELV, the VGB operator community dealing with gas turbines has, in the context of the energy transition, favoured compliance with the BAT conclusions with indicative monitoring of this pollutant.

VGB Standards

VGB-S-121-DE, «Überwachungs-, Begrenzungs- und Schutzeinrichtungen von Gasturbinen» has been published.

VGB-S-121-EN, «Monitoring, limiting and protection devices on gas turbine systems» has been published.

A section on gas turbine-generator sets is currently being added to Standard VGB-S-036, «Preservation of Steam and Gas turbine-generator sets», which is expected to be published in III. 2017.

TG Cooling Systems in Power Plants

Wolfgang Czolkoss

The function of the Technical Group «Cooling Systems in Power Plants» is to pursue opportunities for increasing efficiency and optimising operation and maintenance of cooling systems, taking account of the changes to operation brought about by the current background conditions, with increasing low load and standstill times. In that context, the hygienic requirements for the operation of cooling towers (Figure 6) play an important role.

The Project Group «Microbiology in Cooling Systems», comprising members from the TG «Cooling Systems in Power Plants» and the TG «Chemical Process Engineering», has continued to devote intensive attention to the shaping of the 42nd Federal Pollution Control Ordinance and compilation of VDI standard 2047, Part 3. The ordinance sets down the hygienic requirements for the operation of cooling towers, and in particular the permissible legionella concentration in the cooling water and the necessary microbiological monitoring. It has been possible to distinguish here between «evaporation cooling systems» (for instance in building services and air conditioning systems, or industrial plants) and «cooling towers > 200 MW» which predominate in power plant use. Cooling towers are permitted a higher legionella concentration in the cooling water. This averts an indirect compulsion to use biocides in many power plant cooling systems, which would be superfluous in terms of protecting health. The technical basis for this was established in February 2017 with the publication of the draft VDI standard 2047 Part 3, «Open recoler systems – Securing hygienically sound

operation of evaporative cooling systems – Natural draught cooling towers with a cooling power greater than 200 MW», in the compilation of which members of the TG Cooling Systems and the PG Microbiology in Cooling Systems played a decisive part.

In summer 2017, further measurements of legionella concentrations are to be taken in cooling tower vapours, and studies performed on cooling water specimens and various deposits in cooling systems as part of a VGB research project which is to be supervised by the PG Microbiology and is to be completed at the end of 2017. A comparative study is to be performed on the actual legionella emissions from power plant cooling towers with two different sampling methods, and strategies developed to ensure hygienically safe operation of evaporation cooling systems, without the use of biocides wherever possible.

One essential point in the six-monthly meetings of the TG «Cooling Systems» is the exchange of experience among the participants, in which reporting included methods of cleaning cooling systems, the use of biocides and alternative methods, dealing with increasing downtimes, especially in winter operation, and damage in cooling towers. The opportunities for the use of UV radiation as an alternative to biocide treatment of cooling water circuits were discussed in detail with a supplier. This technology appears to be not particularly suitable for legionella control applications in large power plant cooling systems, and reliable references are not yet available. An opportunity for a pilot test is still being sought.

TG Power Plant Concepts

Oliver Then

The fundamental objectives of this Technical Group «Power Plant Concepts» are the exchange of information on methods of optimising existing processes and systems for the generation and storage of electricity and heat, and the identification and development of future technologies.

In the period under review, the Technical Group focused on the optimisation and flexibilisation of gas-fired combined cycle plants and the conversion of coal-fired power plant units to biomass for co-combustion or as a main fuel.

On the first subject, a visit was made to what is at present the most up-to-date combined cycle plant in France (EdF, Bouchain). Both current operating experience from the point of view of the operator and technological challenges and the main areas for future development of the most important technology media from the point of view of the manufacturer GE were discussed. In addition, reports were delivered on operator experience with the retrofitting of combined cycle plants and on future development potential for steam turbines in highly flexible combined cycle plants from manufacturer Siemens.

The decision by Danish operator DONG to completely change from coal to biomass in Danish plants led to a more intensive discussion of the opportunities and limits of that technology. A tour of inspection of the Studstrupværket plant, currently undergoing conversion, was conducted, and discussions held with the operator and the most important suppliers. The major areas of discussion concerning the use of biomass were the problems and solu-

tions involved in the storage and transport of the fuel, the challenges to the firing system in the case of co-combustion and flexible fuel changes during operation, and the latest technologies for the separate combustion of different types of biomass.

From the point of view of the ambitious climate protection targets in Europe, general consensus has been reached that no major new build activities in the field of coal-fired power plants in Europe are to be expected in future. Accordingly, no major technological progress (in the context of improving efficiency) beyond the level of the ultra-supercritical plants installed to date is expected in the European power plant portfolio either. In contrast, there are both significant new build projects and extensive R&D activities in India, China, Japan and other South East Asian countries. These include, for example, projects aimed at A-USC technology, i.e. steam temperatures up to 700-750 °C, gasification of coal within the framework of IGCC systems, and the use of double reheating.

Thermal storage facilities are increasingly being used to decouple electricity and heat generation in CHP plants. There are different designs and circuit connections, and some of them are also suitable for use in long-term storage. The project and operating experience of the relevant members was compared.

TG Pipes and Valves

Christian Stolzenberger

The Technical Group «Pipes and Valves» regards the flow of information from component manufacturers to operators concerning the discontinuation of spare parts as being in need of improvement. This leads, for example, in cases of demand, to entire controllers such as that of a reheater safety station having to be replaced, as no spare parts are available any longer.

The introduction of pressure specialists to DIN 1591 Part 4 is of doubtful value, as it would involve an amount of work similar to

that in the field of welding. The standard is not mandatory, and each operator can decide whether he wishes to have this service provided by the installation contractor.

A weld seam in a district heating line was not included in the group of 10 % of the seams to be subjected to non-destructive testing after welding, and as a result a 25 cm long lack of fusion which had not been discovered led to leakage in the district heating line. The seam was ground out, rewelded and further seams were subjected to non-destructive testing.

A cooling air cooler in a gas turbine exhibited repeated leakage after 3 years. A boroscopic examination revealed traces of corrosion on the inside of the cooling tubes, and it was recommended to re-examine the design of the cooler, as it appeared that insufficient account had been taken of expansion.

The changeover in operating mode of a process steam line to intermittent operation, causing condensation to collect behind a non-return valve during downtime, led to thermal shock cracks on the downstream tee-piece and the cam of an injection guard during commissioning.

Innovative tools such as 3D programs and 3D laser scanning can avoid potential collisions during the planning of plants, and ensure good accessibility of the components in operation. Calculation programs for pipes and systems facilitate the incorporation of 3D laser scan data, and therefore replanning of existing plants can be performed.

Comments from valve manufacturers on VGB Standard VGB-S-107 have been received. A proposal for leakage rates of valves is currently being compiled and the data sheets revised, with the result that publication will be possible at the end of 2017. The Technical Group will then embark on the conversion of VGB Guidelines of the 500 series into standards.

TG Civil Concepts/ Specific Civil Solutions

TG Civil Structural Maintenance/ Condition Monitoring

Thomas Eck

The two Technical Groups, «Civil Concepts/Specific Civil Solutions» and «Civil Structural Maintenance/Condition Monitoring» and the seven corresponding Project Groups, exchanged experience on current topics in the period under review, and also focused on the drafting of VGB-Standards.



Fig. 6: Cooling tower of the thermal power plant Herne, Steag.



Fig. 7: Dismantling.

VGB-Standards VGB-S-602 «Indication and application of actions on buildings in power plants», VGB-S-609 «Application, design and quality assurance criteria for the use of fibre-reinforced plastics in power plant construction», and VGB-S-641 and VGB-S-642 on industrial stacks in power plants, from principles of design through overall construction to lifetime management, have been completed.

VGB-Standards VGB-S-610 «Structural Design of Cooling Towers», VGB-S-039 «Lifetime Management for Footings, Foundations and Towers of Onshore Wind Turbines» and a fundamentally new VGB Standard VGB-S-044 on the subject of «Lifetime Management of Structures in Industrial Plants and Power Plants» are in progress. An overview of the new generation of VGB-Standards in the field of civil engineering can be found in an article in issue 08/2016 of VGB PowerTech magazine.

A core topic requiring increasing attention in the context of the VGB Standards and the exchange of experience is lifetime management of civil engineering structures, from erection through maintenance to dismantling (Figure 7). This is all the more important in the light of changing residual service life and generally increasing economic pressure.

Dismantling, decommissioning and, in some cases, reuse, result in a variety of requirements for the maintenance of structures. Concepts worthy of note in this connection include the duty to maintain safety, logistics and disposal strategies, and the use of dismantled materials. The VGB committees in the field of engineer-

ing will in future devote more attention to the topic of dismantling, as well as on the topic of refractory construction.

In the course of the exchange of experience between the participants at the meetings, furthermore, discussions were conducted on digitisation in the areas of design and construction, and especially operation of building structures, subsumed under the headings of «Building Design 4.0» and «BIM – Building Information Modelling». This subject will also play a major role in documentation in future. Fundamental changes in this field are expected in the coming years (Figure 8).

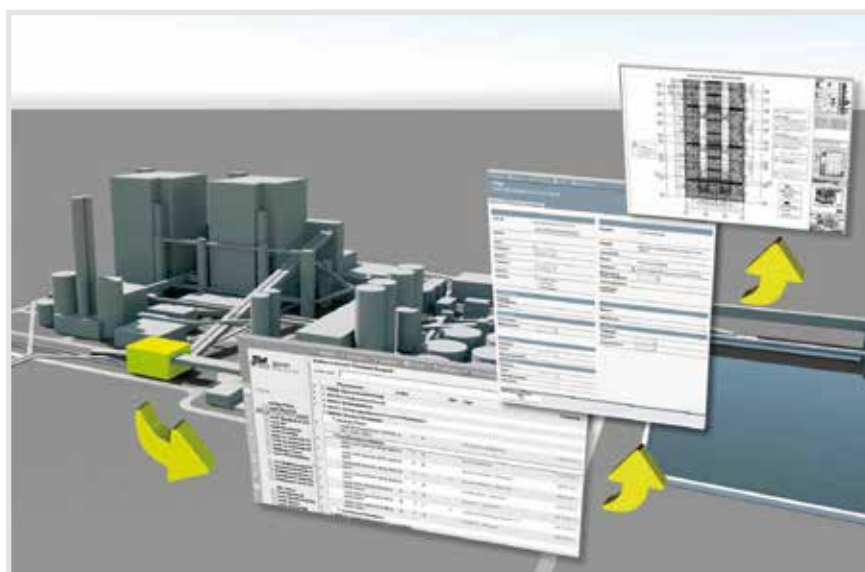


Fig. 8: BIM – Building Information Modelling.

Further topics addressed in the exchange of experience included cathodic corrosion protection as a possible method of repairing chloride-contaminated elements and structures, e.g. cooling towers, as well as the planned introduction of new Model Building Regulations.

TC Materials and Quality Assurance

Olaf Baumann

In the past year, the work of the Technical Committee «Materials and Quality Assurance» focused on the following topics:

- Flexibilisation and lifetime concepts
- Developments in materials
- Quality Assurance measures in the procurement, manufacture and installation of steam boilers, pressure vessels and piping systems
- Evaluation of damage to pressurised components
- Standards on the quality and operation of pressure equipment
- Requirements for fabricated supporting structures of offshore wind turbines and associated transformer stations
- The following research projects were in the focus of attention:
 - Boiler circulating pumps I and II
 - Follow-up project on 12 % chromium steels

Reports were delivered on the meetings of the TG «Supervision of Construction and Assembly/Quality Assurance and

the TG «Pipes and Valves», and also on the activities of the Working Group on T24/HR3C and the latest test results on the material HR3C.

The Working Group «Calculation Methods» focused on the topic of flexibilisation. In the Working Group on Boiler Circulating Systems and its three ad hoc groups on the subjects of

- scope of testing and test methods,
- calculation and intervals for recurrent testing, and
- process engineering for circulation systems,

intensive attention was paid to damage on boiler circulating pumps. A publication on this topic can be found in VGB POWERTECH 4/2016 magazine.

The PG «Corrosion Protection on Wind Turbines» is dealing with Standard VGB-S-021, «Corrosion Protection of Offshore Wind Turbine Components».

With regard to renewables, discussions were conducted on the FeLoSeFl research project (Fatigue Life Load Sequences effects and Failure-probability driven Inspection) and standardisation of welded joints in wind turbines.

TG Supervision of Construction and Assembly/Quality Assurance

Christian Stolzenberger

The Technical Group «Supervision of Construction and Assembly/Quality Assurance» once again addressed the focal topic of «Wind». In this topic, it was considered necessary to strengthen the operators' position, as specific investment costs in %/kW are the highest for the turbine (35 %) and the foundation (24 %). Furthermore, there is as yet no standardised access system from the boat to the offshore wind turbine. There are various kinds of damage to the turbines, extending from pitting on the planetary gear, damage to the drive shaft bearings, lightning strikes on a rotor blade, through a burnt-out power cabinet to cracks in the foundation. Damage surveys have determined that around 80 % of these cases are due to «defects of quality». Measures such as those have been taken by the Project Group on offshore corrosion protection, which is responsible for compiling the VGB/BAW Standard of the same name, are desirable and should be coordinated with the TC «Wind».

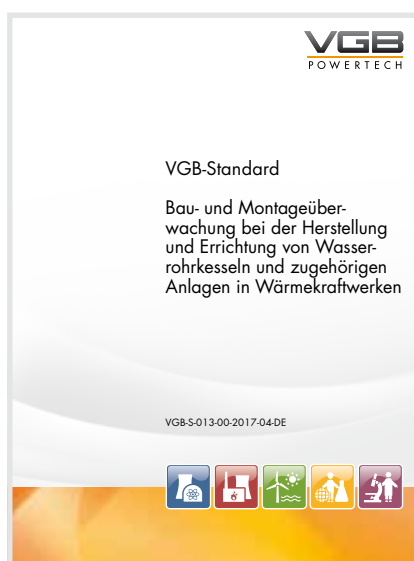


Fig. 9: Construction and installation supervision in the manufacture and assembly of water-tube boilers and associated systems in thermal power plants/Bau- und Montageüberwachung bei der Herstellung und Errichtung von Wasserrohrkesseln und zugehörigen Anlagen in Wärmekraftwerken.
VGB-S-013-00-2017-04-DE.

On the subject of quality management systems, a report was presented on the successful introduction of a QM system to ISO 9001. In this connection, the experience with joint certification to ISO 9001, ISO 14001 and ISO 18001 instead of separate certification was described.

On welding of components in P91/92, changes in the base material in the heat affected zone can be caused by the process itself. If changes can be detected in the micrographs, measures as set out in VGB-Standard VGB-S-517 are to be taken.

A second edition of VGB-S-013 (Figure 9) was published in June 2017 following a revision together with FDBR.

TC Electrical Engineering and I&C

Jörg Kaiser

The Technical Committee «Electrical Engineering and I&C» with its four Technical Groups deals with current issues of the day (e.g. I&C matters, generator damage, monitoring of generation systems, quality assurance, questions concerning the power plant-grid interface) and coordinates research projects. In addition, strategic topics, e.g. concepts for electrical and I&C projects and requirements at the plant-grid interface, are processed and work is performed on standards for the field of electrical engineering and I&C. There is a regular exchange of experience on the above topics and issues.

Research projects

VGB is participating in the «System Services 2030» project organised by the German Energy Agency (Dena). The aim of the study is to analyse the technical, political and economic background conditions and limits of a rising proportion of energy from renewable sources to the supply of system services for the period from 2030 onwards. The development of demand for system services products and the future role of conventional power plants are under consideration. This includes primary, secondary and inertia, reactive power, restoration of supply, redispatch and reserves. Predominantly transmission system operators, distribution system operators and plant manufacturers are involved in this study. As a stakeholder, VGB is contributing the know-how of the power generation companies to the technical discussion. From the point of view of VGB, the sub-projects on inertia and provision of reactive power and their appropriate remuneration as a service contributing to the safe operation of the system as a whole is of special importance. The study is to be completed in September 2017.

Use of new technologies: Increasing use of power semiconductors in the transmission system

New technologies in the transmission system change the familiar interrelationships and can have an adverse influence on the power plant components, e.g. with the increasing use of frequency converters. There is a need for firm answers to the question of whether the feed-in stations from the HVDC links of offshore wind farms or the planned head-end stations of the HVDC transmission networks have an impact on the turbine generator sets at power plants in the vicinity. The hazards presented by sub-synchronous resonance are real and, in the view of VGB, require communication with the TSOs on the power plant-grid interface, monitoring of the grid activities and coordination of the interests of the VGB members.

In several technical meetings on «Sub-Synchronous Torsional Interaction (SSTI)» with transmission system operators, operators of power plants, university academics and manufacturers, the topic has been addressed in a non-proprietary way. The need for research is currently being analysed and firm tasks agreed (Figure 10).

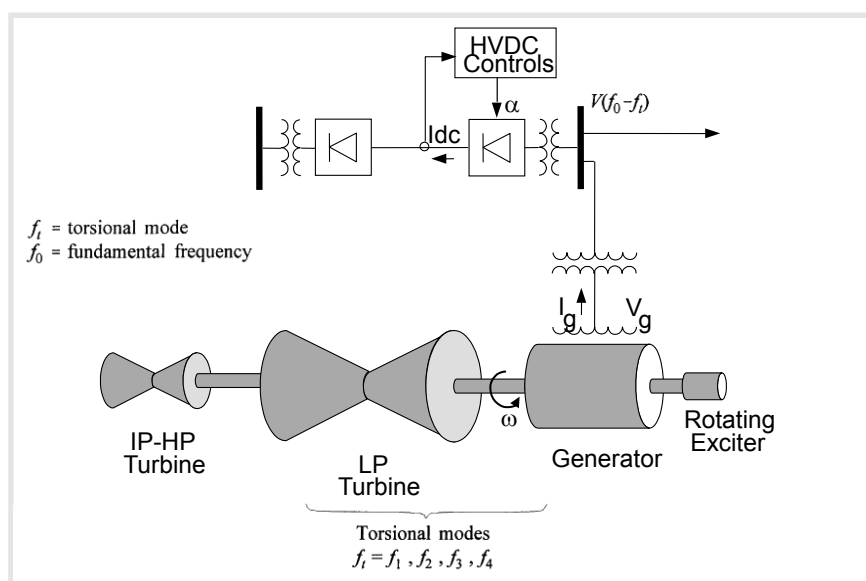


Fig. 10: HVDC Introduction – SSTI Studies.

TG Electrical Equipment

Jörg Kaiser

Work has been performed in the Technical Group «Electrical Equipment» on various VGB Standards in electrical engineering. With the application of those standards, the electrical systems in power plants are optimally designed and rated, procured, installed with quality assurance and maintained. The topic of quality in the manufacture and maintenance of electrical components continues to be of central importance. New requirements on electrical safety and fire protection are being addressed by the Technical Group and a specific exchange of experience conducted on the technical and commercial aspects of early compliance with such new requirements. This applies equally to damage to electrical components.

Generators

The PG «Generators» manages a damage database and conducts technical discussions with the manufacturers in order to evaluate current events and identify optimum solutions for further improvements in the operation and long-term stability of the generators. The database was systematically evaluated in a presentation at KELI 2016. It was shown that even relatively new generators fail to meet the changed operating conditions in Europe as required, and that premature damage is occurring more and more frequently. The operators demand a simple, robust design, which ensures fault-free operation in the required operating period even with high thermal cyclic stresses.

The sub-group «Thermal/Mechanical Generator» has completed the drafting of a new VGB Standard VGB-S-164-11, which has now been published in German and English. The sub-group was composed of experts from the operators and manufacturers of generators driven by steam turbines, gas turbines, hydro turbines and wind turbines.

The PG «Generators» has constituted a sub-group to work on a revision of the existing «Overhaul Recommendations for Turbo-Generators», which is to be published as VGB-S-167. New findings on methods of systematically detecting the factors influencing equivalent operating time and the evaluation of current corporate maintenance strategies and comparison with a damage database are creating a sound basis for this work. The work has commenced within the operators' companies. Manufacturers of generators will be involved in the drafting process in due course, and a supplement for hydro generators is also planned.

Transformers

For large-scale transformers, monitoring methods and techniques, and ageing management, continue to be in the focus. Data collections on the topics of online monitoring, transformer instrumentation and quality requirements for manufacturing and testing are available. A VGB recommendation for maintenance measures is in preparation.

The Working Group on «Electrical Engineering» of the Association for Industrial Construction (AGI) is to revise the AGI Data Sheet «Fire Protection on Transformer

Systems» (J21-1). The PG «Transformers» has nominated representatives to assist in the revision, coordinate interim results with the PG Transformers and safeguard the interests of the operating companies. The work will be completed in 2017.

Representatives of the PG «Transformers» are playing an active part in the revision of the VGB Standard on Fire Protection (VGB-S-108). The requirements are being discussed, mutual understanding improved, and the necessary contents decided upon in joint meetings.

TG Instrumentation and Control

Jörg Kaiser

The Technical Group «Instrumentation and Control» covers a very broad spectrum of topics requiring attention. Events are in some cases making it clear that relatively new I&C systems are not fulfilling the specified requirements, for instance for automatic redundancy switchovers, «controlled» bus communication or loading of updates during operation, etc.

For economic reasons, in contrast, the functions of relatively old I&C systems have to be preserved, and that against the background of decreasing servicing opportunities from the manufacturers and in some cases non-availability or impending discontinuation of spare parts. One blatant example is the I&C systems from Mauell, for which restricted service for a defined residual service period is only available under the terms of special service contracts. The Technical Group has formed a separate sub-group for a specific exchange of experience on the subject of the I&C systems and components which were supplied by Mauell.

The discussions with suppliers were continued, in order to assess the efficiency of the systems on offer and be aware of current trends and developments on an ongoing basis.

Work on Standards

The individual parts of the former VGB-R 170 B series, «Design Standards for Instrumentation and Control Equipment» have been revised by various teams of a Project Group. The objective was to bring the work in line with the current technical and economic challenges without neglecting the requirements for cost-effective operation and maintenance including troubleshooting. The revision of the subject matter was approved by the Technical Group at the end of March 2017, and final editing at the VGB Secretariat has commenced.

IT security for the I&C system

The IT Security Law (IT-SiG) in Germany and the associated Ordinance for definition of critical infrastructures have already been passed, and the Security Catalogue for energy systems (power plants) is to follow by the end of 2017. In the form of the standard VGB-S-175 on IT security, VGB created a basis on which I&C systems were already specified in terms of IT security and operated accordingly in the past. Regular reports on its application are presented at the meetings.

The Technical Group «Instrumentation & Control» is actively involved in the PG «VGB Coordination of IT-SiG» in order to influence the process and respond at an early stage to the new requirements. In addition, at the last meeting of the Technical Group, representatives of the German Federal Office for Information Security (BSI) were invited to discuss in detail the status of legislation and its influence on I&C systems, and the actions necessary for implementation. A regular exchange of information was proposed.

TG Interface Power Plant-Grid

Jörg Kaiser

In the Technical Group «Interface Power Plant-Grid», two Project Groups deal with the extremely extensive changes in the course of the energy transition and the harmonisation of the regulations for the European interconnected network grid at the power plant-grid interface:

PG Network Codes

PG Technical Aspects of German Regulation

The Project Groups «Network Codes» and «Technical Aspects of German Regulation» ensure that there is a coordinated procedure among the operators of generation facilities.

The Technical Group «Interface Power Plant-Grid» is available to the member companies to provide information on all technical and regulatory matters at the power plant-grid interface. Regulations for operation at the power plant-grid interface e.g. redispatch and provision of reactive power, are therefore an issue for operators and a focal area for the TG. The aim is to ensure an overview of the status of the European processes at all times and to assist in shaping them on the European and national levels. The compilation of joint statements and position papers on the European level is the desired result.

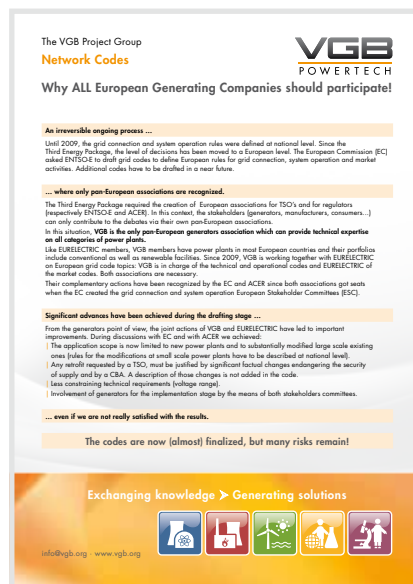


Fig. 11: VGB One-Pager «PG Network Codes».

European Network Codes

European Network Codes are adopted as laws or directives as a basis for the connection and operation of networks and the connected equipment, making a contribution to the harmonisation of the single market and as a condition for increasing feed-in of electricity from volatile generating facilities, with the objective of maintaining a consistently high level of reliability in supply. They are also correspondingly important for the connection and operation of generating facilities. The adoption of common standpoints by the generation companies on the draft Network Codes from Entso-E in close co-operation with EURELECTRIC is therefore essential.

Compilation of the most important Network Code for the generation companies, the «Requirements for Generators» (RfG) was extensively and critically monitored. The Network Code RfG was published in the EU Journal on 17 May 2016 and is to be implemented in national law within 2 years. It is apparent that an intensive European exchange of experience will also be necessary in the TG «Interface Power Plant-Grid» during and after the legislative process and the implementation in national law. At the Agency for Cooperation of Energy Regulators (ACER), Stakeholder Committees have been established to provide support and coordination in the implementation of the Network Codes and Guidelines. VGB as an independent stakeholder has 2 seats on each of the stakeholder committees on «Grid Connection» and on «System Operation».

Further Network Codes are in the resolution phase and require continuous monitoring and involvement by the responsible PG «Network Codes» (Figure 11).

Technical Aspects of German Regulation

The TG «Interface Power Plant-Grid», through its PG «Technical Aspects of German Regulation», is also responsible for coordinated reactions to German requirements resulting from laws and regulations, for instance the consultation and stipulation proceedings of the National Regulator Agency (NRA), the Electricity Market Act from the Ministry of Economic Affairs or the detailed processing of selected interface topics such as redispatch and network fee arrangements. In the period under review, statements have been issued, for example on the draft of the Electricity Market Act, on the drafting of the Capacity Reserve Ordinance, on the calculation of appropriate fees in the course of approval of individual grid fee agreements, and on minimum generation output.

TG Acceptance and Control Tests

Wolfgang Czolkoss

A reliable assessment of the processes of both new and existing plants after retrofitting and modernisation in terms of cost-effectiveness and environmental compatibility of is one of the major aspects of power plant operation. Requirements for acceptance inspection to verify guarantees after finalisation of the work are laid down in specifications and contracts; these are generally verified by specialist measurement teams. The Technical Group «Acceptance and Control Tests» is creating a common basis of understanding between operators and manufacturers, and makes recommendations for selecting specialised metrological instruments and on assessment and evaluation methods.

The new Standard VGB-S-020, «Determination of Measuring Uncertainty in Acceptance and Control Tests» has been completed by a Project Group. Together with explanatory notes on the origins of measuring inaccuracies and their identification, this VGB-Standard contains simple example calculations from acceptance and control tests in practice, and practical notes on the avoidance of measuring errors.

The PG «Pulverised Coal Measurement» has compiled a specification for a non-proprietary process for online measurement in the pneumatic fuel feed lines of

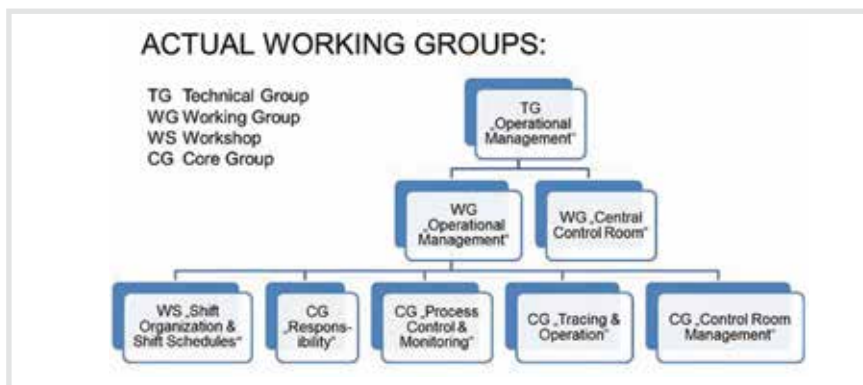


Fig. 12: TG Operational Management. Current Working Groups.

coal and biomass combustion systems. The manufacture and testing of a prototype using existing components was agreed at a workshop with suppliers of the metrological equipment concerned.

The revision of the VGB-Standards VGB-S-130 and VGB-S-131 on acceptance and control tests on water and air cooled turbine condensers was completed by the two Project Groups constituted for that purpose.

A fundamental part of the work of this Technical Group continues to be the exchange of experience and the assessment of new measuring methods and instruments, with particular attention to their usability in acceptance and control tests. The topics of the exchange of experience comprised acceptance measurements which had been performed, favourable effects from the use of process quality monitoring systems, experience with self-calibrating thermocouples and experience with wireless measured value transmission.

A number of members of the Technical Group and its Project Groups are actively involved in standardisation committees on acceptance measurements (VDI 2048, ISO 1888, IEC 60953 and VDI 3921) and thus ensure a good exchange of information during the processing of these standards.

TC Operation & Maintenance

Jörg Kaiser

The Technical Committee «Operation & Maintenance» deals with operational and strategic topics which are of especial interest in the technical management of the generation facilities, and manages the activities of the associated Technical Groups. Following the integration of the maintenance management specialists, there has been a greater focus on maintenance in the work of the TC «Operation & Maintenance». Operation and maintenance

of storage facilities is a new topic in the work of the TC.

Operation and maintenance of the generation facilities in the current market situation requires measures to preserve and improve cost-effectiveness. The consequences for the operating schedules of the generation facilities, for the demands placed upon the personnel deployed and for the need for IT support are focal areas in the work of the TC «Operation & Maintenance».

Early consultation on the effects of planned or new legal or official requirements (in Europe and Germany) on power plant operation is part of the strategic view. Compliance with legal and official requirements, for example with regard to environmental protection, cannot be neglected. At present, many power plant operators are directly affected by the discussions on further reduction of mercury emissions.

The initial and further training of power plant personnel, knowledge management within the companies and the development of new generation of skilled workers are important issues in ensuring the long-term competitiveness of businesses.

From an operational point of view, the topics of quality in the supply and maintenance of power plant components and the evaluation of current events in technical management are worthy of special attention. These issues are building blocks in ensuring the necessary effectiveness and competitiveness, and the basis of activities throughout the industry. VGB provides support for further development in the form of various tools, such as VGB-Standards and databases for events and damage.

TG Operational Management

Kerstin Kofink

The workshop on «Shift Plan Organisation» developed by the Working Group on «Operational Practice» was repeated in Hamburg and Essen, with very good feedback. That feedback was confirmed by one of the members during the meeting of the Technical Committee. Above all, the practical relevance of the workshop was complimented.

The WG «Operational Practice» also plans to develop just such a practical approach with regard to interviews with staff. The idea is to develop a toolbox for a structured comparison of values. This broad concept has been divided into four sub-groups, and examined in greater detail by corresponding core panels. The topics for examination are Responsibility, Process Control & Monitoring, Operator Monitoring & Control, and Control Room Management (see Figure 12).

The PG «Central Control Stations» was founded during a recent meeting of the Technical Group, during which two major suppliers outlined the further development of power plant I&C systems. In that context, the safety aspect is of particular interest to the Technical Group, as is the reliable and competent operation of various plants – always from the point of view of modern and flexible operational management. At the last meeting of the Technical Group, the PG «Central Control Stations» presented its initial results.

It is striking that the cost-effectiveness of a plant depends to a great extent on motivated and qualified operation and maintenance personnel.

In this connection, new qualification opportunities for Power Plant Shift Supervisors and correspondingly qualified personnel were presented to the Technical Group. The PowerTech Training Centre is reacting to the changing conditions in the industry with optional e-learning modules for basic qualifications and optional further training as an Energy Manager.

Furthermore, standards were addressed within the Technical Group, and practicable solutions to problems presented. For example, the effects on work permits resulting from the revision to DIN VDE 0105 Part 100 were described, as were best practice approaches to plant-related hazard assessments in companies. A detailed description can be found in the minutes of the 4th and 5th meetings of the TG Operational Management, which are available to registered VGB members.



Fig. 13: Lignite mining and modern power plant technology in the midst of successfully recultivated green areas.

TG Plant Management Systems and Technical IT

Jörg Kaiser

The Technical Group «Plant Management Systems and Technical IT» is pursuing activities to support the integration of human beings, data and information systems, with the purpose of using information technology as a management tool. The activities are performed with the aim of implementing the added value processing of data into supporting information for all areas from production to management. Digitisation, Industry 4.0 and Smart Business are only a few of the buzz words whose relevance to the generation and storage of electricity and heat is being monitored.

In that context, requirements/criteria are established for plant management systems and other IT systems for process support. The work of the Technical Group centres around an exchange of technical experience and know-how for all aspects of IT support in business processes, from plant systems to generation of electricity and heat, throughout the lifetime of the systems. In addition, protection of the information systems is to be appropriately ensured.

IT Security

The German IT Security Act was passed on 25 July 2015, followed on 3 May 2016 by the associated Ordinance on the Definition of Critical Infrastructure, which fundamentally contains the following:

- Definition of critical infrastructure for generation >420 MW per site and the central control stations when several smaller plants are grouped together.
- Extended reporting obligations.

- Certification under the terms of the IT Security Catalogue on the basis of an Information Security Management System (ISMS) to ISO 27001.

Following publication of the IT Security Catalogue for energy systems (power plants), which is to take place before the end of 2017, the period for providing evidence of certification will start.

In March 2017, there was an extended meeting of the Project Group «VGB Coordination of IT-SiG» as a kind of workshop, also attended by members of the TG «Instrumentation and Control», the TG «Plant Management Systems and Technical IT» and the PG «IT Security in Hydro Power Plants».

With 40 participants, the meeting was extremely well attended and showed that VGB is a suitable platform for the exchange of experience in the field of IT security.

Individual companies presented reports on the status of their preparation for and introduction of ISMS, and provided overviews of technical and organisational measures which have been taken to improve IT security. It became apparent that there was a great need for discussion, especially on the definition of the scope of ISMS (Figure 14).

From the second half of 2017 onwards, IT consultancy and auditing to ISO 27001 can be provided by VGB/KSG with support from a prestigious lead auditor for the energy sector. VGB/KSG hosted an information event on that service at the end of June 2017.

In the process of transferring the European NIS Directive into German law, BDEW took part in the consultation process in cooperation with VGB. The most important matters have already been incorporated in the IT Security Act and the associated Ordinances. Additions predominantly concern the providers of digital services. Contacts remain forthcoming, and the German Federal Office for Information Security (BSI) is to support the providers on request. Attention is to be paid to the impending amendments to the Energy Industry Act (EnWG); in particular, the fines listed there are to apply directly with no warning.

It would be desirable to have an implementation guideline from VGB. This would have to be compiled in several variants so that the individual members can identify their own situations more easily.

External assistance may be necessary for compilation, and possibly the capacities of VGB/KSG could be used.

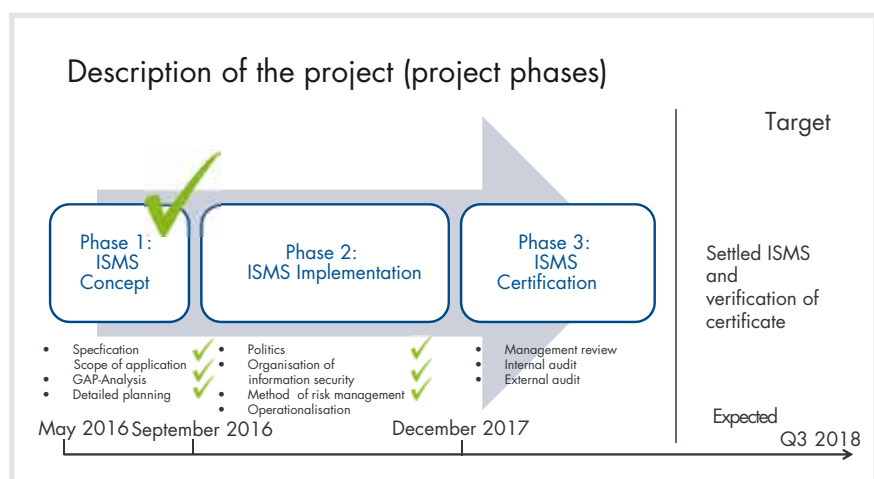


Fig. 14: IT Security Act – Definition of the scope of ISMS.



Fig. 15: Industrial safety. VGB-S-104-O, On-line-Standard.

TG Industrial Safety

Olaf Baumann

The Technical Group «Industrial Safety» has monitored the implementation of the German Ordinance on Industrial Safety and Health (BetrSichV) in the power plant sector and consistently represented the interests of the power plant operators in dealings with the Federal Ministry of Labour and Social Affairs.

A restructuring of the online guideline on implementation of the Ordinance on Industrial Safety and Health in power plants, VGB-S-104 (Figure 15), was performed by the responsible Project Group. Account was taken of the revision of the Ordinance in 2015 and 2016. The online guideline is available on the internet. Under the terms of the new VGB schedule of charges, the guideline is free for ordinary members (operators).

TG Performance Indicators

Stefan Prost

The Technical Group «Performance Indicators» has reorganised itself in the past 12 months and, as temporary working groups reached the end of their remits, founded a new user and member-oriented Project Group «Application». The focus of that group, with an international membership, will be on the following topics:

- Comparison of international indicators and definitions, and deduction of recommendations for the definition work of the TG «Performance Indicators». These may be either new developments or notes on methodology or international harmonisation.
- Analysis of the results of interplant data collection as a core functions of the TG as a whole, and in this case especially the editing and publication of the technical-scientific reports on «Availability» and «Unavailability».

- Contact and coordination with further international associations and groups, such as the World Energy Council.

The VGB Standard «Technical and Commercial Indicators for Power Plants» (VGB-S-002-03) and the exercise booklet to the series (VGB-S-002-33) have been revised, and the versions of August 2016 are available for downloading (as yet in German only) free of charge from the VGB homepage, as are all the standards of the VGB-S-002 series. The VGB Standard «Wind Power – Definitions and Parameters» (VGB-S-002-05) has been translated into English and was published.

In the course of development of the VGB power plant information system database KISSY, several pilot projects have been performed to study new evaluations which, for example of the power plant component level, examine the work involved in and benefits of new indicators of reliability and failure probability, establish interplant statistics on wind turbines, or take account of the integration of the Reserve Power Plant Ordinance in KISSY.

The master data list has been extended so that evaluation of additional groups of power plants such as cogeneration plants or single or multiple shaft combined cycle systems can be performed without any additional annual data collection.

The technical scientific reports «Availability» and «Analysis of Unavailability» of thermal power plants have been revised. Predominantly German groups of power plants have been increasingly replaced by international groups, but a national online evaluation is still possible. Information on the situation of the power generation industry was integrated as background information in the introductory remarks, so as to make interpretation and analysis of the results easier for the readers. The current interplant statistics for the period from 2007 to 2016 were compiled in cooperation

with 37 German and 25 international VGB members with at present 645 power plant units and 173 machine sets at storage and pumped storage power plants, with a total net installed capacity of approx. 273 GW.

In addition, the Group compiled an extensive analysis for the World Energy Council (WEC) on the basis of the results of the interplant data collection in the VGB database KISSY (Figure 16 and 17).

This contained a total of 833 plants with a total capacity of approx. 272 GW, comprising fossil fired plants, combination plants, gas turbines, and storage and pumped storage power plants. The main focus was on trends in recent years, which resulted from influences on the energy sector such as the phasing out of nuclear energy in Germany, deregulation of the market, and also the conversion from carbon-based combustion to electricity generation from renewables. An example worthy of note here is the tripling of unscheduled unavailability within the past 15 years. Even long-term planning has been unable to stop this considerable rise.

A further example is shown by the following trend diagram of energy availability and energy utilisation. As a result of the increase in unavailability, energy availability fell continuously from around 88 % in 1997 to below 80 % in 2015. At the same time, energy utilisation increased from around 47 % to approx. 55%. Between the two curves there is the reserve energy which can be provided by these plants – and that is reduced from around 40 % to 20 %.

Information on further trends and developments can be found in the complete report which is available on the VGB homepage.

TG Reference Designation and Plant Documentation

Andreas Böser

The Technical Group «Reference Designation and Plant Documentation» deals with the development of standards and application guidelines for the identification marking and documentation of energy supply systems and their components. For that purpose, there is a regular exchange of experience on technical issues affecting the topics of designation and documentation.

In the process a network of national and international committees (e.g. DIN, ISO, IEC, eCI@ss, CEN, DKE, etc.) can be used to achieve uniformity of the requirements for reference designations and documentation.

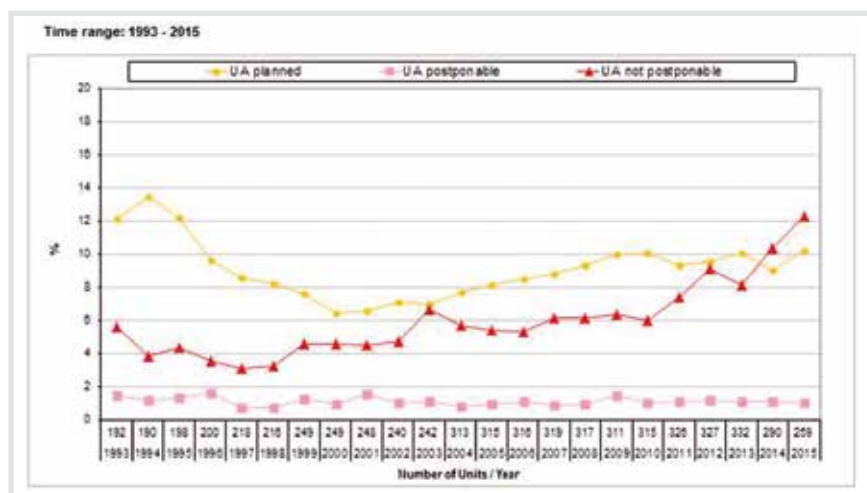


Fig. 16: TSR «Availability», A.2.1.1 Trend of fossil fired units without CCGT's, total.

First level support is available to the users of the standards by email and telephone. The performance of projects on optimising plant designations and documentation is supported. In addition, support from specialist personnel can be arranged.

Three new RDS-PP® application guidelines are currently being compiled.

- VGB-S-823-33 Photovoltaic Power Plants
- VGB-S-823-41 Power to Gas
- VGB-S-823-xx Systems for Distributed Energy Supply with Combustion Engines
- Formation of a PG to create an RDS-PP® application guideline on «Grid Connection» in cooperation with the power distribution association IG-EVU

Additionally the «KKS Pocketbook», VGB-B-105-007 (Figure 18) was published. The printed issue as also the eBook (PDF) are available at no charge and made public.

TG Maintenance Management

Heinrich Grimmelt

In the course of the general exchange of experience, the members of the Technical Group reported on projects, plant inspections and damage. The following discussions frequently produced ideas for improvements of the identification of root causes.

One focal topic was the handling of maintenance against the background of the market position of conventional power generation in Germany, and the resulting massive pressure on maintenance budgets which have already suffered cuts.

The members reported on how their companies are handling the poor earnings position and the shortened generating times in these circumstances. In a number of companies, the budget is being cut by management. Availability is however to be preserved wherever possible. One of the actions taken is to prolong

the annual inspection intervals for certain components.

Other companies compare each measure which exceeds a certain cost with the risk of damage if the work is not performed. This results in a priority list which is used for planning of drawings on the budget. It must of course be ascertained in areas whether unscheduled downtimes are attributable to the cancellation of work. That has not been the case to date, and therefore it has been possible to identify considerable potential savings and implement them.

As a matter of principle, all reserves in individual budgets are eliminated from the calculations.

Other operators regard it as difficult to implement the savings prescribed from above. This is the case, for example, with contractor strategy. Giving fewer orders to contractors will not lead to the desired success on its own, as the employees would look for other work. It is therefore necessary to have a capacity planning system which ensures that correspondingly fewer employees of outside contractors enter the plant site.

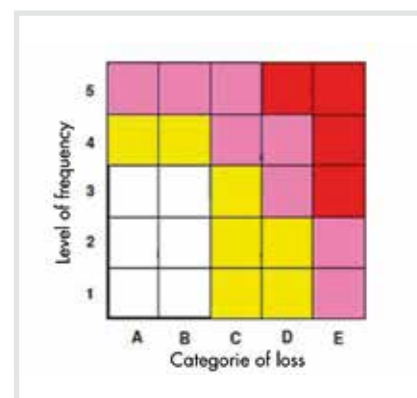


Fig. 19: Risk matrix.

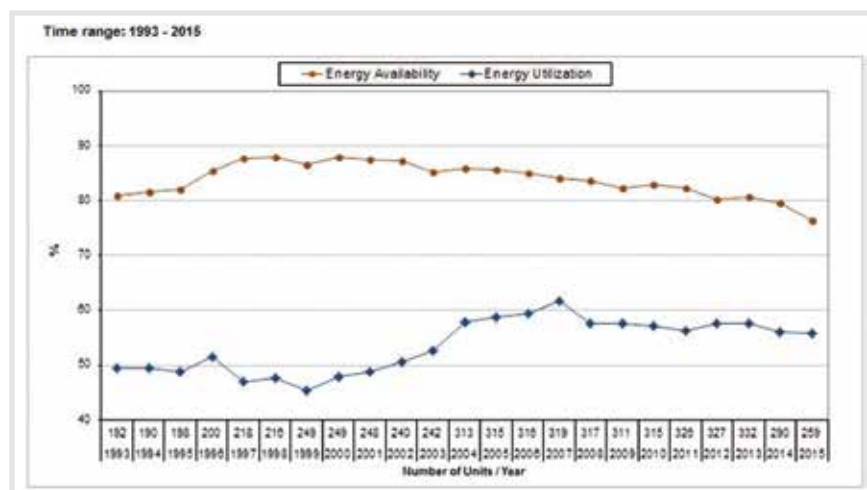


Fig. 17: TSR «Availability», A.2.1.1 Trend of fossil fired units without CCGT's, total.

Some companies are still deliberating on how the expensive consultancy projects on maintenance strategies can be put into practice sustainably in the long term, for instance by incorporation in the SAP/PM module. It is generally recognised that around 20% of the equipment is important and the budget should primarily be used for this.

As the companies are increasingly having recourse to risk-based decisions, a Working Group was founded to revise the rather old technical instruction sheet on «Recommendations for the Introduction of Risk-Based Maintenance» and bring it up to date. Figure 19 shows a typical risk matrix.

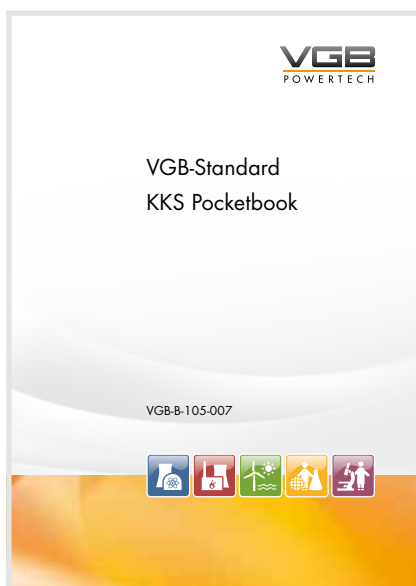


Fig. 18: VGB «KKS Pocketbook».

TG Power Generation Maintenance Optimisation Network (PGMON)

Heinrich Grimmelt

Two meetings of the Technical Group «Power Generation Maintenance Optimisation Network (PGMON)» were held in the period under review.

The autumn meeting took place at Vattenfall Moorburg and once again included a broad variety of presentations.

NUON reported on their approach to asset management.

The asset management process starts with a system criticality analysis to classify the criticality of an installation. To gain insight into the risk profile for the subsystems, the RCM process is applied, and for components Failure Mode Effect Criticality Analysis is used. On the basis of an optimised existing maintenance plan the maintenance tasks are defined according to the budgets. Legal obligations have to be complied with in all cases.

ČEZ reported on their activities in managing unplanned outage at the power plants. Targeted budgeting makes some stations have few outages, while others have a large number. ČEZ categorised their plants in 4 groups and defined a specific maintenance strategy for each group.

Dekra has analysed KISSY data and stated raising forced outages up to 12%.

In the Netherlands, gas fired stations are being mothballed, so as to be returned to service when coal fired stations are taken

out of the market for political reasons. They may face the same problems again.

EDF reported on changes to maintenance policies for the fossil fuelled stations in France. 1,500 MW of capacity was shut down in 2015. For the first time, a reduction of electricity consumption is envisaged in the medium term and the development of energy from renewables is still ongoing. Several years of economic difficulties and the end of the coal programme for political reasons in 2023, together with several open questions around the price of CO₂ and taxes, are leading to uncertainty for the producers.

The spring meeting of 2017 was held at EDF in Paris. The main topic was condition monitoring with the focus on early fault detection.

Latvenergo collects and analyses the condition data of rotating equipment, district heating systems, transformers and boilers. Additional vibration measurements are taken regularly. Several case studies were presented. The condition of the district heating systems, for example, is important for steam turbine efficiency. The district heating system's efficiency depends on various factors, such as the flow, ball cleaning system (Taprogge) efficiency and the wear on the cleaning balls, parameters of the flow media and others. Reduction in district heating system efficiency leads to a reduction in the heat generated. The condition monitoring methodology for district heating systems is based on the ASME code.

STEAG presented their approach to predictive diagnostics to detect faults and problems in power plant operation. Statistical process control uses «key performance indicators» (KPIs) to describe the current component quality or process quality independently of exterior conditions as a standardised parameter: $KPI = \frac{\text{actual value}}{\text{reference value}}$. This permits detection of slow and long-term developments.

EDF presented their impressive e-condition monitoring capabilities. At the thermal power plants, they perform real-time monitoring (level 1). On the second level, the CIT Paris Emonitoring Center checks equipment performance and behaviour. If there is a need for diagnosis by EDF on level three, experts are deployed to start their investigations (Figure 20).

It was proposed to compile a PGMON report on the effectiveness of condition monitoring for boilers, rotating equipment, electrical equipment, etc.

Events

VGB Conference «Cogeneration and Virtual Power Plants»

The VGB Conference on «Cogeneration and Virtual Power Plants took» place at the Hotel MELIA in Berlin on 5 and 6 April 2017. It was the first time that VGB PowerTech e.V., as an international professional association for the generation of electricity and heat addressed these future topics at a dedicated event. An interesting programme with prestigious speakers from the group of operators and manufacturers shed light on technical and operational innovations.

VGB Conference on «Fuel Technology for Firing Systems»

The Conference on «Fuel Technology for Firing Systems» took place in Kassel on 15 and 16 June 2016. Interesting presentations were delivered at the event, with those on operating experience and plaster sand above all receiving a favourable reception.

VGB Conference «Thermal Waste Utilization & Fluidized Bed Firing Systems 2016»

The Conference on «Thermal Waste Utilization & Fluidized Bed Firing Systems 2016» took place in cooperation with the Technical Group on Thermal Waste Utilization at the Turbinenhalle Berlin on 15 and 16 November 2016. The topics of the two Technical Groups were well chosen, making for great interest among all the participants. Presentations were delivered on regulatory topics (the German Cogeneration Act, BREF-LCP, the Ordinance on Industrial Safety and Health, and plant organisation), environmental topics (NH₃ destination, NO_x reduction, phosphorus recycling and Hg) and operational topics (drying and anchoring of refractory materials, ceramic coatings, the System Stability Ordinance and plant optimisation).

Further Events

The Conference on «Thermal Waste Treatment» was hosted in cooperation with the Technical Group on «Fluidized Bed Firing Systems» in November 2016. The focal areas were the technologies and strategies for emission reduction, plant and operation optimisation, flexibilisation and maintenance.

The VGB Conference «Future-proof Reference Designation and Documentation of Energy Supply Systems» took place in



Fig. 20: PGMON group visiting the e-condition monitoring centre of EDF.

Essen on 9 November 2016. The conference was well attended, with around 80 participants.

The Workshop on «Operation-related Maintenance of Industrial Steam Turbines» in Bielefeld on 10 and 11 May 2017 was well attended, with 63 participants, and the topics and presentations were well received. The feedback from this workshop was so favourable that a repeat is planned.

An international VGB Workshop on the subject of fluidised bed firing systems, with simultaneous interpreting into Polish and Chinese, took place in advance of the 12th Fluidised Bed Conference in Krakow on 22 May 2017.

The 4th International VGB Material & Quality Assurance Workshop was conducted at the premises of EVN AG in Maria Enzersdorf (Austria) in May 2017. 64 participants from 14 countries in 4 continents took part in the workshop.

The speakers reported on:

- Lifetime monitoring, flexibilisation and recurrent testing
- New materials, e.g. 12% Cr steels for flexible and efficient power plants
- Modern welding technologies such as electron beam and laser welding
- Quality Assurance and damage, for instance to the austenitic material HR3C, in boiler circulating pumps

Event Outlook

VGB Conference «Steam Generators, Industrial and Cogeneration Plants 2018»

The conference on «Steam Generators, Industrial and Cogeneration Plants», which takes place every two years, will be held in Rostock on 21 and 22 March 2018. The coming conference will deal with a number of important aspects of large steam generators. New testing methods and smart analyses for damage location will be presented. In the further course of

the event, initial results from plants preserved in accordance with the new VGB-Standard VGB-S-116 «Preservation of Power Plants» will be presented.

KELI 2018 (Conference on Electrical Engineering, I&C and IT)

Every two years, VGB PowerTech arranges a Technical Conference on Electrical Engineering, I&C and IT. It addresses operators and designers of all types of generation plants, including conventional, nuclear and hydro power as well as renewable, distributed and industrial generation. Current questions and solutions can be presented in lectures and discussed with international experts from operators, manufacturers, insurers, authorities and universities.

KELI 2018 will take place in Potsdam from (15) 16 to 17 May 2018. The Permanent Programme Committee has already started work, and the Call for Papers will be published in August 2017. The special support to students at KELI has already become a good tradition, and will be continued in 2018.

Further Events

The VGB Oil Workshop will take place in Mannheim/Germany on 15/16 November 2017.

The VGB Conference «Steam Turbines and Operation of Steam Turbines 2018» will take place in Koblenz/Germany on 6 and 7 June 2018.

The VGB Conference «Maintenance in Power Plants 2018» will take place in Bonn/Germany on 28 February and 1 March 2018.

(15) 16 and 17 May 2018
in Potsdam/Germany

VGB CONFERENCE

KELI 2018
Electrical Engineering,
C&I and IT
with Technical Exhibition

www.vgb.org



6 and 7 June 2018
in Koblenz/Germany

VGB CONFERENCE

Steam Turbines
and Operation of
Steam Turbines 2018
with Technical Exhibition

www.vgb.org



28 February and 1 March 2018
in Bonn

VGB CONFERENCE

Maintenance in
Power Plants 2018
with technical exhibition

www.vgb.org



Competence Area

Renewables and Distributed Generation

TC	Use of Renewables and Distributed Generation	C: N. N. A: U. Langnickel
TG	Biomass	C: M. Koch A: S. Zimmerling
TG	Biomass Ash	C: N. Bech A: Dr. H.-J. Feuerborn
TG	Biogas	C: Dr. A. Dengel A: S. Zimmerling
TG	Distributed Generation/Storage	C: C. von Cube A: D. Kückelmann
SF	Wind	C: H. Gassner A: U. Langnickel
TC	Wind Energy	C: P. Steinfeld A: U. Langnickel
TG	User Group Siemens	C: N. N. A: U. Langnickel
TG	User Group Vestas	C: N. N. A: U. Langnickel
SF	Hydro	C: Dr. K.H. Gruber A: Dr. M. Bachhiesl
TC	Hydro Power Plants	C: H.-P. Ernst A: W. Czolkoss
TG	Ecological Aspects of Hydro Power Plants	C: F. Zemanek/ Dr. M. Schletterer A: W. Czolkoss
TG	Operation and Maintenance of Hydro Power Plants	C: Dr. K. Wimmer A: W. Czolkoss
TG	Components of Hydro Power Plants	C: W. Kofler A: W. Czolkoss

Renewables and Distributed Generation

A Mainstay for the Future

Mario Bachhiesl

VGB concerns itself in 22 committees and groups, including temporary project groups dealing with technical and environmental topics as well as with specific issues in the field of renewables and distributed generation. Capitalising on the intensive exchange of experience, it offers its members an ideal international platform with the goal of achieving further improvements in operation, efficiency, safety, environmental friendliness and economy. Along with aspects of the optimisation of plants already in operation, the detailed investigations and in-depth analyses focus on the formulation of technical requirements for the erection of new plants. The whole range of topics encompasses hydro power, wind energy, biomass, biogas, distributed generation and storage technologies. In addition, the activities are increasingly interlinked in cross-cutting committees between the areas of renewables and power plant technologies and environmental protection.

In close consultation with the operators, VGB-Standards, partly in German, English and French, have been created in the Renewables and Distributed Generation sector and are revised at regular intervals to bring them up to date. The list of all standards obtainable from VGB is available on the website at https://www.vgb.org/en/media_catalogue.html, and a list of those standards which are under revision is available at <https://www.vgb.org/en/standards.html>.

Within the framework of the EUSI-RES (Efficient Use and System Integration of Renewables) research programme, VGB took part in nine projects in 2016 (hydro: 1, wind: 3, biomass: 3, system integration: 2).

During the reporting period, the activities and cooperation in particular with EURELECTRIC in Brussels and BDEW (Bundesverband der Energie- und Wasserwirtschaft/

German Association of Energy and Water Industries) were extremely intense, because at the European level, as well as in Germany, a large number of initiatives, guidelines, laws and ordinances had to be revised or introduced for the first time.

Renewables in the EU

Mario Bachhiesl and Ulrich Langnickel

The member states of the European Union (EU) have set high goals for the expansion of renewables. The plan for renewables is to have a 20 % share of gross final energy consumption and 10 % in the transport sector in the year 2020. An individual target value for each EU member state was set for 2020. These national targets take into account the different starting points, the potential in the field of renewables and the economic capacity of the member states. According to the national action plans, for the EU as a whole a share of 34.0 % is expected for the electricity sector, 21.3 % for heating and cooling and 11.3 % for the transport sector.

In 2015, the share of renewables in the gross final energy consumption of the EU was 16.7 % and thus above the forecast figure of approx. 13.0 % for 2015/2016. More than one third of the 28 EU member states have already reached levels that satisfy their national targets for 2020 (Figure 1): Sweden (53.3 %), Finland (39.3 %), Denmark (30.8 %), Croatia (29.0 %), Estonia (28.6 %), Lithuania (25.8 %), Romania (24.8 %), Bulgaria (18.2 %), the Italy (17.5 %), the Czech Republic (15.5 %) and Hungary (14.5 %). Furthermore, Austria needs less than one percentage point to reach its individual targets for 2020. In contrast, the lowest shares of renewables were reported in Luxembourg (5.0 %), Malta (5.0 %), the Netherlands (5.8 %) and the United Kingdom (8.2 %).

SF Strategic Forum
TC Technical Committee
TG Technical Group

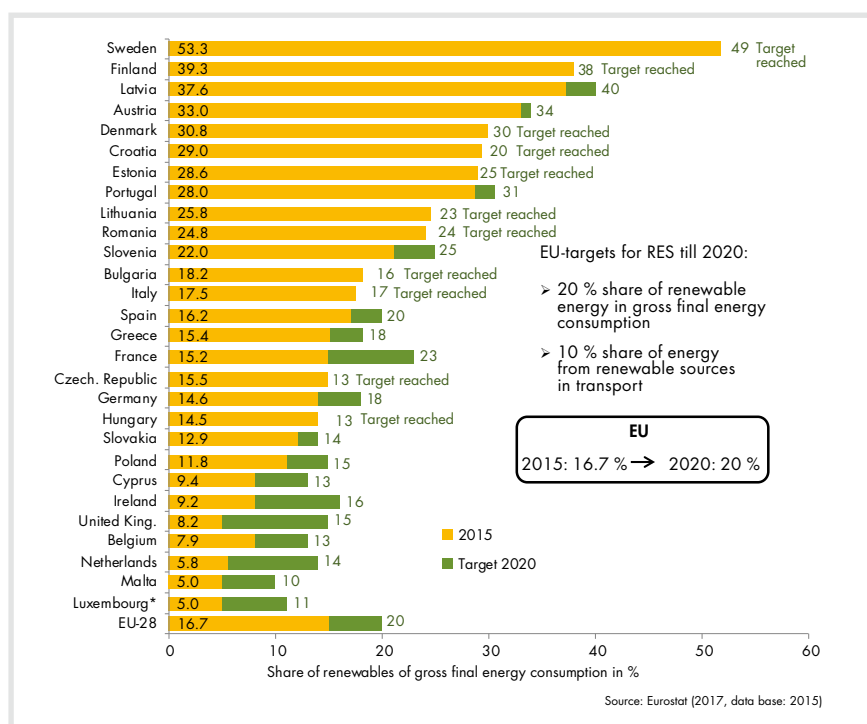


Fig. 1: Share in renewables according to member state (in % of the gross final energy consumption).

In the field of power generation, at the end of 2015 more than 29.7 % of the electricity in the EU was being produced with renewables, with around 42.6 % of that coming from the use of fluctuating sources – wind and solar energy. Wind power generation more than quadrupled in the period from 2004 to 2015. After hydro power, which accounts for more than 35.5 % of the total renewable power generation, wind power now makes the second largest contribution. Power generation from biomass also is growing, attaining a share of 18.1 % in 2015 (Figure 2).

Hydro Power

Mario Bachhiesl and Wolfgang Czolkoss

As the first renewable source of energy, hydro power has been used for power generation since the end of the 19th century. Worldwide, hydro power plants with an installed capacity of 1,212 GW generated around 3,975 TWh of electricity in 2015. Hydro power, with its mature and reliable technology thus makes an essential contribution to power generation without CO₂ emissions. As the use of wind and solar, fluctuating sources of energy

for power generation increases, the ability of hydro power to serve as a universal system service provider for all necessary network services takes on growing importance. Pumped storage power plants and impoundment hydro plants with their fast controllability are particularly well suited for this purpose. Run-of-river power stations are suitable for meeting base load requirements and contribute to the provision of reliable power.

VGB has greatly intensified and expanded its activities and services in the field of hydro power in particular, and has set itself the aims of

- being the single European voice for the operators, manufacturers and suppliers of hydro power plants,
- being the point of contact for all parties interested in technical, ecological and strategic issues related to hydro power, and
- acting as the information hub for the hydro power industry in Europe.

Many of our offers, activities and, in particular, the added value of VGB membership, are described in detail in the documentation available for downloading and at the website (https://www.vgb.org/en/_hydro.html). A hydro power-related media catalogue with 23 VGB-Standards created in close cooperation with operators and manufacturers has been newly compiled. For better clarity as to the area of application, the VGB standards are assigned to specific fields such as construction and commissioning, operation and maintenance.

In the hydro power sector more than 70 companies benefit from membership in VGB and from the information made available there, such as best practice examples in the area of maintenance, and from data such as availability analyses. In the VGB groups and committees (Figure 3), more than 100 members from over 34 member companies from 11 countries actively address a variety of technical and environmental topics relating to hydro power and engage in an intensive exchange of experience.

As the international professional association for the generation and storage of electrical and thermal energy on the European level, VGB PowerTech | Hydro also cooperates closely with various national and regional associations, and on the European level with EURELECTRIC. Under the terms of a Memorandum of Understanding with EURELECTRIC, VGB with its professional expertise is involved in

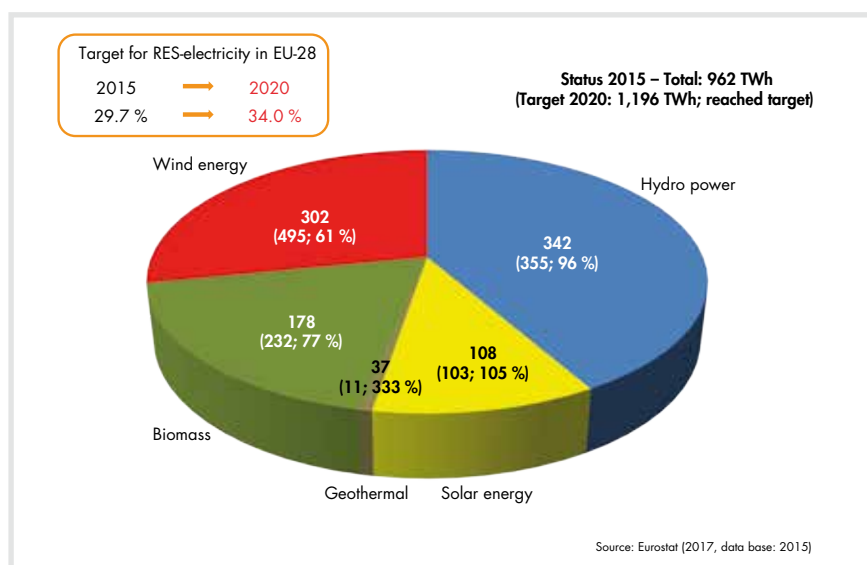


Fig. 2: Shares of renewables in the electricity sector in the EU-28.

the political and strategic work on the EU level concerning all matters of power generation. In this connection, VGB compiles fundamental position papers for the hydro power industry.

SF Hydro

Mario Bachhiesl

The Strategic Forum (SF) «Hydro» comprises top management members of European hydro power operators, offering them a platform for an exchange of expert knowledge and practical experience with current challenges on the highest level. The members possess outstanding and extensive expertise concerning the market situation of the power industry in their home countries and in Europe, on the technical, environmental and economic requirements and challenges, and on energy policy strategies on both the national and EU levels. Furthermore, the Strategic Forum coordinates its activities with EURELECTRIC in Brussels and other national and international organisations, and coordinates the work of the Technical Committee (TC) on «Hydro Power».

In its role as a comprehensive strategic committee, it deals with the following topics:

- Coordination of the interests of the European hydro power plant operators with regard to future requirements and challenges
- Coordination of the interests and requirements of the operators and manufacturers and their public relations and strategic objectives
- Organisation of the representation of interests of the European operators of hydro power plants in important multinational organisations, associations and commissions
- Dealing with important matters related to generation
- Fundamental exchange of experience and findings with regard to investment perspectives
- Initiation of joint European research and development projects

Topics have included the representation of hydro power by VGB in other organisations, and in particular stronger representation of hydro power by VGB on the European level. VGB, as an interface to EURELECTRIC, is the technical platform for European operators of hydro power plants. On political issues such as market design or the German Renewable Energy

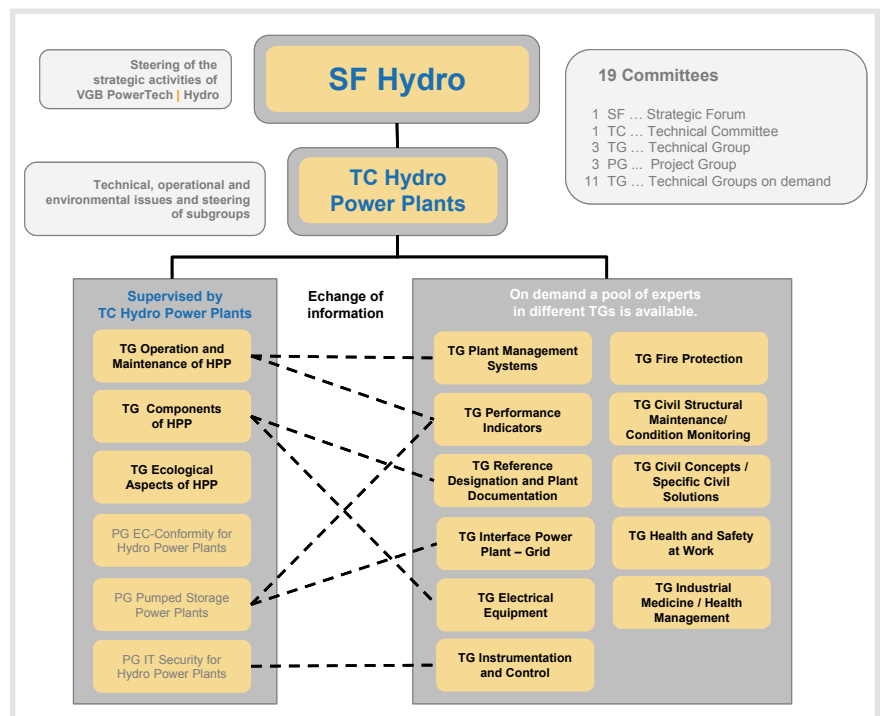


Fig. 3: Committee structure of VGB PowerTech | Hydro.

Act, VGB supports other associations such as the BDEW (Bundesverband der Energie- und Wasserwirtschaft/German Association of Energy and Water Industries) or the AGAW (Arbeitsgemeinschaft Alpine Wasserkraft/Working Group of Alpine Hydro Power).

The brochure «Hydropower – Part of the Renewable Family», issued by VGB and its members, outlines the historical development of hydro power use up to the present state of the art. In addition, the brochure explains the special economic and ecological significance for present and future European power supply, which to an increasing degree is based on renewable sources of energy. The brochure can be downloaded free of charge from the VGB website (Figure 4).

TC Hydro Power Plants

Mario Bachhiesl and Wolfgang Czolkoss

The work of the various Technical Groups and Project Groups are coordinated in the Technical Committee (TC) on «Hydro Power Plants». There is an intensive exchange of technical experience between the members, development projects are coordinated, and liaison and cooperation with other organisations in the field of hydro power (BDEW, DWA), AGAW, etc.) take place.

In the period covered by this report, two meetings took place in Kaprun (Figure 5)

and Essen, at which, among other things, the Reisseck II project, the Bannwill downstream fish pass, the renewal of the Oschenig 1 storage pump, the Gries power plant on the Salzach river and various cases of damage were presented and discussed as part of the exchange of experience. Other topics concerned cost-benefit analysis for the assessment of components subject to fatigue, digitisation projects in the field of hydro power, the provision of ancillary services and the inadequate re-

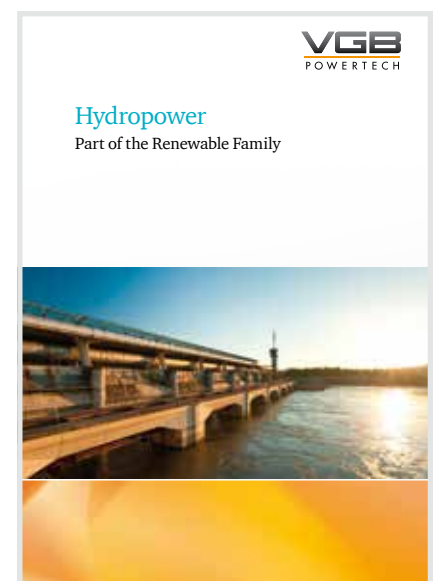


Fig. 4: The new VGB Hydropower brochure.



Fig. 5: Turbine generator set at the Kaprun-Oberstufe power plant.

muneration for doing so. In order to assist in the discussion of grid connection conditions, a survey was conducted on achievable control times for hydro power plants, so as to establish a comprehensive basis for future discussions on the grid stabilisation services provided by hydro power facilities. Due to the dynamic developments in that field, a direct comparison with other storage technologies is of special importance. The major contribution made by hydro power to stabilising the grid with an increasing share of feed-in from volatile renewables has been taken in appropriate account. The newly founded Project Group (PG) «Pumped Storage Power Plants» is dealing with this issue.

The TC «Electrical Engineering, Information & Control» has numerous points of contact with topics involving hydro power. The issue of IT security, for example, is already being dealt with in a PG «IT Security in Hydro Power Plants», which works closely together with the PG «IT Security». Taking the standard VGB-S-175 «IT Security for Generating Plants» as a basis, the project group is identifying the special security risks and consequences to be drawn for the equipment and operation of hydro power plants. Together with an exchange of experience, the members are also monitoring the current status of laws and regulations and clarifying the consequences. The aim of the PG is to compile a VGB minimum requirements list for servicing and maintenance contracts for the IT in hydro power plants.

The current market situation for hydro power is characterised by low achievable earnings for electricity among others due to a lack of subsidies for renewable generation. As a result, the existence of many current plants is threatened. The ex-

pansion of hydropower, desirable from an ecological viewpoint, is not economically feasible under such conditions. The additional services provided, for example for flood control or shipping, thus also are in jeopardy and would have to be provided by other means if the decommissioning of hydropower plants threatens. In general, hydropower is valued by the political community as an important contribution to renewable power generation. However, where promotion and licensing issues are involved, inadequate support is provided. For example, the coming Natura 2000 directive leads to even more lengthy licensing procedures. The Technical Group (TG) «Ecological Aspects of Hydro Power» deals with these and other ecological aspects of hydro power plants. The main objective is to provide assistance to the operators in questions of licensing and to create an appropriate holistic view of the ecological requirements for hydro power plants.

The strained financial situation of many hydro power plants also has the result that expenditure on servicing and maintenance must be reduced. Maintenance intervals are extended and the expected service life of components is increasingly utilised to the limit. The two TGs «Opera-

tion and Maintenance of Hydro Power Plants» and «Components of Hydro Power Plants» deal with these challenges. The conformity of components with the CE directives must be assessed to provide proof of operating safety and reliability not only for new-build projects, but also for modernisation and replacement. Assistance in this area is provided by the VGB Standard VGB-S-033 «Interaction of Conformity Assessment and Industrial Safety in Hydro Power Plants», which has been updated by the PG «Conformity Assessment».

TG Ecological Aspects of Hydro Power Plants

Wolfgang Czolkoss

The TG «Ecological Aspects of Hydro Power Plants», established jointly with the AGAW, provides for the exchange of information on and experience with ecological issues between European operators of hydro power plants. The members take an active part in the Fish Protection Forum organised by the German environmental protection agency UBA. The synthesis paper on the forum's work from 2011 to 2014 has been commented on in detail and successfully presented in the follow-up workshop in September 2016. The comments represent the position of the hydro power plant operators and are intended as an additional argumentation aid in the discussion of the relevant issues. The interests of the operators are also represented by VGB and the members of the TG in other associations and organisations, for instance DWA, BDEW and AGAW.

A further essential part of the work in this committee is the exchange of information between the members on issues and experience with licensing law, and on the results of relevant studies and projects.

Work is proceeding on a continuous basis on reviewing and examining relevant ecological topics with the aim of establishing a general overview of all ecological issues which have a bearing on hydro power. These issues concern not only fish passes,

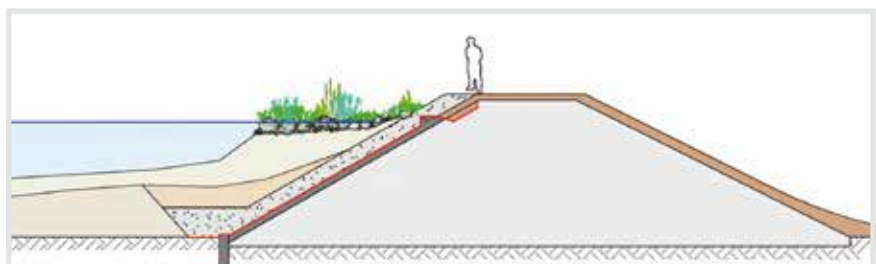


Fig. 6: Dam remediation with ecological improvements to the bank areas (Source: Bayerische Elektrizitätswerke GmbH).

but also topics like fish monitoring, hydro-peaking (surge and low water), or habitat improvements. For instance, VGB is participating in a demonstration project for dam restoration with ecological enhancement of riverbank areas (INADAR – Innovative and ecological approach for dam restoration – Figure 6). Information about this is available on the VGB website and in the chapter on research. Initial ideas on a research project aimed at «Securing of fish populations, acceptable mortality levels and effective methods of making improvements» have been formulated.

TG Operation and Maintenance of Hydro Power Plants

Wolfgang Czolkoss

The Technical Group «Operation and Maintenance of Hydro Power Plants» provides a forum for the exchange of information and experience on the operation, maintenance and asset management of hydro power plants. The group develops maintenance strategies and deals in depth with selected maintenance issues. To this end it also compares the maintenance strategies of other industries. In view of the constraints that lead to extended maintenance intervals and greater use of the calculated lifetime, which have already been discussed in the Technical Committee, the comparison of different maintenance strategies among European operators and the development of a guideline for a risk-based maintenance strategy were defined as a firm task. That guideline is to be completed by 2018, and it is planned to use it as a training document for a workshop.

For this purpose, project groups have been formed within the TG to deal with the following topics:

- Maintenance strategies for Kaplan turbines and generators (rotors)
- Maintenance strategies for barrages and shut-off facilities
- Remote control for hydro power plants (exchange of experience; not a guideline, but a workshop)
- Digitisation of workforce management (exchange of experience)

In connection with operation by remote control, it will be necessary to deal with individual issues related to particular plants, and therefore it will not be possible to establish a general guideline. When, for example, there is a risk of flooding, provision must be made for protection measures in the local systems. Information on the subject of remote control is ex-

	Installed capacity end 2014 [MW]	Installed capacity end 2015 [MW]	Installed capacity end 2016 [MW]
Germany	39,165	44,946	50,019
Spain	22,987	23,025	23,075
Denmark	4,845	5,063	5,227
Italy	8,663	8,975	9,257
United Kingdom	12,440	13,809	14,542
Netherlands	2,805	3,443	4,328
Greece	1,980	2,135	2,374
Sweden	5,425	6,029	6,519
Portugal	4,914	5,050	5,316
Ireland	2,272	2,486	2,830
France	9,285	10,505	12,065
Austria	2,095	2,404	2,632
Finland	627	1,001	1,539
Belgium	1,959	2,218	2,386
Turkey	3,763	4,694	6,081
Norway	819	822	838
Switzerland	60	60	75
Poland	3,834	5,100	5,782
Remaining Europe	6,030	6,087	6,445
Europe	133,908	147,852	161,330

Tab. 1: Installed wind energy capacity in Europe in 2014, 2015 and 2016
(Source: WindEurope 2017).

changed with the VGB PG «IT Security for Hydro Power Plants».

In the exchange of experience, a report was presented on the IT upgrade with remote control at the Pfreimd group of pumped storage power plants.

TG Components of Hydro Power Plants

Wolfgang Czolkoss

The Technical Group «Components of Hydro Power Plants» analyses the current market requirements for operators and manufacturers, and in which way the component quality can be influenced. All project phases, from tendering, drafting of contracts and design through production and installation to commissioning and operation will be considered. To compile specifications and standards for the subsequent maintenance of hydro power plants, close cooperation with the Technical Group «Operation and Maintenance» is necessary. Not only material fatigue, but also the required maintenance effort and expense are considered.

With its core skills, and drawing on experience, the TG will derive recommendations for new-build and replacement projects and publish them as a VGB-Standard.

Wind Energy

Mario Bachhiesl and Ulrich Langnickel

The use of wind power has to be further extended in order to meet the requirements of the European Union within the scope of its Energy and Climate Change Package. However, extensions should be purposefully selected at very favourable «wind sites» taking into account power plant-related criteria. At the end of 2016, about 28,217 wind turbines with an output of 50,019 MW were in operation in Germany. At that time the installed capacity in Europe amounted to 161,330 MW (Table 1) and 486,749 MW worldwide.

For over 16 years now, an intensive exchange of information and experience on the efficient operation of wind turbines has taken place under the roof of VGB PowerTech. The focus is in particular on the requirements of the operators. The declared aim is an expansion of standardisation (best practice) and strengthening of the common interests of the operators, above all in various User Groups.

VGB PowerTech I Wind has set itself the objective of being the first address for all operators of wind turbines on the technical, environmental and strategic aspects, and the information hub for all technical issues within the wind energy industry in

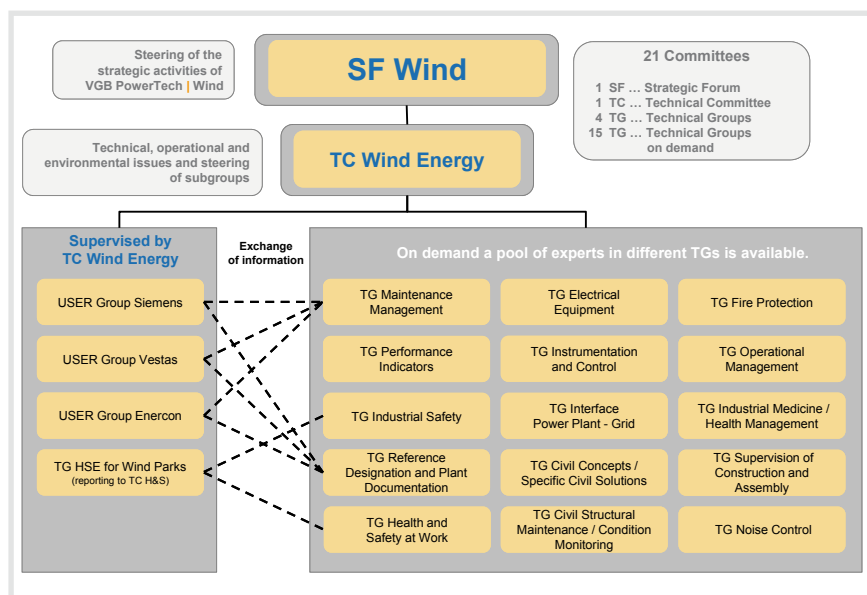


Fig. 7: Committee structure of VGB PowerTech | Wind.

Europe. Further intensive initiatives have been developed and implemented for this purpose, including the updating of the wind homepage (https://www.vgb.org/en/_wind.html). On the homepage, the strategies and current activities of the individual committees and groups are described in detail, and various documents are available for free downloading. A wind power-related media catalogue with 28 VGB Standards has also been newly compiled. For improved clarity of the areas of application, the VGB Standards are assigned to the corresponding areas such as dimensioning, design and planning, operation and maintenance.

VGB members operate wind turbines with a total capacity of more than 38,000 MW, corresponding to around 25 % of the capacity installed in the EU-28. In the VGB committees and groups, over 130 members from 17 countries actively deal with all the technical, operational and environmental issues related to the use of wind energy. Together with the two strategically and technically orientated steering committees, the working platform consists of four further permanent working groups. Additional committees and groups can be involved as required (Figure 7).

SF Wind

Mario Bachhiesl and Ulrich Langnickel

In the Strategic Forum (SF) «Wind», the leading operators of wind power plants, e.g. E.ON, EnBW, innogy, Vattenfall, EDP and Enel, pool their interests under the roof of VGB PowerTech. Apart from

exchanging information and experience, the participating companies seek mainly to advance standardisation (best practice) and to express common operator interests in the different User Groups. The reduction of installation and operating costs as well as the enhancement of operational safety and reliability urgently require co-ordinated and joint analysis of operating experience. The findings and knowledge obtained will provide the basis for determining construction and operating standards (VGB-Standards). In the SF «Wind», the strategic requirements for the utilisation of wind power, from the viewpoint of the operators, are discussed at management level and appropriate measures are initiated. In addition, the activities of the TC «Wind Energy» and the different User Groups are coordinated. These bodies deal mainly with operating experience and requirements, and initiate and support relevant research projects.

One fundamental topic is dealing with the occupational health and safety requirements, which are in many cases strongly determined by specific national regulations. It is the aim of the VGB member companies to establish as high a degree of standardisation in this area too. This also applies to the different skills required for training certificates, for which harmonisation is absolutely essential.

TC Wind Energy

Ulrich Langnickel

The primary objective of the members of the Technical Committee (TC) «Wind Energy» is jointly to reduce the operation and maintenance costs of the wind turbines. Together with an intensive exchange of information and experience, the committee supports the further development of standardisation, initiates corresponding research projects, and assists in designing the contents of VGB events.

To optimise the maintenance strategies, standardisation is an absolute necessity in the wind energy field. Similarly to the recommendations for conventional power plants, various VGB Standards therefore set out requirements and necessary measures for the installation and operation of onshore and offshore wind farms. In total, the newly compiled media catalogue for the field of wind energy comprises 18 VGB Standards, and a further 10 which are exclusively concerned with the challenges in the area of wind energy.

- The VGB Standard «Reference Designation System for Power Plants – RDS-PP® for Wind Power Plants» was published for the first time as early as 2006, and in an updated version in 2014. The stipulations of RDS-PP® VGB-S-823-32-2014-03-EN-DE, based on international standards, make an unequivocal digital exchange of data on the components of a wind turbine possible, and by doing so producing fundamental advantages ranging up to a reduction in costs, as all those involved «speak the same language». VGB PowerTech initiates and updates various measures for implementation of the designation system on a continuous basis.
- Specific information requirement lists for wind turbines were integrated in the VGB Standard «Provision of Technical Documentation (Technical Plant Data, Documents) for Energy Supply Units» (VGB-S-831-00-2015-05-EN) for the first time. The VGB Standard applies to the entire technical documentation required for the execution of projects (planning, erection and commissioning) in order to ensure future operation and maintenance.
- To harmonise the definitions and indicators, members of the TG «Performance Indicators» have compiled such terms for the wind energy sector for the first time and coordinated them with the members of the TC «Wind Energy». They are published in the VGB



Fig. 8: Camera for detection of ice on a rotor blade, Meteotest.

Standard VGB-S-002-05-2015-10-DE, «Wind Turbines – Definitions and Indicators». A medium-term goal of the project group is to create a uniform definition of availability, allowing for comparisons between wind turbines from different manufacturers.

- The VGB Standard «Guideline for Life Cycle Management of Foundations and Towers of Onshore Wind Turbines» deals with the repair and rehabilitation of these wind power plant components, which are made of steel, reinforced concrete and other materials as well as combinations of these. This document also deals with building materials like mortar or coatings which are part of the basic package or are used for repair. However, electrical or electrically conducting components are not considered. Publication of this VGB Standard is scheduled for the end of 2017.
- In collaboration with the Federal Waterways Engineering and Research Institute (BAW), a VGB/BAW Standard VGB-S-021 consisting of six planned parts and entitled «Corrosion protection for offshore wind structures and wind park components» has been drawn up in consultation with specialist associations. This standard was declared as mandatory by BSH in September 2016.
- Members of the TC «Wind Energy», in collaboration with fire protection experts (TG «Fire Protection»), are compiling minimum requirements for fire protection in wind turbines. Early fire detection and identification of fire risks are particularly important. Building on

this, the measures necessary to enable direct extinguishing of locally occurring fires are described. The actions required for personal protection are also explained. The relevant VGB Standard will be published in 2017.

- The high numbers of stress cycles lead to especially stringent requirements for lubrication of the gearbox bearings and gear teeth. In order to achieve a high level of availability for wind turbines, corresponding demands are placed on the quality and cleanliness of the lubricants used. Apart from the specific requirements for the gearbox oils and hydraulic fluids, a VGB Standard is to contain details of oil analysis, oil filtering and the correct procedure for flushing and filling. The VGB Standard is to be published at the end of 2018.
- A standardised acceptance inspection record at the end of the warranty period for wind turbines will in future be defined in a VGB Standard entitled «Take over and end of warranty». The creation of a higher level acceptance inspection record is supported by the members of the TC «Wind Energy».

Icing of the rotor blades significantly influences the efficiency of wind farms in operation. It causes production losses and is a safety risk for passers-by and service personnel (Figure 8). Based on the completed VGB research project, «Evaluation of Ice Detection Systems for Wind Turbines, Part I: Status Quo, User Experience, Recommendations», four blade-based ice detection systems from manufacturers Weidmüller, Eologix, fos4x and Wölfel are being tested in a follow-up project. No non-proprietary comparative studies had previously been performed on blade-based systems, and this is therefore being done for the first time in the VGB research project. The ice detection systems were installed on a Vestas V90 wind turbine at the Swedish wind farm Stor Rotliden, which is operated by Vattenfall Vind AB. In an extensive programme of testing, the behaviour of these systems is to be tested, evaluated and compared during the winter periods of 2016/2017 and 2017/2018. The formation of ice will additionally be documented by a camera. On conclusion of the research project, the members of the TC «Wind Energy» will have a tool for optimum planning of deployment of the blade-based ice detection systems in response to local climatic conditions.

According to the requirements of the German Maritime and Hydrographic Agency (BSH), foundations of wind turbines that are installed in the German Exclusive Eco-

nomie Zone (EEZ) have to be checked every four years and the foundations of transformer platforms every year. In order to reduce the high costs associated with these procedures, the operators are aiming at prolonging the testing intervals. To enable calculation of the real fatigue of the materials used in the foundations, including the welded joints, the relevant loads are being analysed in a project coordinated by TNO (Netherlands Organisation for Applied Research). The general aim of the project is to enable verification of the conservative calculation methods used to date. The results of the research project, in which VGB is participating, could thus have an influence on possible adjustments of the intervals for recurrent in-service inspections. The results of the research project will be available at the end of 2017.

With support from Vattenfall Windkraft GmbH and the TC «Wind Energy», the annual technical conference «Maintenance of Wind Power Plants» took place in Hamburg on 22/23 March 2017. Over 80 participants from 14 countries addressed issues relating to the operation and maintenance of wind turbines both onshore and offshore. The focal topics of this event were in particular optimising the output and prolonging the service life of wind turbines, and also experience with condition monitoring systems. In the offshore segment, the development of «floating foundations» was presented (Figure 9). The presentations and intensive discussions at the conference showed that the process of optimising operation and maintenance strategies has to be continued. The next technical conference will be held in the spring of 2018. Implementation of the necessary measures for continued operation of wind turbines after 20 years will most probably play an important role at that event.



Fig. 9: Floating offshore foundation, EDP.

Wind turbines are highly dynamically stressed structures with large numbers of load cycles, which lead to particularly heavy loads on the lubrication of gearbox bearings and gears. Oil changes and oil analysis have to be performed in a correct way. With the support of the Project Group dealing with the corresponding VGB Standard as well as of Dong Energy Wind Power a two-day workshop on «Oil Monitoring for Wind Power Plants» is scheduled to take place in Copenhagen on 7/8 November 2017.

User Groups Siemens and Vestas

Ulrich Langnickel

There is currently an intensive exchange of information and experience in the User Groups on specific technical issues – from foundations to rotor blades – relating to the wind turbines from certain manufacturers. The goal of the VGB member companies is to optimise the servicing and maintenance measures for the respective systems. For that purpose, in consultation with the member companies, a database of wind turbines has been created. The requirements and suggestions for improvements established jointly are being discussed with the manufacturers. These include in particular the application of the RDS-PP® reference designation system and the provision of the necessary documentation by the manufacturers. Access to the IT systems, however, also plays an important role.

TG HSE for Offshore Wind Parks

Karl-Heinz Puch and Guido Schwabe

The evaluation and communication of accidents are the main topics of the Technical Group «HSE for Offshore Wind Parks». This includes information on protection and safety concepts.

VGB contributed its expertise both to German Statutory Accident Insurance (DGUV) rules like DGUV 203-007 «Wind Energy Plants» and to the guidelines on «Diving in the German Exclusive Economic Zone».

Intensive work was carried out on a number of medical issues. Examples include the Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften e.V. (AWMF) guideline on medical fitness for offshore workers and the DGUV first aid information. Other topics are, for example, drinking water quality, hazardous substances and microorganisms.

Development of the «Offshore Wind Rescue Chain» is supported. This includes questions concerning the use of helicopters and ships (Figure 10) for rescue work, and telemedicine.

Content as well as concepts for initial and further training were addressed.

The Emden Workshop on Occupational Health and Safety has become a regular event and will take place for the eighth time on 1/2 September 2017.

TC Use of Renewables and Distributed Generation

Ulrich Langnickel

The Technical Committee (TC) «Use of Renewables and Distributed Generation» coordinates the activities of the three Technical Groups (TGs) «Biomass», «Biogas» and «Distributed Generation/Storage», and assesses the technical developments and application options of all forms of utilisation of renewables – with the exception of hydro power and wind energy – and of distributed power generation. In addition, the committee supports various national and international research projects and publishes position papers on the efficient use of renewable sources of energy.

In view of the vigorous expansion of renewables and distributed generation, the integration of these systems and the development and demonstration of storage technologies – e.g. batteries, power-to-gas and power-to-heat – will play a major role in the energy sector in future. Together with the associated technical challenges, the committee has also addressed the features of new business models. In this connection, the regulatory framework conditions for integration of storage technologies and the deployment of distributed generation technologies are being analysed in a research project on the international level which is coordinated by VGB. One important issue concerns the requirements for provision of control power.

TG Distributed Generation/Storage

Doreen Kückelmann

The Technical Group «Distributed Generation/Storage» assesses the technical and economic development of small combined heat and power plants (CHP) that are mostly based on conventional reciprocating engines, and of storage technologies. The group's work focuses on the system integration of fuel cell technology and of micro gas turbines and Stirling engines. These technologies enable combined heat and power generation even for units with a very small output, for instance for application in house heating systems, local heating systems and in the industrial sector. As the electricity grid develops, progress is monitored with regard to network expansion, demand management, virtual power plants, the smart grid, smart cities and IT security/communication both related to the grid and in stand-alone applications, and the results are used as the basis for discussion of further business models. The new



Fig. 10: New ships for offshore wind power operation
Source: Knut Gerdes, EMS Offshore GmbH, Emden VGB Workshop 2016.



Fig. 11: Absorption chiller installation at Karlsruhe GartenCarré as part of the joint research project «Field test on absorption chillers for CHP and refrigeration systems» sponsored by the German Federal Ministry of Economic Affairs (BMWi) (FKZ: 03ET1 171 A-D). Source: Stadtwerke Karlsruhe.

name of the TG, «Distributed Generation/Storage» reflects the even greater importance attached at VGB to the technical development of storage technologies in the complex system of distributed energy generation comprising generation, transmission, distribution and consumption.

Pumped storage power plants still provide the largest electricity storage capacity by far. Batteries, compressed air, heat storage, hydrogen and methane and the related services are however contributing more and more to the electricity grid and the energy system, facilitating greater flexibility in a low-carbon system. Both distributed and centralised power generation from renewables are still being expanded, increasing the demands for integration of the fluctuating renewable energy sources. Energy storage is a relevant option in network planning. It gives the electricity system advantages such as demand response, smart grids, flexible generation and reduced grid expansion. Storage facilities can be situated with the consumer, the producer or on the transmission or distribution system level. The location of the storage facility has a decisive influence on the business case and the choice of technology. Sector coupling could lead to further flexibility, which would facilitate improved integration of renewables in the electricity system. Energy storage is confronted with numerous regulations in the individual EU member states, and this fragmentation results in ineffective market integration. A reduction in the amount of administrative work required and the enabling of non-discriminatory grid access for energy storage would reduce the overall costs of the electricity system.

The German «Act on Digitisation of the Energy Transition» came into force on 29 August 2016. Electricity consumption will be recorded by smart meters in the near future.

In the past business year, the topics of «Smart City» and «Adsorption/Absorption cooling machines» were addressed. Smart city refers to intelligent solutions for a broad range of areas of urban development (infrastructure, buildings, mobility, services and security). The implementations are aimed, for example, at increasing energy and resource efficiency and improving the smart control systems in the urban areas, and also the quality of life of the residents. The objective is to increase the share of energy from renewables. The use of storage facilities plays an important role in this connection. As a result of the increasing complexity of the electricity supply system as a whole, a length of 1.3 million km in the distribution system has also to be modernised. The necessary adaptations can be supported by innovative IT solutions.

Producers of district heating suffer from low demand in the summer. New fields of business result from the desire to prolong the running times of the CHP plants. On this basis, the opportunity was discussed to have CHP plants running at higher temperatures in summer operation in order to feed the energy thus made available into absorption chillers. The TG examined the technical requirements, applications and limits to operation. An AGFW study from 2015 indicates, however, that the demand for cooling from district heating is only 1 %.

The absorption chillers «Bee» and «Bumblebee» (Figure 11) represent a more compact form of the otherwise robust and frequently expansive machines. The single stage absorption chillers function with water as the refrigerant and lithium bromide as the absorbent. With this combination of substances, heat input temperatures such as those provided by district heating systems and solar installations are sufficient. Cold water temperatures of around 5 °C can be produced. When suitably incorporated in the heating system, the chillers can also function as heat pumps for building heating. These systems are modular in structure and can be dismantled and reassembled at site when transport conditions are difficult.

In future, increasing dynamics in chillers will become more and more important. The aims of the research programmes also include low running temperatures and high re-cooling temperatures for applications in solar thermal plants in southern Europe and subtropical areas.

Biomass

Sebastian Zimmerling

An evaluation of the national action plans for the use of renewable sources of energy shows that, along with wind energy, hydro power and photovoltaics, the use of biomass plays an essential role in meeting the targets of the European Union for the year 2020. Currently, the VGB member companies operate biomass plants with a total electrical capacity of roughly 3,900 MW.

For 15 years now, VGB has provided a platform for the operators of biomass power plants to exchange experience on technical and environmental issues on an expert level. This takes place in the Technical Group «Biomass» and 33 further technical groups which intensively address technical, operational and environmentally relevant topics (Figure 12). At present, around 30 experts are working in the VGB Technical Group «Biomass».

TG Biomass

Sebastian Zimmerling

The Technical Group «Biomass» – jointly with the other relevant VGB committees and groups that deal with biomass – addresses technical issues related to the operation of biomass-fired power plants. The topics include the entire power plant process from fuel production, provision, and storage up to flue gas cleaning. They cover both purely biomass-fired plants and

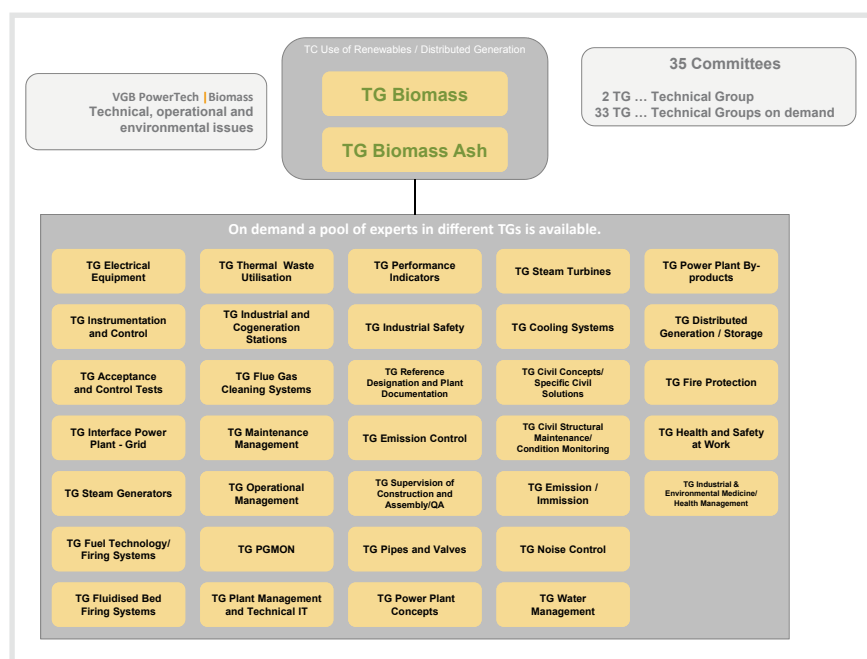


Fig. 12: Committee structure of VGB PowerTech | Biomass.

fossil-fired plants with biomass co-firing. The group also deals with measures required to convert fossil-fired power plant units to 100-percent biomass combustion. The topic of ash utilisation, in particular ash from biomass mono-combustion, is dealt with separately by the TG «Biomass Ash».

An important topic in connection with the surveillance of large biomass piles is the detection and location of hotspots. Due to the insulating properties of biomass, fires smouldering in large storage piles are only detected at a very late stage. In addition, the natural degradation processes inside the pile give rise to large amounts of carbon monoxide, and therefore the detection of this gas cannot be used as the sole indicator for the early detection of fires. With the support of the TG «Biomass» a research project was initiated to solve these problems. On the basis of a comprehensive market study, supplemented by a survey among operators, the identified technologies were presented in a final report with corresponding evaluations and details of conditions for deployment.

On the same subject, a research project sponsored by the German Federation of Industrial Research Associations (AiF) entitled «Analysis and Modelling of the Self-Heating Processes in Biomass Piles of Wood Chips» has been initiated. The project is being conducted as a multidisciplinary joint venture by the Institute of

Agricultural Engineering in the Tropics and Subtropics and the Institute for Microbiology of the University of Hohenheim, the Chair of Energy Systems and Energy Process Engineering of the Ruhr University in Bochum, and the Institute of Wood and Plant Chemistry of the Technical University of Dresden. Following successful completion of the project, a detailed picture of the relationships between the important biological, chemical and physical influencing factors on the self-heating of piles of wood chips will be available. Various experimental studies will permit an estimation of the propensity to self-heating of selected grades of wood chips, thus assisting in the concrete planning of storage processes and storage locations. A newly designed numerical open source model permits systematic incorporation of the influence of changing ambient conditions (humidity, temperature and convective flows) on storage in biomass piles.

In the TG Biomass, the results of a study on the effects of biomass co-combustion on the efficiency of flue gas desulphurisation and on the gypsum quality was presented. The study resulted from the warranty conditions of a flue gas desulphurisation system manufacturer, which permitted a co-firing rate of merely max. 5 % biomass. It was shown that with co-firing, while the K_2O levels in the flue gas rose, the SO_2 values were exclusively dependent on the main fuel, coal. On the basis of this study, it was possible to convince the manufacturer of the flue gas desulphurisation system to extend the service limits of the system to 15 % biomass co-firing.

In addition, it was demonstrated that the quality criteria for eurogypsum can also be maintained with a greater proportion of co-firing. In general, the selection of the fuel combination of a specific type of coal and a specific type of biomass is of decisive importance.

The Avedøre power plant in Denmark (Figure 13) was originally designed for the combustion of coal, natural gas and heavy fuel oil. Unit 1, for combustion of coal, went into service in 1990, followed by Unit 2 for combustion of natural gas and heavy fuel oil in 2001. Contrary to the original plan, which provided for additional combustion of hard coal in Unit 2, a separate straw-fired boiler was installed. In the course of the following years, the system was repeatedly modified and improved, with the result that both units can now burn 100 % biomass. The individual measures taken were reported and discussed many times at the meetings of the TG Biomass. Now that all the actions have been completed, an overview was presented and the plant, with all the individual modifications, inspected and explained.

TG Biomass Ash

Hans-Joachim Feuerborn

Biomass ashes are produced when biomass of any type is fired in grate-fired furnaces, fluidised bed combustion systems and dry-bottom furnaces, and when larger amounts of biomass are co-fired in coal-fired combustion plants. In some EU member countries the trend to more power generation using biomass is unbroken. In some countries, furthermore, the co-combustion of larger quantities in coal-fired plants is planned. The developments are mainly driven by political requirements,



Fig. 13: Avedøre Power Station
Source: Dong Energy A/S.

such as the stipulations on CO₂ reduction based on the Kyoto Protocol, the generation of «green energy», the initiative on the «circular economy» with which, among other things, organic waste is proposed for use as fertilizer, and the Sewage Sludge Ordinance with its requirements for recovery of phosphorus.

The Technical Group «Biomass Ash» deals with all topics related to the production, characteristics and use of biomass ash. The results of a questionnaire on fuel use, firing techniques and ash analysis, and on European and national standards, are being compiled in a status report and regularly revised and expanded. In addition, the results of basic research projects and application research projects are evaluated, and developments for use according to the standards and regulations are given intensive support. This concerns in particular the use as an aggregate in road building, as an ingredient in fertilizers, and for forest liming. The latest findings are discussed with interested professionals in workshops. At a workshop at the end of May 2017, attention focused on the work on development of fertilizers in the Nordic and north European countries, and in particular on forest liming and fertilizing. Attention was also paid to the legal and commercial aspects (Figure 14).



Fig. 14: Biomass ash workshop in Copenhagen, Denmark, 29.05.2017.

The applications for biomass ash in civil engineering and road building are based on technical and application-related standards and regulations, and also involve established certification systems. Over and above that, environmentally relevant requirements in the country of application are to be taken into account. These standards and regulations are subject to continuous development with the aim of incorporating new findings. In some countries, ash is created by the combustion of contaminated scrap wood and cannot be recycled as material, but requires secure disposal. In view of the relatively limited utilisation and disposal options for the ashes, attention now centres on the improvement of their quality through conditioning. Mechanical-miner-

alogical processes and chemical processes are both used for conditioning of the ashes. In these processes, either specific types of metal are obtained or enriched, or the surface condition is influenced in such a way that, among other things, the leaching properties of certain metals or metal compounds are reduced. Apart from that, the possibilities for phosphorus recovery play an important role. Co-firing in biomass furnaces not only has a favourable influence on the chemical composition, but also and especially on the homogeneity of the ash.

Biogas

Sebastian Zimmerling

Biogenic methane mixtures can be used for electricity and heat generation in small cogeneration plants. These plants currently achieve an electrical efficiency of as much as 45 % based on methane as the primary source of energy. However, the cost-effective operation of a biogas plant hinges on the possibility, in addition to electricity generation, of feeding the heat produced into local or district heating grids or putting it to some other alternative use. In Germany, according to the 2012 amendments of the German Renewable Energy Act (EEG) at least 60 % of waste heat has to be utilised.

As a further possibility, biogas also can be conditioned and fed into the natural gas grid. It can be stored temporarily and then systematically used at locations which have a heat sink. The treatment and feeding of biogas into the existing natural gas grid can be considered the decisive advantage of this technology with a view to integrating renewables into existing networks and utilising existing storage potentials.

Currently some 22 biogas feed-in plants are operated by VGB member companies. In the VGB Technical Group «Biogas», at present nine group members from eight member companies in Germany and Belgium actively deal with the widest range of topics relating to biogas generation and cultivate an intensive exchange of experience.

TG Biogas

The optimisation of operation and maintenance is the current core topic of the TG «Biogas», and consequently two plants



Fig. 15: Research biogas facility at the German Biomass Research Centre (DBFZ) Source: DBFZ.

were visited by members of the Technical Group, followed by detailed discussions of their special technical features.

The Bergheim-Paffendorf biogas plant went into operation in early 2016, and feeds conditioned biogas into the local natural gas network. The biomethane can be used for electricity or heat supply to around 3,300 households. The plant input comprises a broad range from the regional farms, including grass and maize silage, perennial rye, sugar beet and alfalfa. New energy crops like cup plants and wildflowers are also being tried in the plant. The technical challenge at this plant is therefore mainly that of the complex logistics both in delivery and storage and in feed to the plant itself. Furthermore, the plant is a test location for an organic solar film. This film, in contrast to conventional photovoltaic modules, is millimetre-thin, light and flexible.

The research biogas facility at the German Biomass Research Centre (Figure 15) consists of two independent plant lines of identical capacity. In principal, the plant can be operated in one or two stages with optional hydrolysis. Special attention was paid to the flexible configuration of the system, and this was achieved by means of a complex pipe network which permits any fermenter combination required. In connection with its semi-industrial scale, the design of the plant allows the investigation of relationships which could not be observed in this way in the laboratory. At the same time, critical operating modes and load conditions can be simulated at the plant, which is not possible in industrial scale facilities owing to the associated commercial risks. A tour of the plant was conducted, and the various possible operating modes and test scenarios were explained in detail.

Competence Area

Environmental Technology, Chemistry, Safety and Health

TC Environment	C: A. van Damme A: S. Göhring
TG Emissions/Immissions	C: Dr. F. Söllenböhmer A: S. Göhring
TG Noise Control	C: K. Knörzer A: S. Göhring
TG Water Management	C: N. N. A: Dr. D. Rutschow
TG Power Plant By-products	C: Dr. D. Brosch A: Dr. H.-J. Feuerborn T. Eck
TG By-products of Waste Incineration	C: W. Schmidt A: K.-H. Puch/ Th. Eck
TG Emissions Monitoring	C: F. Blank A: S. Göhring
TC Chemistry	C: W. Hoffmann A: Dr. A. Wecker
TG Chemical Process Engineering	C: Dr. J. Fahlke A: Dr. D. Rutschow
TG Analytics	C: Dr. M. Hein A: Dr. A. Wecker
TG Chemistry of Light Water Reactors	C: Dr. T. Stoll A: Dr. D. Rutschow
TG Emission Control	C: Dr. F. Fogh A: Dr. A. Wecker
TC Health & Safety (H&S)	C: R. Waumans A: K.-H. Puch G. Schwabe
TG Fire Protection	C: S. Schwenker A: S. Zimmerling
TG Health & Safety at Work	C: Dr. R. Wieder A: K.-H. Puch G. Schwabe
TG Industrial and Environment Medicine/Health Management	C: Dr. T. Schnabel A: Dr. L. Jentjens
TG Health & Safety for Offshore Wind Parks	C: N. N. A: K.-H. Puch
IC Climate and Environmental Protection *)	C: Dr. B. Viertel A: Dr. A. Wecker
ICE Climate Protection	C: A. Nolden A: S. Göhring
ICE Greenhouse Gas Monitoring	C: Dr. J. Altenburg A: S. Göhring
ICE Systems Planning and Licensing	C: Dr. W. Konrad A: Dr. A. Wecker
ICE Water and Soil Conservation	C: B. Viertel A: Dr. D. Rutschow
ICE Waste and By-products	C: H.-D. Kehrman A: T. Eck
ICE Dangerous Goods/Chemical Agents	C: N. N. A: K.-H. Puch Dr. D. Rutschow

TC Technical Committee
TG Technical Group
IC Integrated BDEW/VGB Committee
ICE Integrated Committee of Experts jointly with BDEW

The tasks and results of the Working Panels «Health & Safety at Offshore Wind Parks» and «Biomass Ash» are described in Chapter 2 «Renewables and Distributed Generation».

TC Environment

Sven Göhring

Reports on developments important to power plants in the individual member states and companies as well as the exchange of experience were the main activities of the Technical Committee. Constant observation of the developments in other member states provides, inter alia, the possibility to prepare for requirements which may have to be met by domestic companies. Solutions identified by foreign member companies in this connection may be of benefit at home.

The conclusions of the BREF LCP which have now been adopted and their possible implementation in the individual countries constituted a major topic at recent meetings. It became clear in this connection that different methods of implementation in different countries are conceivable. In the stipulation of emission limits in particular, there will be various approaches within the specified range of limits.

A further topic in the exchange of experience was the implementation of ISO 50001 in the members' companies. There will also be a VGB workshop on this topic in June 2017, at which the issue is to be discussed in greater detail with the member companies.

TG Emissions/Immissions

Sven Göhring

One of the main topics of the work at the Technical Group was the BREF LCP conclusions as published by the Seville office. An issue which was discussed in detail in this context was the demands placed on Hg monitoring with low limits.

A further topic which the Technical Group addressed in detail was the revision of the German Hazardous Incident Ordinance (StörfallV). The implementation of the EU's Seveso III Directive took place in Germany by publication of the 12th Federal Pollution Control Ordinance (12. BimSchV) in January 2017. The members of the group shed light on the fundamental changes

to the Hazardous Incident Ordinance, for instance the new substance classifications resulting from adjustment of the substances list to bring it in line with European chemicals law (CLP Regulation). In addition, the 12th Federal Pollution Control Ordinance also contains more extensive stipulations concerning the «neighbourhood» and public information. This and further potential effects of implementation of the Seveso III Directive will require further action by many of the members.

The Technical Group is planning to conduct a VGB workshop on «Emission Monitoring» in 2018. The workshop is to take place in Essen in February 2018, and further information will be provided in due course.

TG Emissions Monitoring

Sven Göhring

The Technical Group on «Emissions Monitoring» continues to deal intensively with CEN standardisation activities, usually through the participation of TG members in the CEN working groups (WGs). Thanks to the liaison of the VGB Offices with CEN, representatives of member companies can be nominated for membership of the WGs. This is an important opportunity to orient the European standards towards operational practice and adjust them to reflect the circumstances in the industry.

An important focal area addressed by the Technical Group is the performance and support of research projects in the field of emissions monitoring. The research project «Benchmark E-PRTR emission reporting» is approaching completion and the final report is to be adopted and published in the near future. A second research project by the TG will be initiated in the coming weeks. Within that new project, the members of the Technical Group will deal with the topic of «Statistical Guidelines for Emission Compliance Evaluation» One of the aims of the work is to reconcile the uncertainty requirements with the performance of emissions monitoring.

A poll of the members was conducted as part of the work of the Technical Group, in which the national emission factors for PM_{2.5} and PM₁₀ were recorded. On the basis of that poll, the Group will decide whether it will embark on a revision of the VGB/Eurelectric Recommendations of 2010 on the subject of E-PRTR.

TG Noise Control

Sven Göhring

One of the main topics in the Technical Group's discussions was the draft amendments to the Sixth General Administrative Regulation on the Federal Pollution Control Act (Technical Instructions on Protection against Noise – TA Lärm).

The amendment to the TA Lärm provided for in the draft firms up the requirements to be fulfilled by the operators of plants covered by immission protection regulations to avoid harmful effects on the environment caused by noise, when noise from that plant impinges upon an «urban area». The current TA Lärm in force does not contain any guideline values for this new territorial category.

The revised TA Lärm is planned to come into force before the start of the summer vacation.

A further focal area in the work was the subject of construction noise. Methods of dealing with brief noise peaks during the day were of particular interest. A majority of the members use the General Administrative Regulations on Construction Noise (AVV Baulärm) for the required immission forecasts. As an alternative, TA Lärm is also used as a basis, and increases the guideline value for noise peaks by 30 dB (A). The Group points out that attention should be paid in advance to the potential construction noise arising in connection with the impending dismantling of various plants.

The participants in the Group agreed that a further VGB Workshop on the topic of «Noise Abatement in Power Generation Plants» should take place in 2018. The venue is to be the premises of the PowerTech Training Centre in Essen. The final quarter of 2018 is being considered as a possible date for the event.



Fig. 1: Resource potential of the by-products from waste incineration
Source: Kuchta, VGB Workshop, Hamburg 2016.

TG Power Plant By-products

Hans Feuerborn and Thomas Eck

The Technical Group «Power Plant By-products» essentially dealt with regulatory requirements related to the production and utilisation of power plant by-products. In the period covered by this report, special emphasis was placed on:

- The German Administrative Provisions on Technical Building Rules (Verwaltungsvorschrift Technische Baubestimmungen – VV TB) including its requirements on Constructions (ABuG). These give rise to changed constraints for the use of fly ash and bottom ash in concrete, and will have a decisive influence on their use if not actually making it impossible.
- The new Best Available Technique Reference Document (BREF) with requirements for emission limits and state of the art technologies and their influence on the quality of power plant by-products and opportunities for their use.
- The German Substitute Building Materials Ordinance with stipulations on the use of secondary raw materials in unbound earthworks and roadways. In spite of the adoption of a number of comments in the most recent draft, it will only be possible to use power plant by-products under more stringent conditions when the ordinance is introduced, and their use in unbound layers will no longer be possible.

In addition, the group addressed European and national rules and regulations and their application:

- The incorporation of requirements for the environment, health and hygiene (BWR3) in the European product standard EN 450-1 for fly ash for concrete.
- The revision of the European testing standards EN 451-1 (Determination of free calcium oxide content of fly ash) and EN 451-2 (Determination of fineness of fly ash).

- The regulations of the German Road and Transport Research Association (FGSV) with regard to the use of bottom ash in rural roads and pathways.
- The preparation of FGSV terms and conditions for the delivery of fly ash for road construction.
- Risk modelling in the context of the toxicological assessment of gypsum and gypsum products on the basis of a new exposure scenario.
- Registration under the European chemicals regulation (REACH) together with the updating of registrations dossiers.

As part of the group's application-oriented research projects were ordered to continue durability tests on concrete containing fly ash and also new research subjects (alternative pozzolanicity test, production of special clinker with hard coal and lignite fly ash, and the leaching behaviour of bottom ash).

TG By-products of Waste Incineration

Karl-Heinz Puch

The Technical Group «By-products of Waste Incineration» mainly works on the following topics:

- Support in and critical assessment of the development of standards for the recycling/disposal of mineral waste (German Framework Ordinance Introducing the Substitute Building Materials Ordinance, Landfill Ordinance, Waste Catalogue Ordinance, Road and Transportation Research Association (FGSV) Code of Practice on «Bottom ash from incineration of municipal waste»).
- Further support for the revision of the BREF for Waste Treatment and Waste Incineration with the German Environment Agency UBA.
- Classification of bottom ash from incineration of municipal waste in accordance with the Waste Catalogue Ordinance, taking special account of

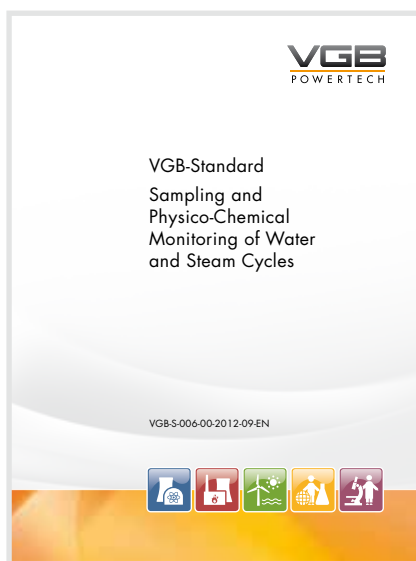


Fig. 2: VGB-Standard «Sampling and Physico-Chemical Monitoring of Water and Steam Cycles» VGB-S-006-00-2012-09-EN.

the «HP» (hazard property) criteria on the basis of the Confederation of European Waste-to-Energy Plants (CEWEP) Bottom Ash Dossier and the legislation on hazardous goods. Assessment of the harmfulness of the bottom ash.

- Handling of incineration residues in Germany and Europe – the market for bottom ash from incineration of municipal waste.
- Research into other possible applications for bottom ash from incineration of municipal waste apart from road building.
- Support of current projects, e.g. on nanoparticles in bottom ash and flue gas cleaning residues or hydrocarbons.
- Support of current projects on new methods for treating bottom ash and flue gas cleaning residues, e.g. wet treatment processes.
- Drafting of a recommendation to members as to how bottom ash is to be classified on the basis of the changed legal situation (CLP).

Separating and recycling the metal fractions from the by-products is an overriding objective (Figure 1). However, this has a considerable impact on the properties of the remaining mineral fraction as building material. Metal recycling stands or falls with the metal prices.

Recycling aspects were examined at a workshop and complemented by additional current issues. The event took place in Hamburg on 17 November 2016.

TC Chemistry

Andreas Wecker

The Technical Committee «Chemistry» had suggested that VGB should play a more active part in the international work on the chemistry of the water-steam cycle, in order to make VGB Standards better known internationally. One means of doing so is membership of the «International Association for the Properties of Water and Steam» (IAPWS). At the international conference in Dresden in November 2016, the membership of VGB, which also applies to the German National Committee, was accepted. IAPWS issues guidelines on the water-steam cycle and also performs fundamental research on that subject.

As a result of reorganisation, retirement and outsourcing, staffing of chemistry departments in the member companies is being continuously reduced, with the result that existing knowledge is being lost. The Technical Committee wanted to counteract that development with an online manual, «Chemistry in Power Plants», and had already taken the first steps. Owing to the lack of capacity for the establishment and updating of such a database, however, further work was put on hold for the time being.

Within the TC Chemistry, the current issues of legionella and mercury capture in the flue gas treatment process were also discussed and results exchanged.

A new VGB Standard on metering systems is currently in preparation. It is intended to provide recommendations for the correct positioning, design, instrumentation and servicing of metering systems in the water-steam cycle. It represents a sup-

plement to the existing VGB Standards S-010-T-00;2011-12-EN, «Feed Water, Boiler Water and Steam Quality for Power Plants/Industrial Plants», and VGB-S-006, «Sampling and Physico-Chemical Monitoring of Water and Steam Cycles» (Figure 2 and Figure 3).

The last conference, «Chemistry in Power Plants 2016», took place in Karlsruhe. The topics covered the fields of the water-steam cycle, flue gas treatment, water treatment and analytics (Figure 4).

TG Analytics

Andreas Wecker

The Technical Group is currently working on the completion of a VGB Standard on analytical methods in power plants, so as to bring the Analysis Manual of 1996 up to date. In the course of this work, all the analytical procedures are checked and obsolete instructions removed. The descriptions of standards which are now available in every laboratory are being removed, and only quotations retained. Where aspects specific to power plants are to be taken into account, supplementary notes are provided. Analytical methods are updated where necessary (Figure 5). The VGB Standard will cover all the matrices which are analysed in the laboratories. This applies in particular to fuel analysis.

Similarly to VGB Standard VGB-S-302 on the standardisation of conditions for activity testing of DeNOx catalysts, a new VGB Standard is currently being compiled for mercury oxidation catalysts.



Fig. 3: Sample conditioning acc. VGB-S-006-2012 (flow indication, constant pressure regulation).



Fig. 4: VGB Conference «Chemistry in Power Plants 2016».

TG Chemical Process Engineering

Dittmar Rutschow

PG Microbiology in Cooling Towers

The Project Group «Microbiology in Cooling Towers», which consists of members of the TGs on «Cooling Technology in Power Plants» and «Chemical Process Engineering», has continued to play an active part in the shaping of the 42nd Federal Pollution Control Ordinance and the drafting of VDI Standard 2047, Part 3. The Ordinance stipulates the hygienic requirements for the operation of evaporation cooling systems, and in particular the permissible legionella concentrations in the cooling water and the required microbiological monitoring. There, a distinction was reached between «evaporative cooling systems» (e.g. in building services, air conditioning or industrial facilities) and «cooling towers > 200 MW» which predominate in power plants. Cooling towers are permitted to have a higher legionella concentration in the cooling water. This enabled an indirect incentive towards the use of biocides in many power plant cooling systems to be avoided, as this would have been unnecessary for health reasons. The technical foundation stone was laid in the form of VDI Standard 2047, Part 3, published as a draft in February 2017, on «Securing the hygienic operation of natural ventilation cooling towers over 200 MW», in which the members of the TG Cooling Technology and the PG Microbiology in Cooling Towers played a decisive role.

Further measurements on legionella concentrations in cooling tower vapours and examinations of cooling water specimens and various deposits in cooling systems are to be performed in summer 2017 in the context of a VGB research project, which is to be managed by the PG Microbiology and completed by the end of 2017. A comparative study is to be performed on the actual legionella emissions from power plant cooling towers

with two different sampling methods and strategies developed for ensuring safe hygienic operation of evaporation cooling systems, where possible without the use of biocides.

PG Cooling Water Standard

Further progress has been made on drafting of the cooling water standard. A number of passages still have to be revised. VGB has already conducted a survey in this connection for the next meeting, which is planned to take place in June. Two of the gentlemen from the TG «Chemical Process Engineering» will support the project group in future. It is envisaged that the standard will be complete by the end of the year, so that it can go into print in the coming year.

Instruction Sheet VGB-M 405 G – «Water Demineralisation by Ion Exchangers»

The last draft of the instruction sheet was proofread by the TG «Chemical Process Engineering», and a number of amendments were proposed, with the majority of these being included in the instruction sheet. VGB will make the editorial changes so that the instruction sheet can be printed as a VGB Standard at the end of the year.

TG assistance to the PG Preservation Guidelines

A member of the TG Chemical Process Engineering has provided support as a member of the PG «Preservation Guidelines». A number of questions arose within that group, and were addressed by the TG. The project group successfully completed the preservation guidelines with the professional support of the Technical Group.

Draft BREF on the subject of mercury

According to the members of the Technical Group on «Chemical Process Engineering», it is only possible to comply with part (the upper values) of the values for mercury in FGD system waste water (0.2 to 3 µg/l) listed in the draft BREF. Compliance with the lower values is, however, problematic for the existing plants, as they cannot at present achieve these limits. The analysis methods permit a detection limit of 0.5 µg/l in saline waste water, and in exceptional cases 0.2 µg/l can be achieved. As a result of the high salt content, the waste water would have to be diluted for analysis, which would also impair the detection limit. It was mentioned that the lower limit was included in the BREF paper as a result of incorrect measurements at a plant.

Dr. Fahlke will compile a table of the mercury levels in the individual plants and distribute the table to the members of the TG.

The issue of mercury is to be added to the agenda for the next meetings, so that the members of the TG have the opportunity to report on their experiences and problems with this topic.

Exchange of experience on FGD waste water treatment systems

At the end of last year, the operators of 2-stage FGD waste water treatment systems met for a joint exchange of experience. The meeting was organised by Mr. Chiovaro of Evonik Technology & Infrastructure GmbH. A further meeting is planned for this year, at which once again the operators of FGD waste water treatment systems will exchange information and details of their experience. The exchange of experience is not to be limited to 2-stage systems at that meeting, but will cover all systems.

TG Chemistry of Light Water Reactors

Dittmar Rutschow

Preservation in the shutdown state

A nuclear power plant in the Netherlands went on line in 1973. With various updates, it has now been running for 44 years, and is planned to remain in service until 2032. The power plant will then have been in operation for a total of 60 years.

The nuclear power plant complies with the VGB Guideline for H-AVT operation in the secondary system. The feedwater



Fig. 5: Magnetit and Hämatit suspension.

contains >0.020 mg/kg hydrazine (in accordance with the VGB Guideline). The maximum approved output is 10 kg/a. During long downtimes, the steam generator and the feedwater tank are preserved with hydrazine.

During inspections from 2017 onwards, film-forming amines are prospectively to be used for the preservation and conditioning of the secondary circuit components, so as to reduce the hydrazine consumption and make external disposal of hydrazine during plant downtimes unnecessary.

The members of the Technical Group reported from their plants that during inspections and long downtimes, dry preservation is frequently used for the steam boiler. Hydrazine is also used for steam boiler preservation.

Revision of Guideline 401

VGB Guideline R 401, which consists of a PWR section and a BWR section, is currently being revised. The members of the TG «LWR Chemistry» have formed two project groups to revise the individual parts of the Guideline.

Members of the TG have proposed that a background paper on the Guideline could also be compiled, in which the experience with power plant chemistry related to KWU plants (preservation of know-how) could be set down. The members of the TG unanimously voted in favour of compiling the background paper. VGB is to create a distribution list and set out a project application with Dr. Stoll, so that the TC «Nuclear Power Plant Operation» can vote on the proposal by the TG.

UV treatment of cooling water

Within the TG «LWR Chemistry», a company delivered a presentation on the topic of «UV treatment of cooling water». With the aid of UV radiation, it is already possible to disinfect various water flows in hospitals, hotels, spa facilities and cooling towers. The function of new UV lamps was compared and contrasted with those of conventional UV lamps. The aim is to protect the main cooling water and therefore the water in the cooling tower from biofouling, and prevent the growth of legionella, mussels and algae. UV treatment can replace the use of disinfectants.

QP database

Programming of the QP (Quality-tested Products) database is complete, and VGB has already awarded the administrator

rights, allowing the successful applicants to enter and modify data in the database. The administrators have already entered 500 products in the database, and therefore the total number of records in the database is at present approx. 1500. The quality assurance for the database itself is to be performed by VGB. There is also an opportunity to have samples analysed in the VGB laboratory. A corresponding offer from VGB is already available to the members of the TG «LWR Chemistry». 50 specimens have already been sent to the VGB laboratory for testing. The analyses are necessary in order to assess and approve products for the database as required by DIN 25493.

FSD 2016 in nuclear power plants

From September to November, an FSD (Full System Decontamination) was performed at a nuclear power plant. The FSD was performed with the HP CORD UV process developed by AREVA (Figure 6). A very good decontamination result was achieved with a very small quantity of secondary waste. The dose rate values of the decontaminated components were significantly below the expected levels. The average decontamination factor was 139.

Current status of DIN 25493 – Correction of dosage limits for seals of FKM/FFKM

PreussenElektra had submitted an application to DIN for correction of DIN 25493 in the 2015 issue. That DIN standard replaced the previous issue of September 1997. In the new DIN standard, the section on «Seals», which contained a table of polymers containing halogens, was revised. That table also included the materials FKM and FFKM, for which the guideline value for the permissible radiation does in

Gy was reduced by a factor of 100. According to the table in DIN 25493, it was noted that there are no secure findings with regard to the release of fluorine for FKM (fluororubber). For FFKM (perfluorinated rubber), at a radiation dose of 10,000 Gy, there is no greater hazard potential from the release of fluorine. For these reasons, the materials FKM and FFKM have been restored to 10,000 Gy in the DIN table.

TG Emission Control

Andreas Wecker

Besides exchanging experience, the European Technical Group also in and particular prepared for and conducted the workshop «Flue Gas Cleaning 2017» in Lisbon. To involve the participants in an even deeper dialogue, at the end of the event a round-table discussion on several key issues was offered and met with interest.

The level of knowledge on the topic of mercury differs between the individual countries. Some countries still have no limits, and therefore the current level of emissions will first have to be ascertained before suitable measures for reduction can be selected. The VGB Initiative «Hg^{cop}» can assist with information in this respect (Figure 7 and Figure 8).

The installation of denitrification catalysts is causing problems in some countries with increased SO₃ formation under adverse flow conditions in the catalytic converter. There is a host of experience on this issue in Denmark and Germany, which may be of assistance in the selection of further measures.

If the emission bandwidths from the BREF LCP as published in the draft are to be achieved, many plants in Europe will re-

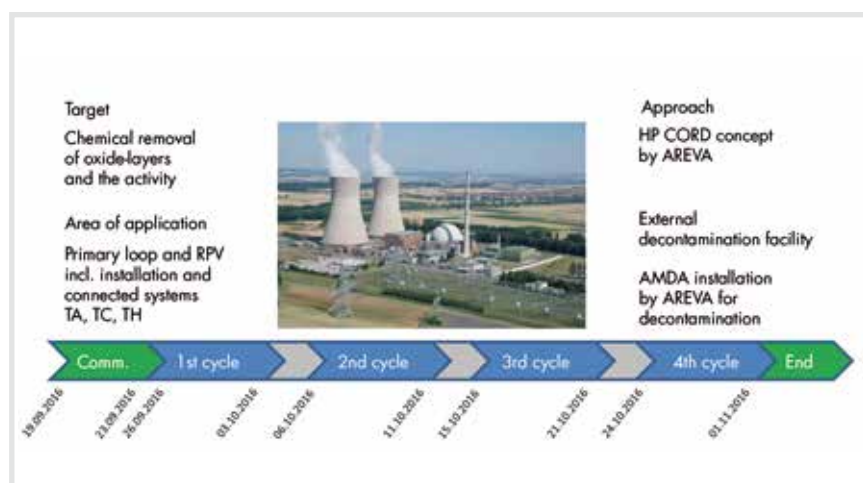


Fig. 6: Full system decontamination performed with the HP CORD UV process developed by AREVA.

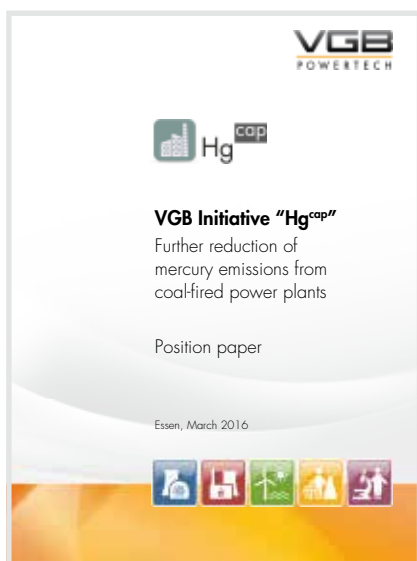


Fig. 7: $Hg^{capture}$, Position Paper.

quire retrofitting, especially for denitrification. Various opportunities for primary and secondary measures are being discussed here and were presented at the workshop.

In several countries, a move from coal to biomass combustion is currently taking place. The problems which result for flue gas cleaning are under discussion.

TC Safety & Health at Work

Karl-Heinz Puch

The definition and interpretation of key performance indicators (KPIs) is a central topic in the field of health and safety. There is a need for an indicator that is unambiguously defined and internationally comparable. The Technical Committee «Safety & Health at Work» has therefore decided in favour of lost time injury frequency (LTIF). This is the number of accidents with lost time of one day or more per one million hours worked. The advantage of this most frequently used definition is its lack of ambiguity. Neither presentation to a doctor, nor various stages of unconsciousness, nor measures beyond first aid require a more exact definition. In contrast, the accident-induced absence on the day following the accident (and longer) is very clear. Referring to the hours worked rather than the number of employees makes better sense since the hours worked differ internationally by as much as 20 percent (Table 1).

The accident rates of contractors are significantly higher than those of in-house employees. To counteract this trend, among the methods, safety walks, awards, safety talks and safety briefings are used.

As before, other topics include internal structures, the role of management, and the relationship between safety at work, health protection and Human Resources, stress management and work/life balance.

Accidents and the methods of investigation employed feature highly in the work of the committee.

TG Fire Protection

Sebastian Zimmerling

The activities of the Technical Group «Fire Protection» focus on the optimisation of fire protection in conventionally fired power plants, biomass-fired power plants and, in cooperation with the Technical Committee «Wind Energy», wind power plants.

The existing VGB guideline VGB-R 108 «Fire Protection in Power Plants» has been the subject of further discussion ever since its publication in 2009. The revision of this guideline by a Project Group and its republication as VGB Standard VGB-S-108 is to be completed by the end of 2017. Specific sections are being revised in cooperation with other VGB committees and groups, an example being the section on «Fire Protection for Transformers» together with the PG Transformers.

The project group that is preparing the VGB-Standard «Fire Protection in Wind Power Plants» in cooperation with the Technical Committee on Wind Energy will send the first draft of the document to a selected group of experts by autumn 2017 with a view to receiving their comments. Similarly to the compilation of a fire protection strategy, all the points relevant for licensing have been described and adjusted to reflect the special features of wind turbines. The VGB-Standard will therefore both describe the issue in its entirety and recommend concrete options for protect-

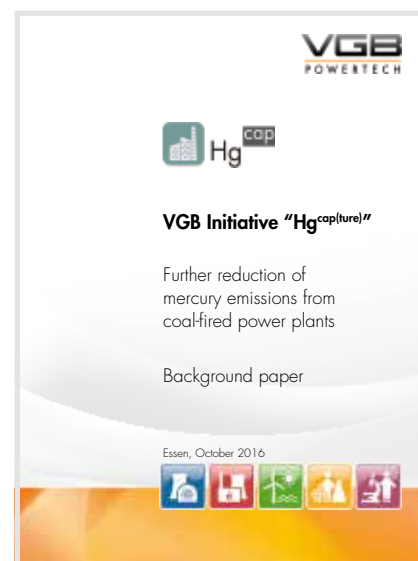


Fig. 8: $Hg^{capture}$, Background Paper.

ing wind power plants and individual components against fire hazards. Publication is scheduled for the end of 2017.

Apart from the general committee work, current changes in explosion protection were presented and discussed. In power plants, not only fuels (coal/pulverised coal, biomass in dust form, gas and certain liquid wastes) are used, but also working materials (such as welding and cutting gases, filter dust and combustible liquids) which can form hazardous, potentially explosive atmospheres either as a result of their material properties or when mixed with air as a result of the process in which they are involved. Since 2013, the entire regulatory framework of explosion protection has been gradually revised and harmonised. All the changes to date, starting with the ATEX Directive, through the German Ordinance on Industrial Safety and Health and Ordinance on Hazardous Substances, to the Technical Regulations

Parameter	Definition	Total/ Average
Fatalities Employees	Number of fatalities	5
Fatalities Contractors		20
LTIF Employees	The sum of work related injuries resulting in lost workday cases or permanent total disabilities, excluding restricted work cases/job transfers and medical treatment cases; per 1,000,000 hours worked.	1.27
LTIF Contractors		1.46
LTIF Combined		1.39
TRIF Employees	The sum of work related injuries/occupational diseases resulting in fatalities, permanent total disabilities, lost workday cases, restricted work cases/job transfers (including medical treatment cases, excluding first aid); per 1,000,000 hours worked.	3.36
TRIF Contractors		6.26
TRIF Combined		5.18

Tab. 1: KPI Report for 2016 (based on input from all members).

on Industrial Safety and Health, the Technical Regulations on Hazardous Substances and the regulations of the employers' liability insurance organisations, were presented and their effects on fire and explosion protection in power plants discussed. Important aspects include for example the transition of explosion protection from the regulations governing industrial safety and health to those governing hazardous substances, clarification of zone definitions and in particular the temporary occurrence of zones with explosion hazards, and the expansion of the definition of explosive mixtures, substances, preparations and products to include non-atmospheric conditions.

TG Industrial and Environmental Medicine/Health Management

Lena Jentjens

One permanent item on the agenda for the six-monthly meetings of the Technical Group is the development of the influenza season. Reports on experience with various vaccines are exchanged and the procedure in the event of a pandemic is discussed. Like the 2015/2016 season, the 2016/2017 season has shown a normal development. The practice index is used as a parameter to monitor the regional influenza activity (Figure 9).

Appropriate leadership is a main factor for employee satisfaction and health. Measures and reports on experience with «Leadership and health» have been recurrent topics of our meetings. Recently, the programme launched by RWE in this regard was presented and discussed.

Furthermore, «Live working» was an important topic. The «Recommendations on medical fitness of staff for live working» published by the ETEM employers' liability insurance association specifies the medical fitness criteria for persons performing work on live systems in accordance with DGUV Standard 103-011 published by the German Social Accident Insurance (DGUV); however, experience shows that most workers performing work on live equipment are not examined in accordance with this standard but only in accordance with the Ordinance on Occupational Healthcare (ArbMedVV).

The risks associated with mercury could recently be seen and were discussed on the example of a small company with about 10 employees. On a Friday afternoon, a worker discovered a mercury spill and called the fire brigade. This resulted in a large scale operation involving 27 fire brigade vehicles, 50 firemen, police officers and officers from the factory inspectorate. Clearance measurements were ordered to be performed for the entire place and a screening was required for all employees. The operation took two weeks and cost more than 100,000 €.

Another topic dealt with by the TG was the implementation of the Preventive Healthcare Act (PrävG) adopted by the German Parliament on 18 June 2015. The health insurance funds will step up their investments in health promotion and preventive healthcare. Some measures have already been launched, but no framework agreement on preventive vaccination has yet been concluded. As the Federal Association of Health Insurance Funds considers itself unable to conclude such a framework agreement, each health insurance fund will have to negotiate a contract with each individual practitioner. It is not yet clear how this is supposed to work in detail. Against the background of the forthcoming general elections in Germany, a result cannot be expected before summer 2018.

TG Medical Scientists at Nuclear Power Plants

Lena Jentjens

The central topic of the TG «Scientists at Nuclear Power Plants», which meets once each year, is the exchange of experience with reports from occupational healthcare practice.

At present, the TG is following up on developments related to the new Radiation Protection Act enacted in Germany, which was recently published in the Federal Gazette.

Health promotion measures are becoming ever more important in daily occupational healthcare practice and have thus ranked high on the discussion agenda.

Every year the employers' liability insurance association records about two or three fatalities caused by electric shock. In this context, distraction is the main risk, and distraction by mobile phones has been found to be a major source of danger. The TG intensely discussed measures resulting from the analysis of such and other accidents.

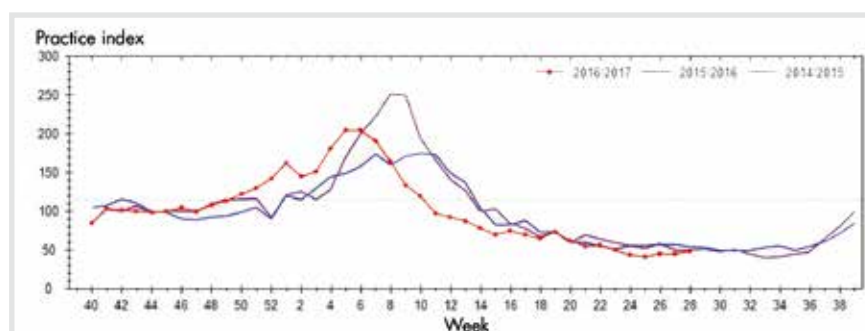


Fig. 9: Influenza activity. Influenza Working Group at the Robert Koch Institute.

Technical Services

Technical Services/ Engineering Consultancy

Christian Ullrich and Oliver Then

The cooperation between the various departments within the VGB Secretariat and the involvement of the VGB network of experts has allowed the high level of expertise of many individual employees of the member companies to be used to the benefit of all VGB-members. In that way it has also been possible to resolve even extremely complex issues. The range of services available covers all areas of energy and power plant engineering. VGB's most prominent fields are as follows:

- Engineering consultancy in the planning, construction and operation of power plants
- Interdisciplinary damage analysis (root cause analysis)
- Materials testing
- Water chemistry examination
- Supervision of construction and field erection, including quality management and expediting

Engineering Consultancy

The fundamental reasons for appointing VGB to perform consultancy and analysis functions are the professional expertise available within VGB, its vendor independence and consequently its role within the industry which is perceived to be similar to that of an independent expert. The function of consultancy as a means to gain new members is also not to be underestimated. The following examples are intended to illustrate the variety of tasks undertaken in the period under review:

- Risk- and hazard analysis for different types of boilers.
- Damage assessment of different types of boilers in Germany and abroad.

- Assessment and review of different types and causes of damages to steam and gas turbines with a broad range of capacity and operation modes; among others, curved housings, damaged blades and axial bearings.
- Optimisation of the operation of turbines to prevent curving of housing and the resulting vibrations.
- Regular peer reviews within the scope of the erection and commissioning of various new build projects by an international VGB member company
- Performance of risk and hazard analysis (Safety Integrity Level, SIL) for the boilers at a chemical site

Maintenance

When major inspections are performed on steam turbines, it is repeatedly observed that errors have been made in the planning and tendering for these inspections. Either necessary work was not listed, and had to be carried out later resulting in additional costs, or no quotations had been obtained for optional work. This opens the floodgates for maintenance contractors claiming high additional charges.

These deficits were recognised by one of our member companies. Jointly with the consultancy department of VGB PowerTech, a bespoke bill of goods and services was formulated for the existing turbine, and is to serve as a basis for future tendering processes. If only a small or medium inspection is planned, the specification can be abridged accordingly.



Fig. 1: The scanning electron microscope (SEM) of the VGB Technical Services.

Turbine condenser

Deposits and corrosion in cooling tubes of turbine condensers and other heat exchangers can be detected and investigated by endoscopic examinations. In several cases, inspections have resulted in the introduction and verification of special cleaning measures or changes in the operating modes of tube cleaning systems. Losses of turbine output have thus been stopped and cooling tube corrosion eliminated, avoiding tube leakage. In one case it was also found that apart from lime deposits which had not been completely removed, air was also entering into a leaking preheater flange at the condenser and was also responsible for output losses. VGB located the air entry point with a special CO₂ leakage detection method.

Steam generators

In the optimization of a power plant site with three thermal power plant units, the main task was independent and neutral engineering consultancy with regard to establishing high level benchmarking of the three units in the areas of generation and logistics, and engineering and maintenance. The technical processes of the single units were assessed and the entire plant was investigated to identify potential for improvement and optimization. The existing steam networks (5 steam systems with pressures of 100 bar to 1.5 bar) were checked in parallel for possible improvements.



Fig. 2: View of the diffractometer for analytics of the VGB Technical Services.

Damage investigations were carried out for five biomass-fired combined cycle power plants. This also involved fuel sampling and laboratory examinations of the tube materials. This holds potential for the future, because insurance companies have hardly any damage engineers of their own. Together with the VGB materials and water laboratory, we are well positioned to assess even highly complex damage cases and to carry out laboratory investigations (a unique feature of VGB PowerTech).

Materials Laboratory

In the period under review, around 250 damage cases were investigated with state of the art laboratory equipment by the VGB materials laboratory. The scanning electron microscope (field emitter) and the X-ray diffraction system are worthy of special mention.

Together with determining the cause of the damage, in most cases the laboratory staff managed to develop solutions jointly with VGB member companies in order to reduce damage occurrence in future. This objective is also achieved through the close exchange of information with the departments of water chemistry, supervision of construction and assembly and the experts in the power plant technology department, and intensive use has once again been made of that cooperation in the period under review.

Apart from damage investigations, numerous investigations were also carried out at the power plant sites of our members. In addition to ambulant metallography for the assessment of lifetime consumption, a large number of special tests were also carried out. Here it is the objective to develop jointly with the member company an objective, non-commercially driven assessment of the component in order to enable cost-effective and most importantly safe further operation of the plant. In this connection, the many installations of thermocouples and creep strain sensors for online monitoring and description of the operating behaviour of various power plant components are worthy of mention.

During the period under review, special was attached to damage caused by unexpected crack formation in the austenitic material HR3C, occurring in reheater 2 of several new build power plants after only a short operating time. The VGB Materials Laboratory performed the damage investigations on several cracked weld seams from the first two power plants affected. In addition, a research project was initiated during the reporting period in order to clarify the essential questions posed by the operators.

Water Chemistry

The department of water chemistry supports operators of fossil, refuse derived fuel and biomass fired power plants of all output ranges. The department has extended the experience it had already gained in the interplay of the working medium and the materials used in the latest generation of large fossil fuelled steam boilers. Thanks to the close cooperation between the materials laboratory and the water chemistry department, it was possible to apply the scientific findings on the behaviour of new materials in practice with successful results.

In the period under review, numerous examinations have been performed at the premises of members in Germany and abroad. In many cases, it was possible to avert damage for the customer and ensure safe and economic operation of the plant. In this connection, a product which is still relatively new is remote water chemistry diagnosis. The data from the measuring instruments installed on site are transmitted online to VGB and assessed. This process gives the VGB experts the opportunity to react systematically to any deviations from normal operating patterns.

Construction and Installation Supervision

In a challenging environment with regard to new-build projects, the construction and assembly supervision team succeeded in successfully handling numerous smaller orders. In addition to a larger order for the monitoring of the construction activities of a combined cycle gas power plant in Germany, numerous construction supervisions were carried out as part of modernisation work. In addition, the supervision of some damages and the monitoring of the refabrication of the concerning components are also worth mentioning

R&D Activities and VGB RESEARCH FOUNDATION

R&D Activities and VGB RESEARCH FOUNDATION

Sabine Polenz, Guido Schwabe and
Ludger Mohrbach

VGB offers its member companies a neutral platform for joint research and cooperation. The research activities are controlled by the experts from VGB member companies organised in the VGB technical committees, with the support of the relevant VGB technical advisors (Figure 1).

The VGB technical committees identify and define research requirements in their respective fields of activity or examine external research proposals with respect to their practical relevance and short- or medium-term practicability for plant operations. The technical committees and VGB technical advisors supervise project execution and transfer of results.

Four key research programmes emerged from this generally bottom-up research coordination:

- Efficient Use and System Integration of Renewables (EUSI-RES)
- New materials for power plants (NWK),
- Waste Management of Coal-fired Power Plants and Waste Incineration Plants (ERKOM),
- Advanced Coal Power Plant with Optimised Efficiency, Economy and Environmental Sustainability (Emax),

The contributions received from member companies are the key to financing projects. In addition to project-related contributions of single member companies, a general research contribution is levied from full member companies. The VGB Board of Directors decides on the use of these funds. Public funds make a significant contribution to research projects of broad interest.

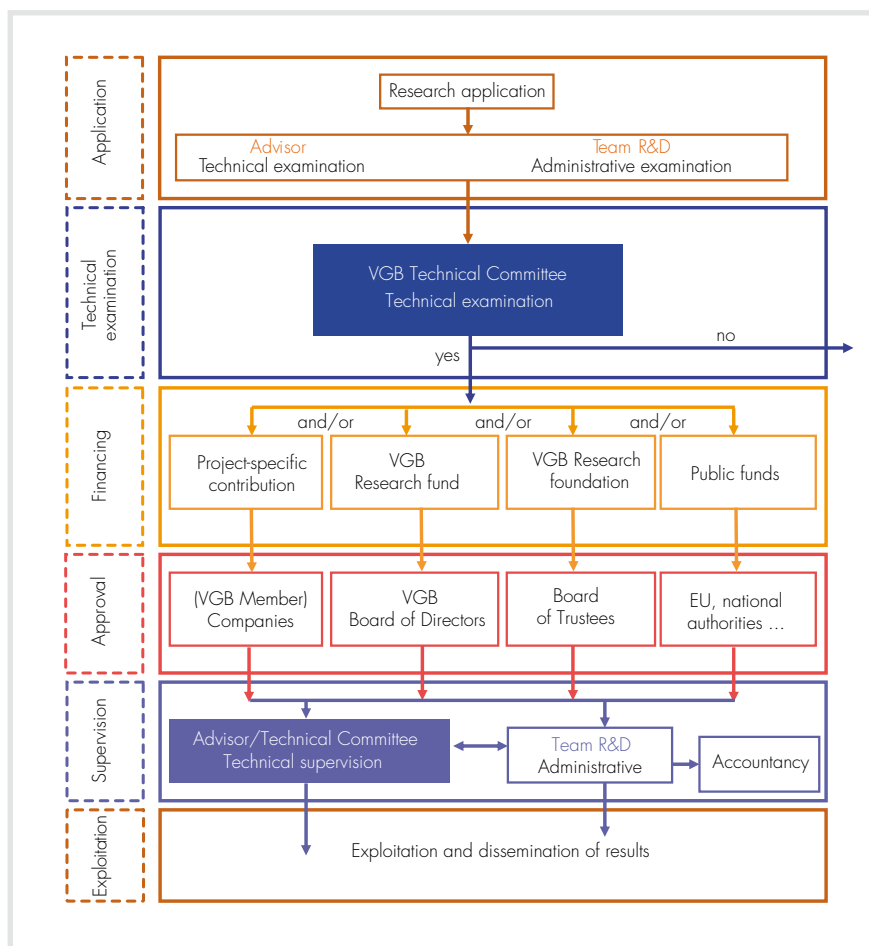


Fig. 1: Organisation of R&D coordination.

Project Funding in 2016

Table 1 shows the status of project funding as of June 2017. It contains information on the funding shares and the publication of research results. Furthermore, the projects worked on within a key research programme are identified.

Short descriptions of the projects, arranged according to topic, are provided on www.vgb.org and are continuously updated. The website also contains information about the relevant expert contact at the VGB Secretariat as well as notes on results.

In 2016 VGB took part in a total of 28 projects with a total volume of 11.8 million € (last year: 30 projects with a vol-

ume of 64.9 million €). Of these, 9 projects with a volume of 1.2 million € were started in 2016 (last year: 7 new projects and 3.7 million €). The share of operator funds spent on these new projects amounts to 42%, raised through 23% project contributions of individual companies and 19% joint research contributions of full VGB members or contributions of the VGB RESEARCH Foundation. Other funds, including contributions from sponsoring members or non-members, accounted for just 6%. More than half of the total project volume was raised through public funding.

Tab. 1: Projects funded by VGB since 2011, completed projects are highlighted in grey (as of 05/2017).

* Focal point research programme «Waste Management of Coal-fired Power Plants and Waste Incinerator Plants» (ERKOM)

** Focal point research programme «New Materials for Power Plants» (NWK)

*** Focal point research programme «Advanced Coal Power Plant with Optimized Efficiency, Economy and Environmental Sustainability» (Emax)

**** Focal point research programme «Efficient Use and System Integration of Renewables» (EUSI-RES)

No.	Abbreviated title	Duration	Project results
	Projects no. 1 to 339 (total)	1971 to 2010	
340	Availability of biomass****	2011	Final report
341	Measurement of low mercury emissions	2011 to 2013	Final report
342	Crack growth rates under thermomechanical loading conditions***	2011 to 2012	Final report
343	Gips-Zement-Puzzolan-Hüttensand-Bindemittel*	2011 to 2014	Final report
344	AKR-Vermeidung durch Flugasche* (Fortsetzung 300)	2010 to 2013	Final report in progress
345	System stability of electricity supply****	2011 to 2013	Final report
346	Verification of Repair Concept on Service Exposed A617**	2011 to 2017	
347	Annealing studies of P91/P92**	2011 to 2013	Final report
348	New 12% chromium steels**	2011 to 2013	Final report
349	ASR - Variation of Prestorage Time*	2011 to 2014	Final report in progress
350	Predictive Emissions Monitoring Systems	2011 to 2013	Final report
351	COORETEC TD-2: ZfP Nickelguss-Komponenten, Vorstudie***	2011 to 2012	Final report
352	Hybrid High Solar Share Gas Turbine System (HYGATE)****	2011 to 2014	Final report
353	Seewasser für REA und Trinkwassergewinnung	2012 to 2014	Final report
354	HWT II***	2011 to 2015	Final report
355	ENCIO****	2011 to 2015	Final report
356	COMTES+***	2011 to 2018	
357	Bromide addition	2012 to 2013	Final report
358	Work-related stress among employees in wind turbines****	2012 to 2014	Final report
359	HOSEP (Self-ignition of biomass I)****	2012 to 2013	Final report
360	Market analysis of control loop performance OMS	2012	Final report
361	Reliability indicators with KISSY	2012 to 2013	Final report
362	Wear investigation model	2012 to 2015	Final report
363	Calculation methods	2012 to 2014	Final report in progress
364	Sulphate resistance - literature research*	2012 to 2014	Final report in progress
365	Knowledge to avoid coarse grain structure in austenitic materials**	2012 to 2013	Final report
366	Standardised remote terminal unit for wind power plants****	2012 to 2013	Final report in progress
367	MACPLUS-COMTES700/ETR/TV-Cooperation***	2012 to 2016	Final report in progress
368	Further investigations of the sulphate resistance of fly ash concrete (Continuation 336)*	2012 to 2013	Final report in progress
369	Optimierung Spindelabdichtung II (Fortsetzung 317)	2013 to 2015	Final report
370	Investigations and possible solutions to avoid stress corrosion cracking on welds made of T24 material**	2010 to 2013	Final report, VGB PT 11/2011, p. 40-44
371	Heat Treatment T24**	2013 to 2014	Final report
372	Alkali Silica Reaction - External Alkali Supply*	2013 to 2017	
373	Fly ash with higher LOI - Use in concrete*	2013 to 2014	Final report in progress
374	Alkali Reaction - Long-term storage*	2013 to 2016	Final report in progress
375	Affiliate coal-fired power plant for electricity generation based on renewables****	2013 to 2015	Final report
376	Wear of generators due to delivery of reactive power	2013 to 2014	Final report
377	Combustion of mechanically agitated lumpy solid fuels (Continuation 328)****	2013 to 2016	Final report
378	Burner-induced vibration values of boilers	2014	Final report
379	Flue gas flow rate determination to EN ISO 16911	2014 to 2015	Final report in progress
380	Ammonia Masking in SNCR Plants	2014 to 2016	Final report in progress
381	Sulphate Resistance - Long-term Storage*	2014 to 2016	Final report in progress
382	Design Optimisation of Grate Firings for Biomass - European Transfer of Results****	2014 to 2017	
383	Condition Monitoring of Wind Turbines, Part I – Best Practice Study****	2014	Final report
384	Balancing energy provided by wind and PV plants****	2014 to 2016	Final report in progress
385	Biomass Storage Monitoring, Part I****	2014 to 2016	Final report
386	Efficiency of air filters at high humidity****	2014 to 2017	
387	Inspection intervals of welded offshore wind structure (FeLoSeFI)****	2014 to 2018	
388	Investment requirements in European electricity-generation infrastructure towards 2050	2014 to 2015	Final report
389	New Materials for Steam Turbines V (Continuation 314)**	2014 to 2020	
390	Microbiological emissions from cooling towers	2015 to 2017	
391	DENA Ancillary services platform****	2015 to 2018	
392	Ice Detection Systems for Wind Turbines, Part I: Best Practice Study****	2015	Final report
393	Impact of flexible power plant operation on boiler circulation pumps**	2015	Final report
394	Development of a CO ₂ -scrubbing process using lime stone powder	2015 to 2017	
395	Mercury emission and control in the USA	2015 to 2016	Final report
396	INADAR (Hydro power plant dam restoration)****	2015 to 2019	
397	New 12% chromium steels**	2016 to 2018	
398	Long term prospects of CHP	2016	Final report
399	Impact of operation conditions on lifetime of boiler circulation pumps (Continuation 393)**	2016 to 2017	Final report in progress
400	Benchmark E-PRTR emission reporting	2016 to 2017	
401	Ice Detection Systems for Wind Turbines, Part II: Field test****	2016 to 2018	
402	ASR - Variation of Prestorage Time II (Continuation 349)*	2016 to 2018	
403	Pozzolanic reactivity of fly ash - New test procedure*	2016 to 2017	
404	Belit-Calciumsulfoaluminat-Cement from lignite and hard coal fly ash*	2016 to 2017	
405	Mercury detector in flue gas cleaning systems	2016 to 2019	
406	Self-ignition of biomass II: Analysis and modelling of initial self-heating (Continuation 359)****	2017 to 2019	
407	Power plant flexibility by thermal energy storage****	2017 to 2019	
408	DG and storage regulation****	2017	
409	Emission compliance evaluation	2017 to 2018	

Nuclear Power Engineering

The subcommittees and panels of the General Committee «Nuclear Power Plants» fund operation-related research and development projects for nuclear power plants. They are financed by the nuclear power plant operators according to the cost-sharing principle across all the plants involved in each project. In 2016, 42 projects with a total funding volume of 2,328,499 € (last year: 39 projects with 3,484,277 €) were awarded.

Collaboration with Universities and Promotion of Vocational Training

VGB's close collaboration with university institutes is mainly realised through the work of the VGB Scientific Advisory Board, which supports VGB on all issues related to research, development and education. The VGB Scientific Advisory Board comprises some thirty experts from twelve European countries (Austria, Belgium, Czech Republic, Denmark, Finland, Germany, Greece, Italy, Poland, Slovenia and Sweden), who represent all faculties dealing with power generation and cover all topics of power supply from basic research to application.

Financed by the VGB RESEARCH FOUNDATION, a summer school course was again held for advanced students from 22 August to 2 September 2016. The summer school POWER PLANTS provides a concise insight into the practice of electricity and heat generation. The programme includes presentations from all areas of power and heat generation as well as attractive excursions. In 2016, 18 Students from ten German, Austrian, Greek and Slovenian universities took part (Figure 2).

VGB RESEARCH FOUNDATION also funds subscriptions to the VGB PowerTech Journal for university institutions in order to support practical education. The subscription also includes the digital edition, providing access mainly for students and university staff to current data and information from the industry.

As a neutral sponsor, VGB RESEARCH FOUNDATION facilitated the participation of 25 students in the VGB KELI Conference (Conference on Electrical Engineering, C&I and IT in Power Plants) held from 10 to 12 May 2016 in Cologne. With the Students' Forum, the conference included a special section which was oriented towards the interests of the engineers of tomorrow, presented career opportunities in the energy industry and provided an opportunity for interested students to get into direct contact with VGB member companies.



Fig. 2: Participants from the summer school POWER PLANTS 2016.

VGB Innovation Award

The Board of Trustees of VGB RESEARCH FOUNDATION presented the VGB Innovation Award to

- Josef Langen for further development of measuring systems for the online measurement of fireside corrosion of evaporator walls.

The award, which includes a prize money of 10,000 euros, was handed over by the Chairman of the VGB Board of Directors on the occasion of the VGB Con-

gress POWER PLANTS 2016 in Leipzig, Germany (Figure 3).

Since 1981, VGB RESEARCH FOUNDATION has been recognising outstanding achievements of young university graduates who work in the field of power and heat generation. The prize was renamed VGB Innovation Award in 2015. Further information, also on the results of the 2017 awards presentation, is available online at www.vgb.org.



Fig. 3: Dr. Bernhard Fischer (left) presents the VGB Innovation Award 2016 to Josef Langen (middle) at the VGB Congress, Leipzig, Germany.

KRAFTWERKSSCHULE E.V.

Kraftwerksschule e.V. (KWS)

Ernst Michael Züfle

General

KRAFTWERKSSCHULE E.V. (KWS, Power-Tech Training Centre), based in Essen-Kupferdreh, has been the central training facility for all technical fields of power and heat generation for 60 years. Plant operators all over the world trust KWS to provide training and advanced training to their specialists, and benefit from expert advice on technical matters and problems of organisation and human resources development. In 2016 more than 2,800 participants took advantage of the offer of around 290 courses. As a reliable partner, KWS thus contributes to a safe, environmentally friendly and affordable supply of energy.

Initial and Advanced Training at KWS

Conventional Power Plant Technology

KWS is the leading training facility for technical power plant personnel at conventional power plants. Its training activities cover the entire range of functions from plant attendants and chargehands to control room operators and shift supervisors. The advanced training offered includes, for example, environmental protection, fire protection, industrial safety, maintenance, leadership and business management. One focus of development is content relating to cost effectiveness in operation and maintenance as well as the optimum interplay between highly available thermal power plants and fluctuating generating units.

Renewables

KWS offers initial and advanced training in all fields of renewables. This applies to biomass and onshore/offshore wind power plants as well as to hydroelectric power plants.

The «Service Technician for Wind Power Plants» course, which is comparable to the training for control room operators in conventional power plants, concludes with a Chamber of Industry and Commerce (IHK) examination.

Organisational Development

The demands on power plant personnel are constantly growing, especially in the area of operational excellence, change manage-



Training in the International Activities Section.

ment and human resources development. The Organisational Development competence team addresses these requirements and offers process analyses, best practice workshops, reviews of shift manning levels and manager training, and provides advice during phases of change or organisational development.

Simulator Training

KWS makes state-of-the-art power plant simulators available to its customers for training in operational and failure situations. Specifically, these are the simulator variants for 800 MW hard coal-fired plants, 1,100 MW lignite-fired units including main instrumentation and control (I&C) supplied by Siemens (SPPA T3000), and 1,100 MW hard coal plants with main I&C supplied by ABB (ABB 800 XA). In addition, a new combined-cycle simulator variant with main I&C supplied by Siemens (SPPA T3000) is available for training situations of whatever kind. Another focus of work is the provision of simulators for performance of virtual commissioning prior to the real commissioning of power plants. The training models used in the simulators are constantly being improved to reflect the increased demands of grid operation.

Nuclear Power Engineering/ Radiation Protection

KWS is a reliable and important partner to nuclear power plants in the area of maintenance, shift personnel, radiation protection and preservation of technical qualifications.

The Nuclear Power Engineering/Radiation Protection competence team offers a broad range of officially recognised courses for training of the responsible nuclear power

plant personnel and preservation their technical qualifications. In the area of radiation protection, apart from offering a course for plant supervisors specialising in radiation protection, the team offers a wide selection of courses for both acquiring and upgrading knowledge and skills. Relevant issues in connection with disassembly and idle operation of nuclear power plants also are taken into account. This is a growth market, and with the opportunities afforded by its partner power plant Zwentendorf, KWS has a unique facility for practical training.

International Activities

KWS is supporting members' activities in foreign countries and can carry out simulator training and theoretical training worldwide. KWS is familiar with many of the structures of initial and advanced training outside Germany. Additionally, KWS establishes operational solutions jointly with plant operators. In addition to German, instruction can be given in English and Dutch. A complete series of publications covering all topics of relevance to power plants is also available in English and Dutch.

Apartment Building and Conference Venue

With the new apartment building opened in mid-July 2013, KWS now also has a central location for the accommodation of course participants at the Deilbachtal Energy Campus in Essen-Kupferdreh.

KWS can therefore also offer a venue for conferences of any kind – also over several days – in state-of-the-art conference rooms that meet the demands of modern communications technology. |

VGB: Events and Publications



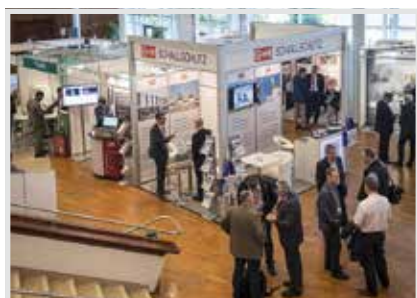
VGB Congress «POWER PLANTS 2016», Leipzig, Germany



VGB Conference «Chemistry in Power Plants 2016», Karlsruhe, Germany.



VGB Conference «Cogeneration and Virtual Power Plants 2017», Berlin, Germany.



VGB Conference «Gas Turbines and Gas Turbine Operation 2017», Friedrichshafen, Germany.

VGB Events

Angela Langen

In the period under review, July 2016 to June 2017, VGB hosted 27 events attended by a total of about 2,050 people. Five events were accompanied by trade exhibitions, at which 135 companies presented their products and services.

VGB Congress «POWER PLANTS 2016» in Leipzig

The VGB Congress «Power Plants 2016» took place in Leipzig from 21 to 22 September 2016. Under the motto of «New Horizons: Navigating the Power Industry in Times of Change», the congress brought together more than 400 participants from 22 countries.

47 plant operators, manufacturers and service providers presented their products and services at the flanking trade exhibition held in the foyer spaces of the Leipzig Congress Centre.

VGB Conference «Chemistry in Power Plants 2016» in Karlsruhe

The long-established VGB Chemistry Conference with trade exhibition took place in Karlsruhe from 25 to 27 October 2016.

39 exhibitors and 254 conference participants exchanged experience. This 52th Chemistry Conference started with a report on power plant chemistry experience and future challenges. Topics included savings on water consumption and a critical review of guidance levels and limit values in water chemistry. Further topics addressed included water-steam cycle with online measurement and analysis for water treatment, biology and biofilm management in the cooling water cycle, mercury, and regeneration of SCR catalysts.

VGB Conference «Cogeneration and Virtual Power Plants 2017» in Berlin

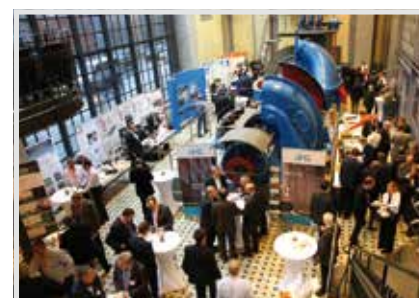
Held from 5 to 6 April in Berlin, this new conference provided a forum for raising and addressing issues with special relevance for the municipal utility and captive power plant segments.

Participants, exhibitors and cooperation partners from the power sector used the event as an opportunity to build and maintain business and personal contacts.

VGB Conference «Gas Turbines and Operation of Gas Turbines 2017» in Friedrichshafen

Every two years, owners/operators, manufacturers, insurance companies, authorities and R&D experts get together to discuss topical issues related to gas turbines and their operation. As once before in 2013, the 2017 event was again held at the Graf-Zeppelin-Haus in Friedrichshafen. From 7 to 8 June 2017, about 210 participants and 27 exhibitors used the opportunity to exchange experience and maintain and deepen business contacts, both in discussions at the exhibition booths and during background programme.

We should like to thank all the participants, sponsors, cooperating partners and exhibitors for their support and attendance in large numbers. We look forward to further good cooperation and future events.



VGB Conference «Waste Incineration & Fluidized Bed Firing Systems 2016», Berlin, Germany.



VGB Congress «POWER PLANTS 2016», Leipzig, Germany

Date	Place	Kind of event	Title
9 and 10 September 2016	Emden	Workshop	7. Emden Workshop Offshore Wind Power Plants – Occupational Health
13-15 September 2016	Essen	Seminar	Practical Chemistry in Water Steam Cycle (German)
14-15 September 2016	Edertal-Hemfurth	Workshop	Oil in Hydro Power Plants
21 and 22 September 2016	Leipzig	Congress with exhibition	Power Plants 2016
27 September 2016	Essen	Workshop	KISSY
29 and 30 September 2016	Hannover	Workshop	Preservation of Power Plants
5 and 6 October 2016	Zolling	Workshop	Biomass
27 to 29 October 2016	Karlsruhe	Conference with exhibition	Chemistry in Power Plants
9 November 2016	Essen	Conference	Future-proof identification and documentation in power plants
15 and 16 November 2016	Berlin	Conference with exhibition	Waste Incineration & Fluidized Bed Firing Systems
17 November 2016	Hamburg	Workshop	Products of Waste Incineration
22 to 24 November 2016	Höhr-Grenzhausen	Training	Immission Control and Hazard Commissioners (German national law only)
7 to 9 March 2017	Essen	Workshop	Water Treatment
22 and 23 March 2017	Hamburg	Conference	Maintenance of wind power plants
5 and 6 April 2017	Berlin	Conference with exhibition	Cogeneration and virtual power plants
25 to 27 April 2017	Höhr-Grenzhausen	Training	Training for water protection and waste management commissioners (German National Law, only)
3 and 4 May 2017	Lisboa	Workshop	Flue gas cleaning
10 and 11 May 2017	Bielefeld	Workshop	Operation dependent maintenance of industrial steam turbines
18 and 19 May 2017	Maria Enzersdorf	Workshop	Materials & quality assurance
22 May 2017	Krakow	Workshop	Operating experience with fluidized bed firing systems
29 May 2017	Copenhagen	Workshop	Biomass ash
7 and 8 June 2017	Friedrichshafen	Conference with exhibition	Gas turbines and operation of gas turbines
8 and 9 June 2017	Berlin	Workshop	Mercury Control
20 June 2017	Essen	Workshop	Energy efficiency and energy management systems
28 June 2017	Essen	Info	Implementation of management systems on ISO 27001 for Kritis operators in the energy sector
27 to 29 June 2017	Essen	Seminar	Damage mechanisms in the power plant technology (German)
28 and 29 June 2017	Essen	Workshop	Damages in Power Plants (German)

Tab. 1: VGB events July 2016 to June 2017.

Energy fairs 2016 and 2017

VGB PowerTech e.V. and VGB PowerTech Service GmbH were represented at the following fairs/events:

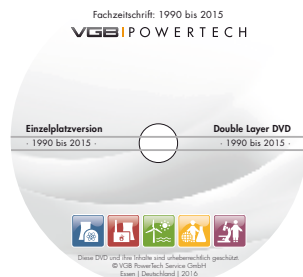
- WindEnergy Hamburg, 27 to 30 September 2016
- Kraftwerkstechnisches Kolloquium, Dresden, 18 to 19 October 2016
- Windenergietage (Spreewindtage), Potsdam, 8 to 10 November 2016
- E-world 2017, Essen, 7 to 9 February 2017
- PowerGen Europe 2017, Cologne, 27 to 29 June 2017

VGB Publications

Christopher Weißelmann

VGB PowerTech Journal

From 1 July 2016 to 30 June 2017 a total of 163 technical articles were published in 11 editions of the International VGB PowerTech trade journal. Since January 2001, the joint international German-English bilingual edition of the former VGB KraftwerksTechnik has been published under the name of «VGB PowerTech». The redesign of VGB PowerTech has been produced a high level of acceptance amongst member companies, subscribers and readers.



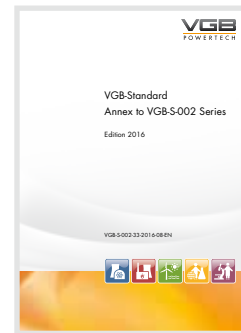
Since 2006, VGB PowerTech offers a digital version of the trade journal. The annual edition is always published at the end of May of the following year. In the meantime, the issues since 1990 were digitised and are available on DVD covering some 22,000 pages.

VGB-Standards

In the course of the Europeanisation of VGB PowerTech e.V., it was decided that all VGB Guidelines and Instruction Sheets (hereafter marked and abbreviated VGB-R/M for ease of reference) should basically be published in German and English. They should be converted into documents with the new designation VGB-Standards (VGB-S) by August 1, 2011.

The following VGB-Standards, VGB Guidelines, VGB Instruction Sheets, Books and Reports have been completed during the year under review:

- VGB-S-002-03-2016-08-DE Technische und kommerzielle Kennzahlen für Kraftwerksanlagen
- VGB-S-002-03-2016-08-EN Technical and Commercial Key Indicators for Power Plants
- VGB-S-002-33-2016-08-DE Anlage zur Schriftenreihe VGB-S-002
- VGB-S-002-33-2016-08-EN Annex to series VGB-S-002
- VGB-S-013-00-2017-04-DE Bau- und Montageüberwachung bei der Herstellung und Errichtung von Wasserrohrkesseln und zugehörigen Anlagen in Wärmekraftwerken
- VGB-S-040-00-2017-03-DE Präqualifikation von Partnerfirmen für eine qualitätsgerechte Instandhaltung
- VGB-S-041-00-2016-04-EN Standards for Professional Leadership Behaviour
- VGB-S-104-O Online-Leitfaden zur Umsetzung der Betriebssicherheitsverordnung in Kraftwerken – 2007 (Update 2017; update ongoing)
- VGB-S-110-R-00;2012-07.EN Heat exchangers and boilers in the steam-water cycle of thermal power plants
- VGB-S-115-00-2016-01-EN Recommendations for the Inspection and Overhaul of Steam Turbines
- VGB-S-116-00-2016-04-DE Konservierung von Kraftwerksanlagen
- VGB-S-116-00-2016-04-EN Preservation of Power Plants
- VGB-S-116-00-2016-04-EN Preservation of Power Plants
- VGB-S-121-00-2016-04-DE VGB-Standard für Überwachungs-, Begrenzungs- und Schutzeinrichtungen von Gasturbinen
- VGB-S-121-00-2016-04-EN Monitoring, limiting and protection devices on gas turbine systems
- VGB-S-145-00-2015-11-EN Guide for the Procurement of Steam Turbine Plants; Part A: General Part, Part B: Technical Part, Bid, Scope of Supply, Part C: Specification, Agreed Scope of Supply
- VGB-S-164-11-2016-08-DE Empfehlungen für den maschinen-technischen Generatorschutz
- VGB-S-164-11-2016-08-EN Recommendations for thermal/mechanical generator protection
- VGB-S-164-12-2016-10-DE Vermeidung von Generatorschäden in Folge von Betauung spannungsführender Teile
- VGB-S-169-11-2015-11-EN Quality requirements for mineral oils in power transformers
- VGB-S-609-00-2016-03-DE Anwendung, Konstruktion und Güteüberwachung von faserverstärkten Kunststoffen im Kraftwerksbau
- VGB-S-821-00-2016-06-DE RDS-PP Kennbuchstaben für Kraftwerkssysteme (Systemschlüssel).
- VGB-S-821-00-2016-06-EN RDS-PP Letter Code for Power Plant Systems (System key). 4th Edition
- VGB-S-832-00-2016-04-DE-EN Dokumentenkennzeichen für Anlagen der Energieversorgung Designation codes for document kind classification code (DCC key)
- TW 103 Ve (2016) VGB/EURELECTRIC – Availability of Power Plants 2006 – 2015, Edition 2016
- TW 103 V (2016) VGB/EURELECTRIC – Verfügbarkeit von Kraftwerken 2006 – 2015, Ausgabe 2016
- TW 103 Ae (2016) VGB/EURELECTRIC – Analysis of Unavailability of Thermal Power Plants 2006 to 2015, Edition 2016
- TW 103 A (2016) VGB/EURELECTRIC – Analyse der Nichtverfügbarkeit von Wärmekraftwerken 2006 bis 2015, Ausgabe 2016



Cooperation in Associations and Organisations

VGB PowerTech is co-operating with the following organisations and associations worldwide (in alphabetical order):

AGFW | Der Energieeffizienzverband für Wärme, Kälte und KWK e. V.

Arbeitsgemeinschaft Kernmaterial-Überwachung (AKÜ)

Arbeitsgemeinschaft Druckbehälter (AD)

Arbeitsgemeinschaft warmfeste Stähle

ASME American Society of Mechanical Engineers

Association of European Gypsum Industries

Bundesverband der Energie- und Wasserwirtschaft (BDEW)

BDI Bundesverband der Deutschen Industrie

Berufsgenossenschaft der chemischen Industrie

Berufsgenossenschaft Feinmechanik und Elektrotechnik

Bundesverband der Gipsindustrie e. V.

BVK Bundesverband Kraftwerksnebenprodukte e. V.

CEN – Europäisches Komitee für Normung

CENELEC European Committee for Electrotechnical Standardization

Deutsche Akkreditierungsstelle »Stahlbau und Energietechnik e. V. (DASET)«

Deutsche Elektrotechnische Kommission (DKE)

dena – Deutsche Energie-Agentur

Deutsche Gesellschaft für chemisches Apparatewesen e. V. (DECHEMA)

Deutsche Vereinigung für Verbrennungsforschung e. V. (DVV)

Deutscher Ausschuss für Stahlbeton (DAfStb)

Deutscher Verband für Schweißtechnik e. V. (DVS)

Deutsches Atomforum e. V. (DAfF)

Deutsches Institut für Bautechnik

Deutsches Institut für Normung e. V. (DIN)

Deutsches Komitee Instandhaltung (DKIN)

ECOBAs European Coal Combustion Products Association

EIPPCB European Integrated Pollution Prevention and Control Bureau

EnergieAgentur NRW

Entsorgungskommission (ESK)

EPPSA, European Power Plant Suppliers Association

EPRI Electric Power Research Institute

ENTSO European Network of Transmission System Operators for Electricity

EUnited Turbines – European Association of Gas and Steam Turbine Manufacturers

EURATOM Supply Agency

EURELECTRIC Union of the Electricity Industry

European Association for Coal and Lignite (EURACOAL)

European Wind Energy Association (EWEA)

Fachverband für Strahlenschutz e. V. (FS)

FDBR Fachverband Dampfkessel-, Behälter- und Rohrleitungsbau e. V.

FGSV Forschungsgesellschaft für Straßen- und Verkehrswesen

FORATOM, European Atomic Forum

Gemeinschaftsausschuss Kennzeichnungssysteme (GA KS)

GfS Gesellschaft für Simulatorschulung mbH

GVC/DECHEMA-Fachausschuss »Abfallbehandlung«

Hauptverband der gewerblichen Berufsgenossenschaften

HEA – Fachgemeinschaft für effiziente Energieanwendung e. V.

IAEA International Atomic Energy Agency

IEA International Energy Agency

IEA Clean Coal Centre

IERE Central Office

ITAD – Interessengemeinschaft Thermischer Abfallbehandlungsanlagen Deutschland e. V.

Kerntechnische Gesellschaft (KTG) e. V.

Kerntechnischer Ausschuss (KTA)

KSG Kraftwerks-Simulator-Gesellschaft mbH

Nationales Komitee des Weltenergie Rates der Bundesrepublik Deutschl and DNK

OECD/NEA Nuclear Energy Agency

Performance Indicator Working Group (PIWG)

PGP-Committee (Performance of Generating Plant)

Reaktor-Sicherheitskommission (RSK)

Stahlinstitut VDEh

Strahlenschutzkommission (SSK)

TEC FLAM (Universitäts-Arbeitsgemeinschaft Technische Flammen)

TENPES – Thermal and Nuclear Power Engineering Society, Tokyo, Japan

VDMA Arbeitsausschuss »Gasturbinen«

Verband Kommunaler Städtereinigungsbetriebe (VKS)

Verband der Industriellen Energie- und Kraftwirtschaft e. V. (VIK)

Verein Deutscher Ingenieure (VDI)

Verein Deutscher Zementwerke (VDZ)

Wirtschaftsverband Kernbrennstoff-Kreislauf und Kerntechnik e. V. (WKK)

World Association of Nuclear Operators (WANO)

World Energy Council (WEC)

Power Plant Statistics

Stefan Prost and Jean-François Lehoue

A few definitions and results from the VGB Statistics «Availability of Thermal Power Plants» are presented in the accompanying summary. The data pool was created with the help of the VGB power plant information system «KISSY». Using KISSY, the operating data from 655 power plants and 173 machine sets of storage and pump hydro power plants were recorded online.

VGB analysed the data in detailed in its annual reports «Availability of Thermal Power Plants» (VGB-TW 103 V) and «Analysis of Unavailability of Thermal Power Plants» (VGB-TW 103 A). The current annual reports contain the operating results for the operating period between 2007 and 2016.

Basic terminology for assessing the capacity of a power plant are shown in Figure 1 and Figure 2. All definitions are explained in detail in the VGB-Standard VGB-S-002-03 «Basic Terms of the Electric Utility Industry».

A free download of this VGB-Standard is available at www.vgb.org

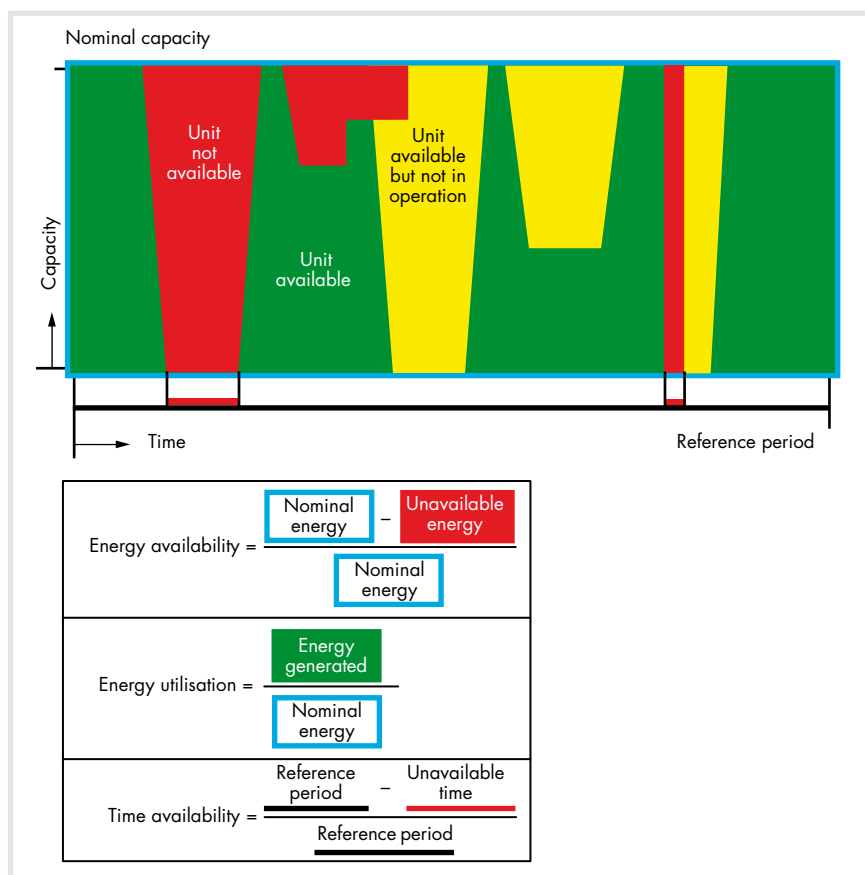


Fig. 2: Operating diagram and performance indicators.

In the explanatory statements and in the statistical analyses, care was taken to highlight in green the operating times in which the power plant was continuously «available».

Times of unavailability are highlighted in dark red (unplanned) or in light red (planned) throughout. Times in which a power plant was available, but could not be used, are highlighted in yellow.

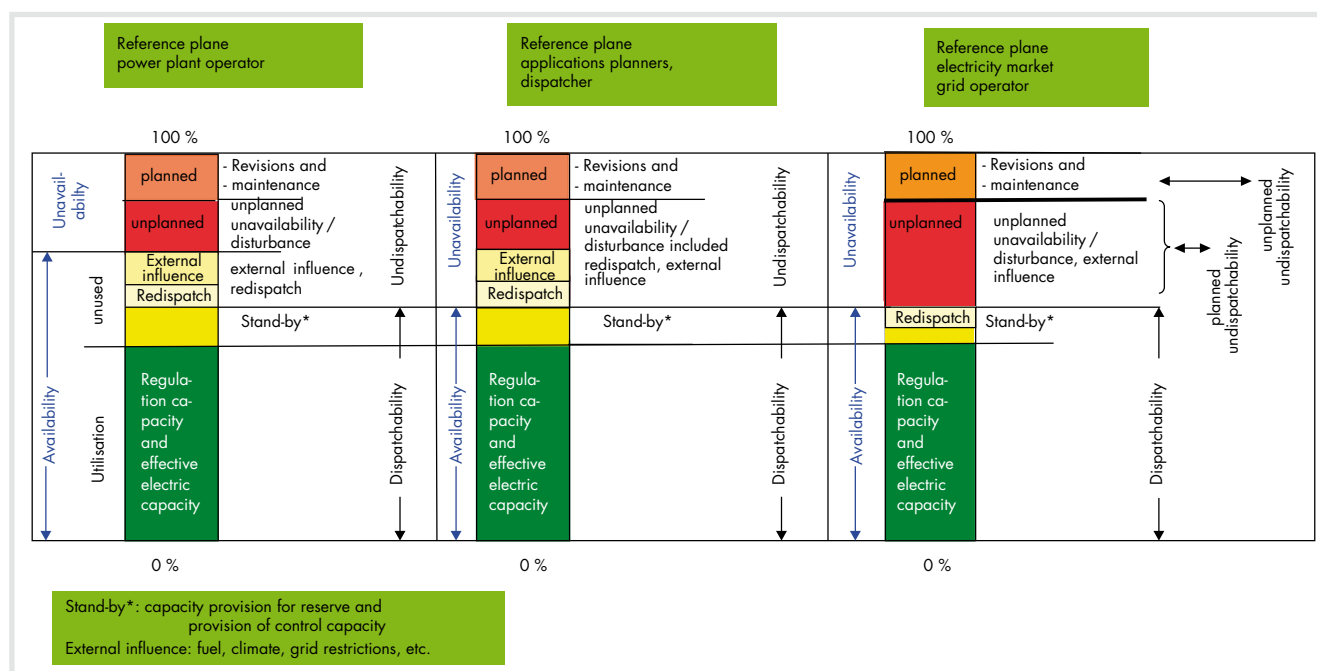


Fig. 1: Analysis of unavailability, availability, dispatchability (reference plane net). Different views of the power industry.

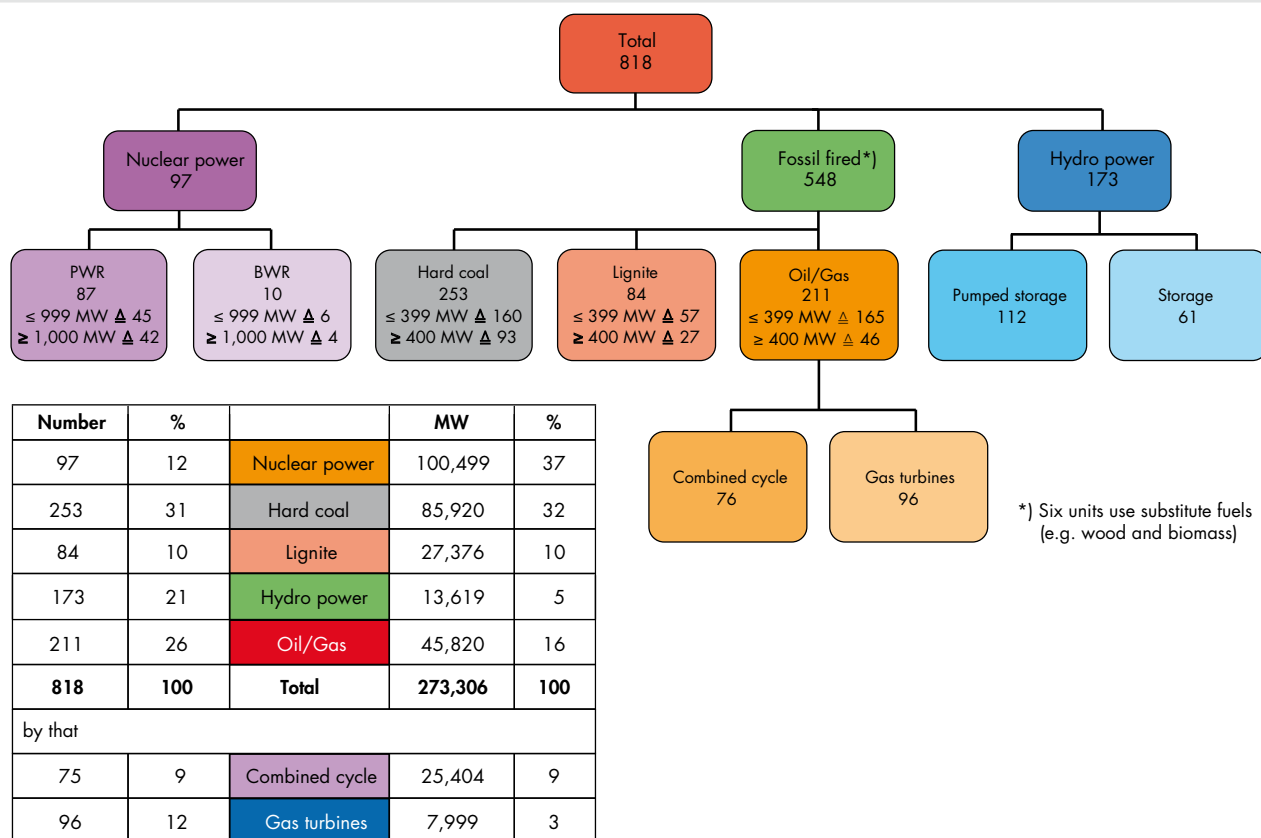


Fig. 3: VGB member units evaluated in 2016.

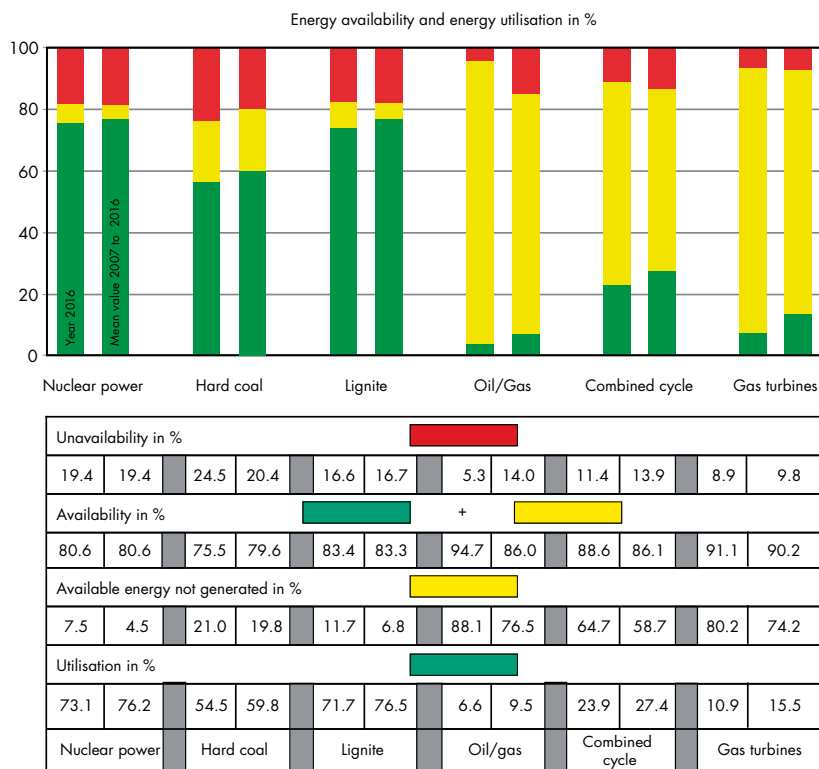
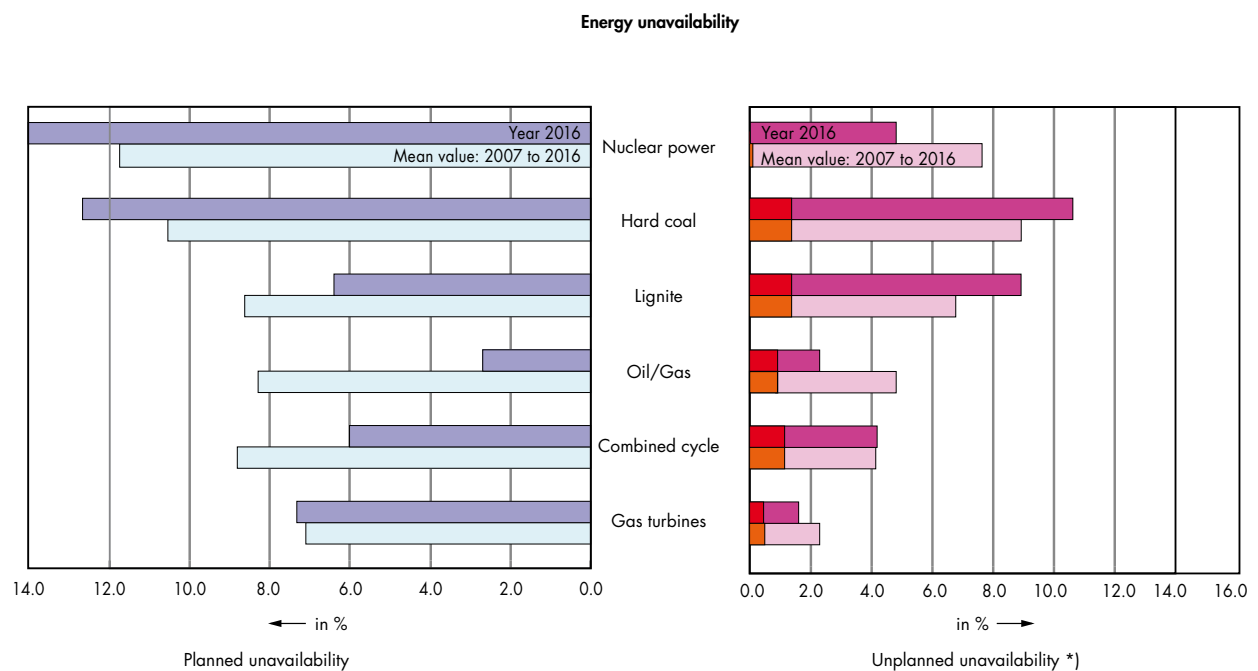


Fig. 4: Energy availability and energy utilisation. Data for 2016 and mean values for 2007 to 2016.



	14.2					0.1	5.1		
	11.8		Nuclear power			0.1	7.5		
	12.5					1.0	11.0		
	10.4		Hard coal			1.0	9.1		
	6.5					1.3	8.8		
	8.4		Lignite			1.4	6.9		
	2.4					0.7	2.2		
	8.2		Oil/Gas			0.9	4.9		
	6.1					0.8	4.4		
	8.7		Combined cycle			1.0	4.1		
	7.2					0.4	1.4		
	7.1		Gas turbines			0.4	2.2		

*) French nuclear power plants without "unplanned disposable energy unavailability"

Fig. 5: Energy unavailability. Data for 2016 and mean values for 2007 to 2016
 *) French nuclear power plants without «unplanned disposable energy availability».

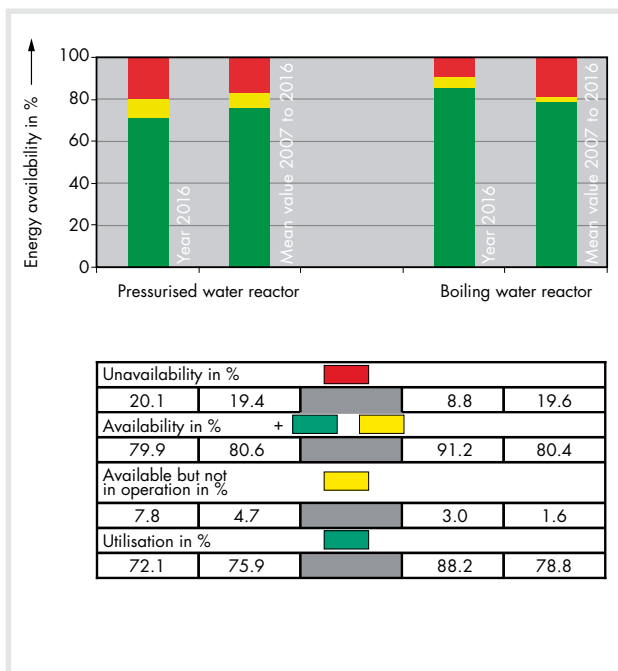


Fig. 6: Nuclear power plants: availability data year 2016 and mean values 2007 to 2016.

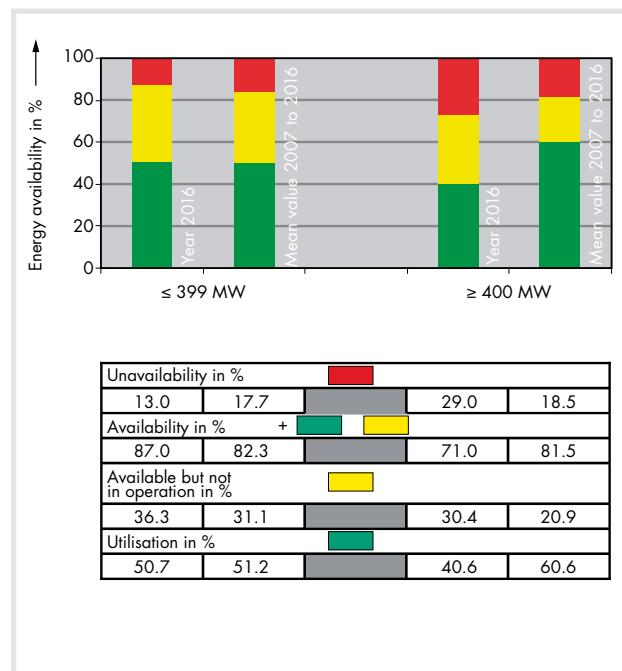


Fig. 7: Hard coal-fired power plants: data for availability year 2016 and mean values 2007 to 2016.

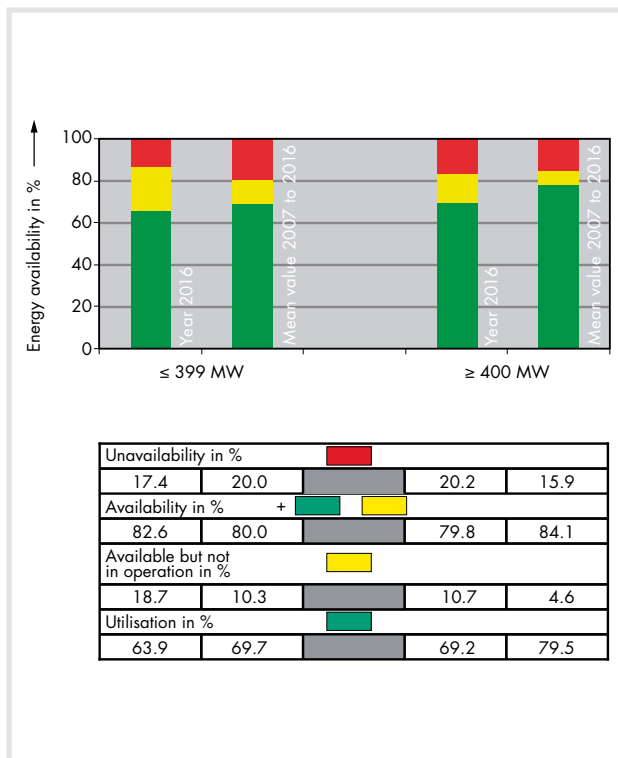


Fig. 8: Lignite-fired power plants: data for availability year 2016 and mean values 2007 to 2016.

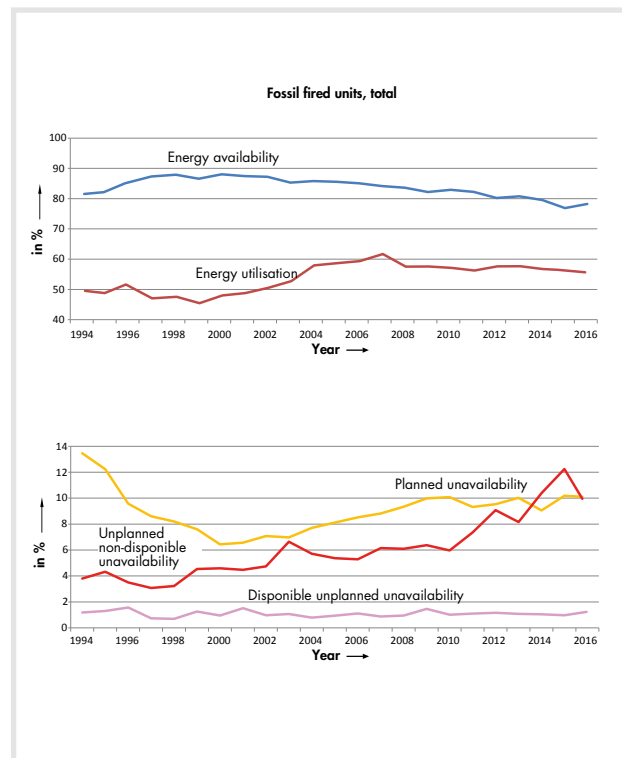


Fig. 9: Fossil-fired power plants: data for availability and unavailability 1994 to 2016.

VGB Membership

Benefits and conditions of VGB membership

VGB PowerTech e.V. (VGB) aims, in accordance with statutory regulations, to unite all companies for which the power industry is an important basis, with the objective of joint support and raising operating safety, availability, compatibility with the environment and cost-effectiveness for the members of existing and future plants for heat and power generation.

VGB is working on the standardisation and the drawing up of Technical Guidelines and Regulations in the area of the above-mentioned plants.

Membership of VGB is voluntary. Membership with VGB is open to all companies operating the above-mentioned plants. There are three types of membership:

a) Ordinary members

are companies operating or owning plants for the generation of power and heat. Companies with power plants in different locations can become a member as one body or each power plant can be a separate member.

b) Affiliated members

are authorities, associations and federations interested in planning, construction and operation of plants for the generation of power and heat. The individual members of such associations and federations do not become members of the VGB.

c) Sponsoring members

are companies and individuals making a substantial contribution to the planning, construction and operating of plants for the generation of power and heat.

Structure of members

The entire installed capacity of 433,000 MW of the VGB PowerTech members is represented in the following power plants (as of 30 June 2017):

238,500 MW fossil-fired power plants

117,500 MW nuclear power plants

77,000 MW hydro power plants and other renewables

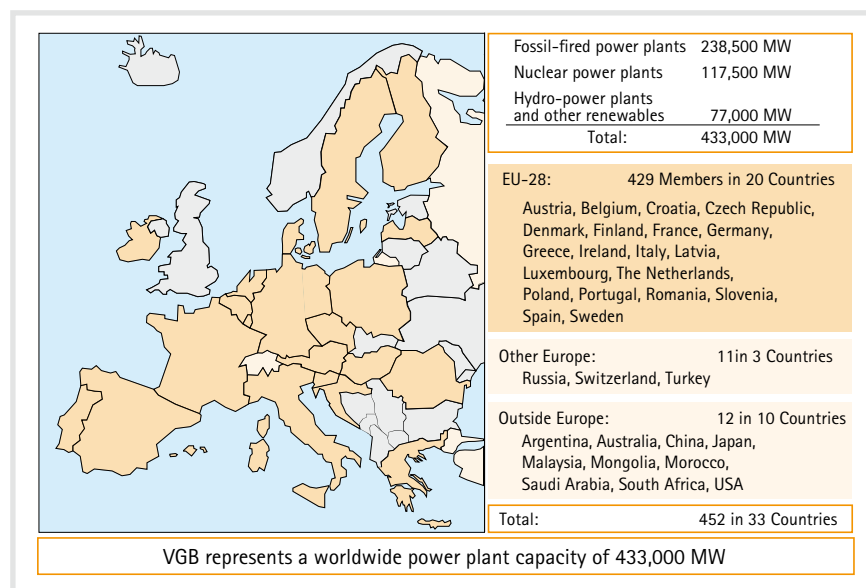
The member contributions are taken in accordance with the contribution regulation for thermal power plants on the installed steam generating capacity and, for non-thermal power plants, for the electrical gross capacity.

In the reporting period 2016/2017, 15 companies joined the VGB with a total capacity of 10,000 t/h. 41 companies with a total capacity of 119,000 t/h withdrew from VGB.

The installed steam generating capacity of the members at that point reduced by 109,000 t/h or 8.9 % to a total of

1,221,000 t/h as a result of the steam generating capacity of the new members and after the drop in the steam generating capacity of the withdrawn companies.

The headquarters of 330 members are located in Germany, the country in which VGB PowerTech was set up in 1920. The headquarters of 122 members (27 %) are located in further 32 countries in Europe and other parts of the world.



1	Argentina
1	Australia
31	Austria
4	Belgium
1	China
2	Croatia
2	Czech Republic
7	Denmark
10	Finland
1	France
330	Germany
1	Greece
1	Ireland
3	Italy
3	Japan
1	Latvia
2	Luxembourg
1	Malaysia
1	Mongolia
1	Morocco
16	Netherlands
5	Poland
1	Portugal
1	Romania
2	Russia
1	Saudi Arabia
2	Slovenia
1	South Africa
3	Spain
6	Sweden
7	Switzerland
2	Turkey
1	USA
452	Companies from 33 countries

Fig. 1: VGB memberships according to European countries.
Outside of Europe, another 12 companies in 10 countries are VGB members

Size of members with thermal power plants according to installed steam capacity:

Size		Share		Share of total steam capacity	
		2015/2016 in %	2016/2017 in %	2015/2016 in %	2016/2017 in %
up to	200 t/h	33.0	35.0	1.2	1.3
201 to	500 t/h	21.5	21.3	1.3	1.3
501 to	1,000 t/h	8.5	7.8	1.1	1.1
more than	1,000 t/h	37.0	35.9	96.4	96.3
Total		100.0	100.0	100.0	100.0

On June 30, 2017 VGB had the following membership:

	Companies		Steam capacity	
	Number	in %	in t/h	in %
Public supply companies (utilities)	157	64.1	1,183,200	96.9
Industrial supply companies	88	35.9	38,000	3.1
Total (supply companies)	245	100.0	1,221,000	100.0
Affiliated members	33			
Sponsoring members	174			
Total	452 members			

The installed capacity of the 88 industrial member companies is divided over the following branches of industry:

Industry	2015/2016 in %	2016/2017 in %
Mining	10.7	10.6
Chemical industry	27.0	26.7
Iron and steel industry	17.7	17.8
Textile industry	2.2	2.2
Paper and cellulose industry	17.1	17.6
Potassium, aluminium, glass and cement industry	0.5	0.5
Oil refineries, petrol industry	10.3	10.2
Apparatus industry, electrical and automotive industry, shipyard	10.5	10.4
Rubber, linoleum and leather industry	0.3	0.3
Breweries, food and washing-agent industry	1.0	1.0
Waste management and recycling	2.7	2.7
Total	100.0	100.0

List of ordinary, affiliated and sponsoring VGB Members

(Status: June 30, 2017)

Ordinary members

3M Deutschland GmbH, Wuppertal, Germany

Abfallwirtschaftsbetrieb des Landkreises Neu-Ulm
Weißenhorn, Germany

Abfallwirtschaftsbetrieb Stadt Nürnberg, Nuremberg, Germany

Air Liquide Industrie B.V., Rotterdam, Netherlands

Allessa GmbH, Frankfurt am Main, Germany

AMK – Abfallentsorgungsgesellschaft des Märkischen Kreises mbH,
Iserlohn, Germany

AS Latvenergo, Riga, Latvia

AVA Velsen mbH, Saarbrücken, Germany

AVBKG Abfallverbrennungs- und Biokompost-Gesellschaft mbH,
Tornesch-Ahrenlohe, Germany

AVEA Entsorgungsbetriebe GmbH & Co. KG,
Engelskirchen, Germany

AVG Abfallentsorgungs- und Verwertungsgesellschaft Köln mbH,
Cologne, Germany

AVR-Afvalverwerking B. V., Duiven, Netherlands

AWG Abfallwirtschaftsgesellschaft mbH Wuppertal,
Wuppertal, Germany

Axpo Power AG, Baden, Switzerland

Basell Polyolefine GmbH, Wesseling, Germany

BASF SE, Ludwigshafen (Rhein), Germany

Bayer AG, Bergkamen, Germany

Bayer AG, Berlin, Germany

Bayer AG, Leverkusen, Germany

Bayernfonds BestEnergy 1 GmbH & Co. KG,
Schkeudits, Germany

BEKW Bioenergiekraftwerk Emsland GmbH & Co. KG,
Emlichheim, Germany

Berliner Stadtreinigungsbetriebe, Berlin, Germany

BioMa Energie AG, Salzburg, Austria

biotherm Hagenow GmbH, Hagenow, Germany

BKW ENERGIE AG, Berne, Switzerland

BMC Moerdijk BV, Moerdijk, The Netherlands

Boehringer Ingelheim Pharma KG, Ingelheim am Rhein, Germany

BP Europa SE, Lingen/Ems, Germany

Brauerei Beck GmbH & Co. KG, Bremen, Germany

Braunschweiger Versorgungs-AG & Co. KG,
Braunschweig, Germany

Bremerhavener Entsorgungsgesellschaft mbH,
Bremerhaven, Germany

Cargill Deutschland GmbH, Krefeld, Germany

Centrales Nucleares Almaraz Trillo, Madrid, Spain

CEZ a.s., Praha, Czech Republic

Colakoglu Metalurji, Kocaeli, Turkey

Covestro Deutschland AG, Brunsbüttel, Germany

CURRENTA GmbH & Co. OHG, Leverkusen, Germany

Daimler AG, Sindelfingen, Germany

Deutsche Windtechnik X-Service GmbH, Osnabrück, Germany

Donausäge Rumpfmayr GmbH, Enns, Austria
 DONG Energy Power A/S, Fredericia, Denmark
 Dow Deutschland Anlagengesellschaft mbH, Walsrode, Germany
 DREWAG – Stadtwerke Dresden GmbH, Dresden, Germany
 DS Smith Paper Deutschland GmbH, Aschaffenburg, Germany
 DSM Nutritional Products GmbH, Grenzach-Wyhlen, Germany
 E.ON Climate & Renewables GmbH, Essen, Germany
 EdeA v.o.f., Geleen, Netherlands
 EDP Gestao da Producao de Energia S. A., Lisbon, Portugal
 EEW Energy from Waste GmbH, Helmstedt, Germany
 EEW Energy from Waste Stavenhagen GmbH & Co. KG, Stavenhagen, Germany
 Egger Holzwerkstoffe Brilon GmbH & Co. KG, Brilon, Germany
 EGK Entsorgungsgesellschaft Krefeld GmbH & Co KG, Krefeld, Germany
 Electrabel Nederland n.v., Zwolle, Netherlands
 Electricite de France, Paris, France
 EnBW Energie Baden-Württemberg AG, Stuttgart, Germany
 EnBW Kernkraft GmbH, Obrigheim am Neckar, Germany
 ENEL Ingegneria e Ricerca S.p.A., Roma, Italy
 ENERGIE AG Oberösterreich, Linz, Austria
 Energie Eolienne du Maroc, Casablanca, Morocco
 Energie und Wasser Potsdam GmbH, Potsdam, Germany
 Energiedienst AG, Rheinfelden, Germany
 Energieservice Westfalen Weser GmbH, Kirchlegern, Germany
 Energieversorgung Oberhausen AG (EVO), Oberhausen, Germany
 Energieversorgung Offenbach AG, Offenbach am Main, Germany
 Enertec Hameln GmbH, Hameln, Germany
 ENTEGA AG, Darmstadt, Germany
 envia THERM GmbH, Halle, Germany
 EPZ, Vlissingen, Netherlands
 ERZ Entsorgung + Recycling Zürich, Zürich, Switzerland
 ESB Electricity Supply Board, Dublin, Ireland
 ESKOM Johannesburg, South Africa
 Essent, Eindhoven, Netherlands
 EVN AG, Maria Enzersdorf am Gebirge, Austria
 Evonik Industries AG, Marl, Germany
 EWN Entsorgungswerk für Nuklearanlagen GmbH, Lubmin, Germany
 Fernwärme Ulm GmbH (FUG), Ulm, Germany
 Fjernvarme Fyn A/S, Odense, Denmark
 Forsmarks Kraftgrupp AB, Östhammar, Sweden
 Fortum Power and Heat Oy, Fortum, Finland
 Fraunhofer Institut Umwelt-, Sicherheits-, Energietechnik UMSICHT, Oberhausen, Germany
 Freudenberg & Co. KG, Weinheim, Germany
 GDF SUEZ – ELECTRABEL, Brussels, Belgium
 Gebr. Lang GmbH Papierfabrik, Ettringen, Germany
 Gemeinschaftskraftwerk Weser GmbH & Co. oHG, Emmerthal, Germany
 Gemeinschafts-Müll-Verbrennungsanlage Niederrhein GmbH, Oberhausen, Germany
 GfA – Gemeinsames Kommunalunternehmen für Abfallwirtschaft, Olching, Germany
 GHP Glunz Holzwerkstoffproduktions GmbH, Horn-Bad Meinberg, Germany
 GKS Gemeinschaftskraftwerk Schweinfurt GmbH, Schweinfurt, Germany
 Grace GmbH & Co. KG, Worms, Germany
 Grosskraftwerk Mannheim AG, Mannheim, Germany
 Gunvor Raffinerie Ingolstadt GmbH, Ingolstadt, Germany
 Heizkraftwerk Pfaffenwald der Universität Stuttgart, Stuttgart, Germany
 Heizkraftwerk Pforzheim GmbH, Pforzheim, Germany
 Heizkraftwerk Würzburg GmbH, Würzburg, Germany
 Heizkraftwerksgesellschaft Cottbus GmbH, Cottbus, Germany
 Helen Ltd., Helsinki, Finland
 Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany
 HIM GmbH, Biebesheim, Germany
 HOFOR A/S, Copenhagen, Denmark
 Huntsman P&A Germany GmbH, Duisburg, Germany
 INEOS Manufacturing Deutschland GmbH, Cologne, Germany
 InfraServ GmbH & Co Höchst KG, Frankfurt a.M., Germany
 InfraServ GmbH & Co. Gendorf KG, Burgkirchen, Germany
 InfraServ GmbH & Co. Wiesbaden KG, Wiesbaden, Germany
 innogy SE, Essen, Germany
 Iskenderun Enerji Üretim Ve Tic. A. S., Ankara, Turkey
 Javno Podjete Energetika Ljubljana p.o., Ljubljana, Slovenia
 JELD-WEN Deutschland GmbH & Co. KG, Mittweida, Germany
 Jülicher Entsorgungsgesellschaft für Nuklearanlagen mbH (JEN), Jülich, Germany
 Jungbunzlauer Ladenburg GmbH, Ladenburg, Germany
 K+S Aktiengesellschaft, Kassel, Germany
 KAMMERER Energie GmbH, Osnabrück, Germany
 Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany
 KELAG-Kärntner Elektrizitäts-AG, Klagenfurt, Austria
 Kernkraftwerk Gösgen-Däniken AG, Däniken, Switzerland
 Kernkraftwerk Leibstadt AG, Leibstadt, Switzerland
 KNG Kraftwerks- und Netzgesellschaft mbH, Rostock, Germany
 Kraftwerk Mehrum GmbH, Hohenhameln, Germany
 Kraftwerk Obernburg GmbH, Obernburg, Germany
 Kraftwerke Mainz-Wiesbaden AG, Mainz, Germany
 Laborelec S. A. (for the GDF Suez Group), Linkebeek, Belgium
 Lahti Energia Oy, Lahti, Finland
 Lappeenranta Lämpövoima Oy, Lappeenranta, Finland
 Lausitz Energie Kraftwerke AG, Cottbus, Germany
 Lech-Elektrizitätswerke AG, Augsburg, Germany
 Lenzing AG, Lenzing, Austria
 Mainova AG, Frankfurt am Main, Germany
 Mälarenergi AB, Västerås, Sweden
 Mark-E Aktiengesellschaft, Hagen, Germany

Martinswerk GmbH, Bergheim, Germany
 MAYR-MELNHOF KARTON GmbH, Frohnleiten, Austria
 Meridian Energy Australia Pty Ltd., Chatswood NSW, Australia
 MHB Hamm Betriebsführungsgesellschaft mbH, Hamm, Germany
 MIBRAG mbH, Zeitz, Germany
 MIRO Mineraloelraffinerie Oberrhein GmbH & Co. KG, Karlsruhe, Germany
 Mondi Neusiedler GmbH, Ulmerfeld, Austria
 Moritz J. Weig GmbH & Co. KG, Mayen, Germany
 Müllheizkraftwerk Kassel GmbH, Kassel, Germany
 Müllverbrennungsanlage Bielefeld-Herford GmbH, Bielefeld, Germany
 Müllverbrennungsanlage der Stadt Solingen, Solingen, Germany
 MVV Energie AG, Mannheim, Germany
 N.V. Delta Nutsbedrijven, Middelburg, Netherlands
 Nettingsdorfer Papierfabrik AG & Co KG, Haid bei Anselden, Austria
 Nucleoelectrica Argentina SA, Buenos Aires, Argentina
 Nuon Energie & Service GmbH, Heinsberg/Oberbruch, Germany
 Nuon Power Buggenum, Buggenum, Netherlands
 OMV Deutschland GmbH, Burghausen, Germany
 OMV Refining & Marketing GmbH, Vienna, Austria
 OXEA GmbH, Oberhausen, Germany
 Papierfabrik August Koehler SE, Oberkirch, Germany
 Papierfabrik Meldorf GmbH & Co. KG, Tornesch, Germany
 Perstorp Chemicals GmbH, Arnsberg, Germany
 Pfeifer & Langen GmbH & Co. KG, Cologne, Germany
 Pfeleiderer Baruth GmbH, Baruth/Mark, Germany
 PreussenElektra GmbH, Hanover, Germany
 Public Power Corporation S. A., Athens, Greece
 PVO-Lämpövoima Oy, Vaasa, Finland
 R.D.M. Arnsberg GmbH, Arnsberg, Germany
 RAG Anthrazit Ibbenbüren GmbH, Ibbenbüren, Germany
 REMONDIS Production GmbH, Lünen, Germany
 RheinEnergie AG, Cologne, Germany
 Romande Energie SA, Morges, Switzerland
 ROMONTA GmbH, Seegebiet Mansfelder Land, Germany
 RWE AG, Essen, Germany
 RWTH Aachen, Aachen, Germany
 Salzburg AG, Salzburg, Austria
 Salzgitter Flachstahl GmbH, Salzgitter, Germany
 Sappi Austria Produktions-GmbH Co. KG, Gratkorn, Austria
 SCA Hygiene Products GmbH, Mannheim, Germany
 Schluchseewerk AG, Laufenburg, Germany
 SEO Societé de l'Our Centrale de Vianden, Vianden, Luxembourg
 Shuaibah Water & Electricity Company, Jeddah, Saudi Arabia
 Smurfit Kappa Herzberg Solid Board GmbH, Herzberg am Harz, Germany
 Smurfit Kappa Zülrich Papier GmbH, Zülrich, Germany
 Solvay Acetow GmbH, Freiburg, Germany

Solvay Chemicals GmbH, Rheinberg, Germany
 SRS EcoTherm GmbH, Salzbergen, Germany
 SSAB Special Steels, Oxelösund, Sweden
 Städtische Werke Energie + Wärme GmbH, Kassel, Germany
 Stadtreinigung Hamburg, Hamburg, Germany
 Stadtwerke Augsburg Energie GmbH, Augsburg, Germany
 Stadtwerke Bielefeld GmbH, Bielefeld, Germany
 Stadtwerke Bochum Holding GmbH, Bochum, Germany
 Stadtwerke Duisburg AG, Duisburg, Germany
 Stadtwerke Düsseldorf AG, Düsseldorf, Germany
 Stadtwerke Flensburg GmbH, Flensburg, Germany
 Stadtwerke Hannover AG, Hanover, Germany
 Stadtwerke Leipzig GmbH, Leipzig, Germany
 Stadtwerke Münster GmbH, Münster, Germany
 Stadtwerke Rosenheim GmbH & Co. KG, Rosenheim, Germany
 Stadtwerke Rostock AG, Rostock, Germany
 Stadtwerke Saarbrücken GmbH, Saarbrücken, Germany
 STEAG GmbH, Essen, Germany
 Stora Enso Maxau GmbH, Karlsruhe-Maxau, Germany
 SWB Energie- und Wasserversorgung Bonn/Rhein-Sieg GmbH, Bonn, Germany
 swb Entsorgung GmbH & Co. KG, Bremen, Germany
 swb Erzeugung AG & Co. KG, Bremen, Germany
 SWB Verwertung MVA Bonn GmbH, Bonn, Germany
 SWN Stadtwerke Neumünster GmbH, Neumünster, Germany
 Tampereen Sähkölaitos, Tampere, Finland
 TAURON Wytwarzanie S.A., Katowice, Poland
 TEAtherm GmbH, Dinkelsbühl, Germany
 Technische Hochschule Lund, Lund, Sweden
 Technische Universität München, Forschungsneutronenquelle Heinz Maier-Leibnitz (FRM II), Garching, Germany
 Technische Werke Ludwigshafen AG, Ludwigshafen am Rhein, Germany
 Teollisuuden Voima Oyj, Eurajoki, Finland
 Thyssen Krupp Steel AG, Duisburg, Germany
 TIWAG-Tiroler Wasserkraft AG, Innsbruck, Austria
 Trianel Gaskraftwerk Hamm GmbH & Co. KG, Aachen, Germany
 Trianel Kohlekraftwerk Lünen GmbH & Co. KG, Lünen, Germany
 Twence BV, Hengelo, The Netherlands
 Uniper Benelux N.V., Rotterdam, The Netherlands
 Uniper Kraftwerke GmbH, Düsseldorf, Germany
 Universität Göttingen, Göttingen, Germany
 UPM-Kymmene Austria GmbH, Steyrermühl, Austria
 Vantaan Energia Oy, Vantaa, Finland
 Vaskiluodon Voima Oy, Vaasa, Finland
 Vattenfall Europe New Energy GmbH, Hamburg, Germany
 Vattenfall Europe Nuclear Energy GmbH, Hamburg, Germany
 Vattenfall Europe Wärme AG, Berlin, Germany
 Vattenfall Vindkraft AB, Stockholm, Sweden
 Vattenfall Wärme Hamburg GmbH, Hamburg, Germany

Vattenfall Wasserkraft GmbH, Hohenwarte, Germany
 Veolia Industriepark Deutschland GmbH,
 Heinsberg/Oberbruch, Germany
 VERBUND Hydro Power GmbH, Vienna, Austria
 VERBUND Thermal Power GmbH & Co. KG, Graz, Austria
 voestalpine Stahl GmbH, Linz, Austria
 Vorarlberger Illwerke AG, Schruns, Austria
 VSE AG, Ensding, Germany
 VW Kraftwerk GmbH, Wolfsburg, Germany
 Wels Strom GmbH, Wels, Austria
 wep Wärme-, Energie- und Prozesstechnik GmbH,
 Hückelhoven, Germany
 WIEN ENERGIE GmbH, Vienna, Austria
 WIEN ENERGIE GMBH, Betriebsstätte Spittelau, Vienna, Austria
 WindMW Service GmbH, Bremerhaven, Germany
 Windtest Grevenbroich GmbH, Grevenbroich, Germany
 WSW Energie und Wasser AG, Wuppertal, Germany
 YTL Power Services Sdn Bhd, Kuala Lumpur, Malaysia
 Zellstoff Pöls AG, Pöls, Austria
 Zellstoff Stendal GmbH, Arneburg, Germany
 Zweckverband Abfallverwertung Südostbayern,
 Burgkirchen, Germany
 Zweckverband für Abfallwirtschaft Südwestthüringen,
 Zella-Mehlis, Germany
 Zweckverband Müllverwertung Schwandorf, Schwandorf,
 Germany
 Zweckverband Müllverwertungsanlage Ingolstadt,
 Ingolstadt, Germany
 Zweckverband Restmüllheizkraftwerk Böblingen (RBB),
 Böblingen, Germany

Affiliated members

AGR Abfallentsorgungsgesellschaft Ruhrgebiet mbH,
 Herten, Germany
 ALL-RUSSIA THERMAL ENGINEERING INSTITUTE,
 Moskva, Russia
 AUCOTEC, Hanover, Germany
 Bundesverband der Deutschen Kalkindustrie e. V.,
 Cologne, Germany
 DBFZ Deutsches BiomasseForschungsZentrum
 gemeinnützige GmbH, Leipzig, Germany
 DBI Gas- und Umwelttechnik GmbH, Leipzig, Germany
 DEKRA Solutions BV, Arnhem, The Netherlands
 DTU Mechanical Engineering, Lyngby, Denmark
 EKONERG, Zagreb, Croatia
 Elektroistitut Milan Vidmar, Ljubljana, Slovenia
 Fachverband Dampfkessel, Behälter- und Rohrleitungsbau e.V.,
 Düsseldorf, Germany
 FORCE Technology, Broendby, Denmark
 Fraunhofer-Institut für Werkstofftechnik IWM, Freiburg, Germany
 Germanischer Lloyd SE, Hamburg, Germany
 Helmholtz-Zentrum Geesthacht Zentrum für Material- und
 Küstenforschung GmbH, Geesthacht, Germany
 ICEMENERG – Institut für Forschung und Modernisierung der
 Energiewirtschaft, Bucharest, Romania
 Japan Coal Energy Center, Tokyo Minato-ku, Japan
 JSC ATOMENERGOPROEKT, Moskva, Russia
 K2 Management GmbH, Hamburg, Germany
 KRAFTWERKSSCHULE E.V., Essen, Germany
 KSG Kraftwerks-Simulator-Gesellschaft mbH, Essen, Germany
 MPA Stuttgart, Materialprüfungsanstalt Universität Stuttgart –
 Abteilung Werkstoffverhalten, Stuttgart, Germany
 Müller und Medenbach GmbH, Gladbeck, Germany
 SP Technical Research Institute of Sweden – Energy Technology
 Boras, Sweden
 Technische Universität Darmstadt – Fachgebiet und Institut für
 Werkstoffkunde, Darmstadt, Germany
 The Government Implementing Agency ENERGY Authority
 Ulaanbaatar, Mongolia
 TÜV AUSTRIA SERVICES GmbH, Vienna, Austria
 TÜV Nord Systems GmbH & Co. KG, Hamburg, Germany
 TÜV Rheinland Industrie Service GmbH, Cologne, Germany
 TÜV Süd Industrie Service GmbH, Munich, Germany
 TÜV Technische Überwachung Hessen GmbH,
 Darmstadt, Germany
 TÜV Thüringen e.V., Erfurt, Germany
 Verband der TÜV e.V. (VdTÜV), Berlin, Germany

Sponsoring members

3P-Solutions S. A., Echternach, Luxembourg
ABB AG – Division Energietechnik, Mannheim, Germany
Abeinsa Business Development SA, Sevilla, Spain
admeritia GmbH, Langenfeld, Germany
Allianz Risk Consulting GmbH, Munich, Germany
Amec Foster Wheeler Energia Oy, Espoo, Finland
ANDRITZ AG, Raaba, Graz, Austria
Andritz Hydro GmbH, Ravensburg, Germany
ARCA Regler GmbH, Tönisvorst, Germany
Areva GmbH, Erlangen, Germany
AXA Corporate Solutions, Cologne, Germany
B&B-Agema GmbH, Aachen, Germany
Balcke-Dürr GmbH, Düsseldorf, Germany
Bertsch Energy GmbH & Co. KG, Bludenz, Austria
Bechmann, Dr., Cologne, Germany
Bilfinger SE, Oberhausen, Germany
BHK Aindling GmbH, Herten, Germany
Bockhold, Dr., Marl, Germany
Bopp & Reuther Sicherheits- und Regelarmaturen GmbH,
Mannheim, Germany
Braun Industrieservice, Dortmund, Germany
Brenner GmbH, Bürstadt, Germany
Burmeister & Wain Energy A/S, Kgs. Lyngby, Denmark
C.C. Jensen A/S, Svendborg, Denmark
Caliqua AG, Basel, Switzerland
Camfil Power Systems GmbH, Bremen, Germany
CARMEUSE, Louvain-la-Neuve, Belgium
Chubb European Group Ltd., Düsseldorf, Germany
Clyde Bergemann GmbH, Wesel, Germany
Conco Systems SPRL, Lillois, Belgium
Container Company GmbH & Co. KG, Krefeld, Germany
Daume Regelarmaturen GmbH, Isernhagen, Germany
Deloro Wear Solutions, Koblenz, Germany
Diamond Power Germany GmbH, Zörbig, Germany
DOK-ING d.o.o., Zagreb, Croatia
Doosan Babcock Energy Germany GmbH, Hohenthurm, Germany
Doosan Lentjes GmbH, Ratingen, Germany
DURAG GmbH, Hamburg, Germany
EBINGER Katalysatorservice GmbH & Co. KG,
Wildeshausen, Germany
Ed. Züblin AG, Duisburg, Germany
Eisenkrein, Ms., Bochum, Germany
EMIS Electrics GmbH, Lübbecke, Germany
enco Energie- und Verfahrens-Consult GmbH,
Braunschweig, Germany
Energoinstal SA, Katowice, Poland
ENEXIO Germany GmbH, Bochum, Germany
Envirotherm GmbH, Essen, Germany
ERC Emissions-Reduzierungs-Concepte GmbH,
Buchholz, Germany

ESI Eurosilo BV, Purmerend, Netherlands
ETABO Energietechnik und Anlagenservice GmbH,
Bochum, Germany
EthosEnergy GmbH, Mülheim, Germany
Eugen Arnold GmbH, Filderstadt, Germany
Eutech Scientific Engineering GmbH, Aachen, Germany
F & S Prozessautomation GmbH, Dohna, Germany
Fichtner GmbH & Co. KG, Stuttgart, Germany
Flowserve Service Center Ost, Launa, Göhren, Germany
FLSmidth Hamburg GmbH, Pinneberg, Germany
FMT Industrieholding GmbH, Wels, Austria
FUEL TECH S.r.l., Gallarate, Italy
GABO IDM mbH, Erlangen, Germany
GE Power AG, Mannheim, Germany
Georg Hagelschuer GmbH & Co. KG, Dülmen, Germany
GESTRA AG, Bremen, Germany
GFI – Kennflex mbH, Buchholz, Germany
GiS Gesellschaft für integrierte Systemplanung mbH,
Erlangen, Germany
GNS Gesellschaft für Nuklear-Service mbH,
Essen, Germany
GWT Gesellschaft für Wasser- und Wärmetechnik GmbH,
Leobersdorf, Germany
Hamon Enviroserv GmbH, Essen, Germany
Hamon Thermal Germany GmbH, Bochum, Germany
Harrer Turbine Consult, Vienna, Austria
HDI-Gerling Industrie Versicherung AG, Hanover, Germany
HDI-Gerling Sicherheitstechnik GmbH, Hanover, Germany
Heitkamp Ingenieur- und Kraftwerksbau GmbH, Essen, Germany
Hochtief Solutions AG, Essen, Germany
Holter Regelarmaturen GmbH & Co. KG,
Schloss Holte-Stukenbrock, Germany
Howden Ventilatoren GmbH, Heidenheim, Germany
HYDAC TECHNOLOGY GMBH, Sulzbach (Saar), Germany
Hydro-Engineering GmbH, Mülheim an der Ruhr, Germany
IEM Fördertechnik GmbH, Kastl, Germany
IHI Corporation, Tokyo, Japan
Ingenieurbüro Björn Reese GmbH, Gummersbach, Germany
Ingenieurbüro GABO GmbH, Leipzig, Germany
Ingenieure Prof. Sturm + Partner GmbH, Dresden, Germany
INP Deutschland GmbH, Römerberg, Germany
Inwatec GmbH & Co. KG, Bergheim, Germany
IRS GmbH, Mannheim, Germany
Japan Nus Co. Ltd., Tokio, Japan
Kaefer Industrie GmbH, Bremen, Germany
Knick Elektronische Messgeräte GmbH & Co. KG, Berlin, Germany
Kohler, Dr., Heilbronn, Germany
Konrad M & R GmbH, Gundremmingen, Germany
Kraftanlagen München GmbH, Munich, Germany
Krätzig & Partner Ingenieurgesellschaft, Bochum, Germany
Krohne Messtechnik GmbH, Duisburg, Germany
Kurita Europe GmbH, Ludwigshafen, Germany

Küttner Energy & Environment GmbH, Essen, Germany
 La Mont GmbH, Berlin, Germany
 LAB GmbH, Stuttgart, Germany
 Lahmeyer International GmbH, Bad Vilbel, Germany
 Lanxess Deutschland GmbH, Köln, Germany
 LISEGA SE, Zeven, Germany
 Lloyd's Register Quality Assurance GmbH, Cologne, Germany
 Magaldi Power S.p.A., Salerno, Italy
 MAN Diesel & Turbo SE, Oberhausen, Germany
 Marsh GmbH, Düsseldorf, Germany
 MC-Bauchemie Müller GmbH & Co. KG, Bottrop, Germany
 ME-Automation Projects GmbH, Fulda, Germany
 Menger Engineering GmbH, Leipzig, Germany
 Minimax GmbH & Co. KG, Bad Oldesloe, Germany
 Mitsubishi Hitachi Power Systems Europe GmbH,
 Duisburg, Germany
 Mitsubishi Hitachi Power Systems Europe Ltd.,
 Vienna, Austria
 MPC Industrietechnik GmbH, Hamm, Germany
 MPG Mendener Präzisionsrohr GmbH, Menden, Germany
 Müller-BBM GmbH, Planegg, Germany
 Mumberg Engineering GmbH, Krefeld, Germany
 Nalco Deutschland GmbH, Frankfurt am Main, Germany
 National Electric Coil (NEC), Ohio, U.S.A.
 Noakowski, Prof. Dr.-Ing., Düsseldorf, Germany
 NUKEM Technologies Engineering Services GmbH,
 Alzenau, Germany
 NVEnerTech GmbH, Dinslaken, Germany
 OELCHECK GmbH, Brannenburg, Germany
 Outotec GmbH & Co. KG, Oberursel, Germany
 P. V. Energoservis s.r.o., Kadan, Czech Republic
 PELZ GmbH & Co. KG, Moers, Germany
 Pöyry Deutschland GmbH, Hamburg, Germany
 Preller Gesellschaft für Leittechnik mbH,
 Adelsdorf-Aisch, Germany
 Pro Novum Sp.z.o.o., Katowice, Poland
 RAFAKO S.A., Raciborz, Poland
 RAMBOLL IMS, Hamburg, Germany
 Rechtsanwaltskanzlei Geisseler, Freiburg, Germany
 REICON Wärmetechnik und Wasserchemie Leipzig GmbH,
 Leipzig, Germany
 REMBE GmbH, Brilon, Germany
 REWITEC GmbH, Lahnau, Germany
 Richard Kablitz GmbH, Lauda-Königshofen, Germany
 Rico-Werk Eiserlo & Emmrich GmbH, Tönisvorst, Germany
 SAR Elektronik GmbH, Dingolfing, Germany

SBB Energy S.A., Opole, Poland
 Shanghai Electric Group Co. Ltd., Shanghai, China
 Siemens Aktiengesellschaft, Erlangen, Germany
 SIPOS Aktorik GmbH, Altdorf, Germany
 SSB Wind Systems GmbH & Co. KG, Salzbergen, Germany
 Stadler + Schaaf Mess- und Regeltechnik GmbH,
 Offenbach, Germany
 Standardkessel Baumgarte GmbH, Duisburg, Germany
 StoCretec GmbH, Krieffel, Germany
 Stork Technical Services GmbH, Essen, Germany
 STRABAG AG, Düsseldorf, Germany
 Sweco GmbH, Bremen, Germany
 Taproge Gesellschaft mbH, Wetter (Ruhr), Germany
 TEC-RCE GmbH, Lünen, Germany
 TMS Turbomaschinenservice GmbH, Bad Dürkheim, Germany
 TUBACEX S.A., Lugo, Spain
 Turbo-Technik GmbH & Co. KG, Wilhelmshaven, Germany
 UCC Europe GmbH, Moers, Germany
 Uniper Energy Sales GmbH, Düsseldorf, Germany
 VAG-Armaturen GmbH, Mannheim, Germany
 Vallourec Deutschland GmbH, Düsseldorf, Germany
 Valmet Automation GmbH, Leverkusen, Germany
 Valmet GesmbH, Vienna, Austria
 Veltec GmbH & Co. KG, Speyer, Germany
 Veolia Water Technologies Deutschland GmbH, Celle, Germany
 Viessmann Industrial Boiler Solutions GmbH, Dillenburg, Germany
 VINCI Energies Deutschland GmbH, Frankfurt a. M., Germany
 VliegASUNIE B.V., Culemborg, Netherlands
 voestalpine Böhler Welding Germany GmbH, Hamm, Germany
 Voith Hydro GmbH & Co. KG, Heidenheim, Germany
 VPC GmbH, Vetschau/Spreewald, Germany
 W. L. Gore & Associates GmbH, Putzbrunn, Germany
 Wärtsilä Deutschland GmbH, Hamburg, Germany
 Welland & Tuxhorn AG, Bielefeld, Germany
 Wessel GmbH, Xanten, Germany
 Witzemann GmbH, Pforzheim, Germany
 WSB Service Deutschland GmbH, Dresden, Germany
 XERVON Plastocor GmbH, Gelsenkirchen, Germany
 YARA Environmental Technologies GmbH, Vienna, Austria
 ZETCON Ingenieure GmbH, Bochum, Germany
 ZPP Ingenieure AG, Bochum, Germany

Board of Directors

(Status: June 30, 2017)

Executive Board

Bünting, Hans, Dr. (Chairman)
Chief Operating Officer Renewables,
innogy SE,
Essen, Germany

Altmann, Hubertus, Dipl.-Ing.
(1st Vice-Chairman)
Member of the Board of Directors,
Lausitz Energie Kraftwerke AG,
Lausitz Energie Bergbau AG,
Cottbus, Germany

Giger, François, Dr.
(2nd Vice-Chairman)
Manager Strategy,
EDF Fossil-fired Generation and Engineering,
Saint-Denis, France

Frank, Michael J.,
Managing Director/CEO,
Uniper Anlagenservice GmbH,
Gelsenkirchen, Germany

Gruber, Karl-Heinz, Dipl.-Ing. Dr.
Member of the Managing Board,
VERBUND Hydro Power GmbH,
Vienna, Austria

Members of the Board

Brockmeier, Udo, Dr.
Chairman of the Board of Directors,
Stadtwerke Düsseldorf AG,
Düsseldorf, Germany

Broos, Wim
Director Fleet Management,
ENGIE,
Brussels, Belgium

Cieslik, Wolfgang, Dr.
Member of the Board of Directors,
STEAG GmbH,
Essen, Germany

Elsen, Reinhold, Prof. Dr.
Head of Research and Development,
RWE Power AG,
Essen, Germany

Fuchs, Michael, Dr.
Senior Vice President Technology,
PreussenElektra GmbH,
Hanover, Germany

Hilken, Günter, Dr.
Chairman of the Executive Board,
Currenta GmbH & Co. OHG,
CHEMPARK Leverkusen, Germany

Janas, Jacek
President of the Management Board,
TAURON Wytwarzanie S.A.,
Jaworzno, Poland

Jašek, Martin
Asset Management Director,
ČEZ, a.s.,
Praha, Czech Republic

Koko, Matshela,
CEO,
Eskom Holdings SOC Limited,
Sunninghill, South Africa

Mathis, Rolf W.
Director Hydraulische Energie,
Axpo Power AG | Hydroenergie,
Baden, Switzerland

Michels, Jörg
General Manager,
EnBW Kernkraft GmbH,
Philippsburg, Germany

Miesen, Roger
Chief Technical Officer (CTO),
Hard Coal, Gas, Biomass, Nuclear Power,
RWE Generation SE,
Essen, Germany

Petersen, Maren, Dr.
Division Manager Generation,
BDEW Bundesverband der Energie- und Wasserwirtschaft e.V.,
Berlin, Germany

Roll, Hansjörg, Dr.
Member of the Managing Board,
MVV Energie AG,
Mannheim, Germany

Schumacher, Manfred
Member of the Board,
Chief Technical Officer,
Grosskraftwerk Mannheim AG,
Mannheim, Germany

Stamatelopoulos, Georgios, Dr.,
Senior Vice President Generation,
EnBW Energie Baden-Württemberg AG,
Stuttgart, Germany

Testa, Roberto,
Head of Engineering and Technical Support,
ENEL,
Roma, Italy

van Ofwegen, Alexander
Directeur Nuon Warmte,
Head of BU Heat Netherlands,
Nuon Warmte,
Amsterdam, The Netherlands

Executive Managing Director

Christensen, Erland
VGB PowerTech e.V.,
Essen, Germany

Technical Advisory Board Committee (TABCOM)

(Status: June 30, 2017)

Giger, François, Dr. (Chairman)
Manager Strategy,
EDF Fossil-fired Generation and Engineering,
Saint-Denis, France

Benesch, Wolfgang, Prof. Dr.-Ing.
(Vice Chairman)
Director Energy Technology,
STEAG Energy Services GmbH, Essen, Germany

Elze, Nikolaus, Dipl.-Ing.
Head of Technology,
EnBW Energie Baden-Württemberg AG,
Stuttgart, Deutschland

Harreiter, Herfried, Dipl.-Ing.,
Prokurist, Leiter Instandhaltung,
VERBUND Hydro Power GmbH,
Vienna, Austria

Jürgens, Bernd, Dr.
Leiter Kraftwerke,
Currenta GmbH & Co. OHG,
Leverkusen, Germany

Kahlert, Joachim, Dipl.-Ing.
Prokurist, Director Power Plant Development
Lausitz Energie Kraftwerke AG,
Cottbus, Germany

Keustermans, Jean-Pierre, Dr. ir.
Research Partnership Manager,
ENGIE LAB Laborelec,
Linkebeek, Belgium

Klemp, Karsten, Dr.-Ing.
Head of Power Plants,
RheinEnergie AG,
Cologne, Germany

Szynol, Kazimierz, Dipl.-Ing.
Director, TAURON Wytwarzanie SA,
Jaworzno, Poland

VGB Secretariat

Christensen, Erland
Executive Managing Director

Bachhiesl, Mario, Dr.
Head of Renewables and Distributed Generation,
Health & Safety

Mohrbach, Ludger, Dr.
Head of Nuclear Power Plants

Then, Oliver, Dr.
Head of Power Plant Technologies
VGB PowerTech e.V., Essen, Germany

Technical Advisory Board (TAB)

(Status: June 30, 2017)

Giger, François, Dr. (Chairman)
Manager Strategy,
EDF Fossil-fired Generation and Engineering,
Saint-Denis, France

Benesch, Wolfgang, Prof. Dr.-Ing.
(Vice Chairman)
Director Energy Technology,
STEAG Energy Services GmbH, Essen, Germany

Aumüller, Adolf, Dr. techn.
Geschäftsleiter Kraftwerke,
EVN AG,
Maria Enzersdorf, Austria

Bonfanti, Stefano
Head of Process Equipment Engineering,
Enel Ingegneria e Innovazione SpA,
Milano, Italy

Danwerth, Klaus, Dipl.-Ing.,
Manager Power Plants,
Stadtwerke Bielefeld GmbH, Bielefeld, Germany

Elze, Nikolaus, Dipl.-Ing.
Head of Technology,
EnBW Energie Baden-Württemberg AG,
Stuttgart, Deutschland

Giehl, Martin, Dipl.-Ing.
Head of Technical Controlling, Environment &
Quality Management,
Stadtwerke Düsseldorf AG, Düsseldorf, Germany

Gutschek, Andreas, Dipl.-Ing.
Stadtwerke Duisburg AG, Duisburg, Germany

Harreiter, Herfried, Dipl.-Ing.,
Prokurist, Leiter Instandhaltung
VERBUND Hydro Power GmbH
Vienna, Austria

Kahlert, Joachim, Dipl.-Ing.
Prokurist, Director Power Plant Development
Lausitz Energie Kraftwerke AG,
Cottbus, Germany

Keustermans, Jean-Pierre, Dr. ir.
Research Partnership Manager,
ENGIE LAB Laborelec,
Linkebeek, Belgium

Klemp, Karsten, Dr.-Ing.
Head of Power Plants,
RheinEnergie AG, Cologne, Germany

Koko, Matshela,
CEO,
Eskom Holdings SOC Limited,
Sunninghill, South Africa

Kollenda, Christoph, Dipl.-Ing.
Stadtwerke Hannover AG,
Hanover, Germany

Linkevics, Olegs, Dr.
Head of Development Sections,
AS Latvenergo, Riga, Latvia

Manns, Joachim, Dr.
Executive Managing Director,
MVV Umwelt GmbH, Mannheim, Germany

Meijer, Ronald
Head of Section Green Thermal Power & Environmental
Compliance Management
DNV GL Energy, Arnhem, The Netherlands

Noyens, Koen,
Manager
EURELECTRIC AISBL, Brussels, Belgium

Pohl, Wolfgang, Dipl.-Ing.
Head of Section,
RWE Power AG, Essen, Germany

Preziati, Simone Giangiacomo
EDP Gestao da Producao de Energia, S.A.,
Lisaboa, Portugal

Struckmann, Peter, Dr.
Head of Asset Risk & Governance,
Uniper Kraftwerke GmbH,
Düsseldorf, Germany

Suomi, Juha
Head of International Q&M,
Fortum Power and Heat Oy, Espoo, Finland

Szynol, Kazimierz, Dipl.-Ing.
Director, TAURON Wytwarzanie SA, Jaworzno, Poland

Witt, Markus, Dipl.-Ing.
Prokurist, Direktor System Optimization,
Vattenfall Europe Wärme AG, Berlin, Germany

VGB Secretariat

Christensen, Erland
Executive Managing Director

Bachhiesl, Mario, Dr.
Head of Renewables and Distributed Generation

Mohrbach, Ludger, Dr.
Head of Nuclear Power Plants

Polenz, Sabine,
R&D Coordination

Then, Oliver, Dr.
Head of Power Plant Technologies

VGB PowerTech e.V., Essen, Germany

Scientific Advisory Board

(Status: June 30, 2017)

Elsen, Reinhold (Chairman)
Head Research & Development
RWE Power AG, Essen, Germany

Görner, Klaus, Prof. Dr. (Vice-Chairman)
Lehrstuhl für Umweltverfahrenstechnik und Anlagentechnik,
Universität Duisburg-Essen, Germany

Bauer, Hans-Jörg, Prof. Dr.
Lehrstuhl und Institut für Thermische Strömungsmaschinen,
Karlsruher Institut für Technologie, Karlsruhe, Germany

Beckmann, Michael, Prof. Dr.
Institut für Energietechnik, Fakultät für Maschinenwesen,
Technische Universität Dresden, Dresden, Germany

Betzüge, Marc Oliver, Prof. Dr.
Energiewirtschaftliches Institut an der Universität zu Köln
Cologne, Germany

Chmielniak, Tadeusz, Prof.
Institute of Machines and Power Generation,
Silesian University of Technology, Gliwice, Poland

D'Haeseleer, William, Prof. Dr. ir.
Energy Institute, Katholieke Universiteit Leuven,
Leuven, Belgium

Dam-Johansen, Kim, Prof. Dr.
Technical University of Denmark,
Dept. of Chemical Engineering, Lyngby, Denmark

Eppel, Bernd, Prof. Dr.
Institut Energiesysteme und Energietechnik,
Technische Universität Darmstadt, Darmstadt, Germany

Haider, Markus, Prof.
Institut für Energietechnik und Thermodynamik,
Technische Universität Vienna, Austria

Hald, John, Prof.
Technical University of Denmark,
Department of Mechanical Engineering, Lyngby, Denmark

Hrdlička, František, Prof.
Czech Technical University in Prague,
Faculty of Mechanical Engineering, Praha, Czech Republic

Hupa, Mikko, Prof. Dr.
Process Chemistry Centre,
Åbo Akademi University, Åbo, Finland

Hurtado, Antonio, Prof. Dr. habil.
Professur für Wasserstoff- und Kernenergietechnik,
Technische Universität Dresden, Dresden, Germany

Janicka, Johannes, Prof. Dr.
Fachgebiet für Energie- und Kraftwerkstechnik,
Technische Universität Darmstadt, Germany

Johnsson, Filip, Prof.
Chalmers University of Technology, Energy and Environment,
Division of Energy Technology, Gothenborg, Sweden

Kakaras, Emmanouil K., Prof. Dr.
School of Mechanical Engineering,
Laboratory of Steam Boilers and Thermal Plants,
National Technical University of Athens, Greece

Kather, Alfons, Prof. Dr.
Institut für Energietechnik,
TU Hamburg-Harburg, Germany

Kneer, Reinhold, Prof. Dr.
Lehrstuhl für Wärme- und Stoffübertragung,
RWTH Aachen, Aix-la-Chapelle, Germany

Krautz, Hans-Joachim, Prof. Dr.
Lehrstuhl für Kraftwerkstechnik,
Brandenburgische Technische Universität, Cottbus, Germany

Macchi, Ennio, Prof.
Politecnico di Milano, Energy Department, Milano, Italy

Mark, Peter, Prof.
Ruhr-Universität Bochum, Fakultät für Bau- und
Umweltingenieurwissenschaften, Bochum, Germany

Meyer, Bernd, Prof. Dr.
Lehrstuhl für Energieverfahrenstechnik und
thermische Rückstandsbehandlung,
Technische Universität Bergakademie,
Freiberg, Germany

Oechsner, Matthias, Prof. Dr.
Technische Universität Darmstadt, Fachgebiet und Institut für
Werkstoffkunde, Darmstadt, Germany

Rehtanz, Christian, Prof. Dr.
Technische Universität Dortmund, Lehrstuhl für Energiesysteme
und Energiewirtschaft, Dortmund, Germany

Sauer, Dirk Uwe, Prof.
RWTH Aachen, Institut für Stromrichtertechnik und Elektrische
Antriebe, Aachen, Germany

Scheffknecht, Günter, Prof. Dr.
Institut für Feuerungs- und Kraftwerkstechnik,
Universität Stuttgart, Stuttgart, Germany

Scherer, Viktor, Prof. Dr.
Institut für Energietechnik,
Ruhr-Universität Bochum, Germany

Sekavcnik, Mihael, Prof. Dr.
Fakultät für Maschinenbau, Universität Ljubljana, Slovenia

Spliethoff, Hartmut, Prof. Dr.
Lehrstuhl für Energiesysteme,
Technische Universität München, Munich, Germany

Tsatsaronis, George, Prof. Dr.
Institut für Energietechnik,
Technische Universität Berlin, Berlin, Germany

Weber, Harald, Prof. Dr.
Institut für Elektrische Energietechnik,
Universität Rostock, Germany

Zenz, Gerald, Prof.
Technische Universität Graz, Institut für Wasserbau und
Wasserwirtschaft, Graz, Austria

Guest

Elsen, Reinhold (Chairman)
Head Research & Development
RWE Power AG, Essen, Germany
(ex officio as Chairman of the Technical Advisory Board of VGB)

VGB Secretariat

Christensen, Erland
Executive Managing Director
Mohrbach, Ludger, Dr.
Head of Nuclear Power Plants
Polenz, Sabine
R&D Coordination
VGB PowerTech e.V., Essen, Germany

Board of Trustees of the VGB RESEARCH FOUNDATION

(Status: June 30, 2017)

Board

Bünting, Hans, Dr. (Chairman)
Chief Operating Officer Renewables,
innogy SE,
Essen, Germany

Meixner, Willibald
(Representative of the power plant
manufacturing industry)
Chief Executive Officer, Power and Gas
Siemens AG, Erlangen, Germany

Kather, Alfons, Professor Dr.-Ing.
(Representative of research)
Institut für Energietechnik,
Technische Universität Hamburg-Harburg, Germany

Giger, François, Dr.
Manager Strategy,
EDF Fossil-fired Generation and Engineering,
Saint-Denis, France
(ex officio as 2nd Vice-chairman of VGB PowerTech and
Chairman of the Technical Advisory Board of VGB PowerTech)

Görner, Klaus, Professor Dr.
(Representative of research)
Lehrstuhl für Umweltverfahrens- und Anlagentechnik,
Universität Duisburg-Essen, Germany

Karakas, Emmanouil K., Prof. Dr.
(Representative of research)
School of Mechanical Engineering,
Laboratory of Steam Boilers and Thermal Plants,
National Technical University of Athens, Greece

Members of the Board

Altmann, Hubertus, Dipl.-Ing.
Member of the Board of Directors,
Lausitz Energie Kraftwerke AG,
Lausitz Energie Bergbau AG,
Cottbus, Germany
(ex officio as 1st Vice-chairman of VGB PowerTech)

Elsen, Reinhold
Head Research & Development
RWE Power AG, Essen, Germany
(ex officio as Chairman of Scientific Advisory Board)

Managing Secretary

Christensen, Erland
VGB PowerTech e.V., Essen, Germany

Research Coordinator

Mohrbach, Ludger, Dr.
VGB PowerTech e.V., Essen, Germany

Polenz, Sabine
VGB PowerTech e.V., Essen, Germany

Imprint

Publisher

VGB PowerTech e.V.
Deilbachtal 173
45257 Essen/Germany

Layout

Koch Werbekommunikation
Alfredstraße 61
45130 Essen/Germany

Editing and production

VGB PowerTech Service GmbH
Deilbachtal 173
45257 Essen/Germany

Printing

inpuncto asmuth
druck + medien gmbh
Richard-Byrd-Straße 39
Medienzentrum Ossendorf
50829 Köln

Figure credits

DONG energy

Leag

RWE

Siemens

Steag

Vattenfall

Verbund

