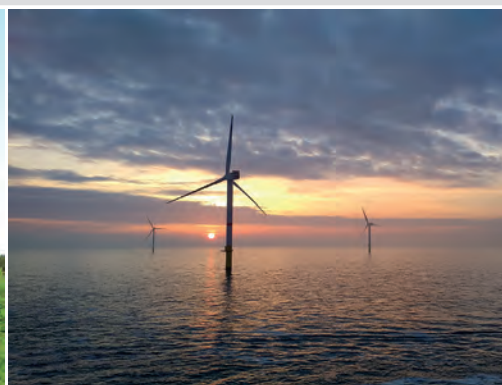


ANNUAL REPORT

1 JULY 2017 TO 30 JUNE 2018



VGB PowerTech Annual Report

1 July 2017 to 30 June 2018

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Preface

Ladies and Gentlemen,

This annual report summarises the results of the work and activities of VGB PowerTech e.V. for the reporting year 2017|2018. VGB is an international professional association and technical competence centre for all topics relating to the generation and storage of electricity and heat. Our member companies are at the centre of our activities. We support them in operational and strategic matters. We are the contact and link for international contacts and the worldwide exchange of experience and knowledge around the core topics of electricity and heat generation and storage. VGB focuses on cost-effectiveness, efficiency, safety, environmental friendliness, and occupational health and safety throughout the life cycle of power plants.

Generation in times of global change and transition

Our industry has always been confronted with challenges for which we find forward-looking solutions with innovations, expertise and the experience and commitment of our employees. Today's processes of change, which can be observed worldwide and are associated with a multitude of topics, have a new, completely different dimension, which goes far beyond energy generation itself. Some characteristic keywords are digitisation, flexibility, security of supply, energy storage, decentralisation, integrated energy, mobility, climate protection and market design.

Therefore, the focus is on the core topic and core competences of our VGB: technology, its efficient and economical application and further development. Solutions to the questions of the future outlined above will always be reflected in the technology of power and heat generation and, increasingly, their storage. In a changing market environment, we are continuously orienting ourselves towards the technical and economic challenges in order to support our members optimally in times of change. Two special features of VGB in its almost 100-year history are certainly its technologically neutral diversity and its cross-technology synergies.

VGB members: Represented and networked internationally

The continuing stable membership structure of VGB is an indication of the extent to which its members appreciate the competence, expertise and work of the association. Our 437 member companies are based in 33 countries worldwide. The European Union remains the most strongly represented region with 414 members. 23 members come from three other European countries or are based in ten countries outside Europe. Expressed in figures, the association represents a total power generation capacity of 302,000 megawatts.

VGB: Active for its members - breaking new ground

VGB is also proactively changing with the challenges and changes in the industry. With a vision and strategy for the complex energy system of the future, we adapt the structures and the range of services of the association to the changing requirements of its members in order to support them with an optimum portfolio. Our competence areas «Power Plant Technologies», «Renewables and Distributed Generation», «Nuclear Power Plants» and «Environmental Technology, Chemistry, Safety and Health» provide the basis for this, with work platforms increasingly based on digital communication. The portfolio is supplemented by the «Technical Services» comprising services in the fields of engineering consultancy, construction and installation supervision, the materials laboratory and water chemistry. A new addition here is the oil laboratory with its modern equipment, providing all services relating to oil management. Our two identification labelling systems for power generation, the KKS Identification System for Power Stations and the RDS-PP® – Reference Designation System for Power Plants, have been adopted by users on all continents and provide the basis for efficient digital management of generation plants. The 23 VGB events in 2017/2018 attended by around 2,400 participants and the exchange of experience in the committees characterise VGB as the technical platform for the industry.



One example of international activities is the «Hydropower Fact Sheets» presented jointly by Eurelectric and VGB PowerTech in Brussels with important key statements on the importance of hydro power in Europe. Further cooperation arrangements exist with the Chinese Electric Power Planning & Engineering Institute (EPPEI), the EEC Excellence Enhancement Centre for Indian Power Sector, the Japanese Thermal and Nuclear Power Engineering Society, the VTI All-Russia Thermal Engineering Institute and the Turkish-German Energy Forum (TGEF). The «Flexibility Toolbox», created with the support of the Federal Ministry for Economic Affairs and Energy within the framework of the Indo-German Energy Forum, offers a unique and universally applicable group of measures for extended flexible power plant operation.

Together with the PowerTech Training Centre (KWS) and the KSG|GfS simulator centre, the «Deilbachtal Energy Campus» in the Kupferdreh district of Essen is a central contact point for topics relating to power generation. Training, further and advanced education, technical training, simulator training and the exchange of technical experience and services in engineering consultancy, construction and installation supervision, the materials laboratory, water chemistry, the oil laboratory and services for the digital world are offered on the basis of a common infrastructure in close cooperation.

We wish you an interesting read of the VGB Annual Report 2017|2018.

Dr. Hans Bunting
Chairman of the VGB Board of Directors

Dr. Oliver Then
VGB Executive Managing Director

Being part of VGB PowerTech
| Being part of a powerful operators' network

VGB
POWERTECH

VGB at a glance
VGB PowerTech e.V. is the European technical association for power and heat generation. Since its foundation in 1920, VGB has become the technical centre of competence for the operators. The membership is open for companies and institutions active in the power business.

We represent an installed capacity of 461 gigawatt based on a wide energy mix and covering all sources of electricity production.

We have 488 members in 33 countries, over 90% European based.

Our mission
| Support our members in their operational business.
| Support our members in strategic challenges.
| Be a key contact for international energy stakeholders.

Our objectives
| Keep operational and plant safety on a high standard.
| Ensure high availability and reliability of power plants.
| Ensure environmental compatibility of power plants.
| Secure occupational health and safety.
| Ensure cost-effective power plant operation.

Exchanging knowledge > Generating solutions

info@vgb.org www.vgb.org

Tasks and Structure of the VGB Secretariat

VGB's vision is to be the top address for all technical issues regarding the planning, the construction, the operation and the dismantling of energy plants.

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 437 members from 33 countries represent a power plant capacity of 302,000 MW (Figure 1).

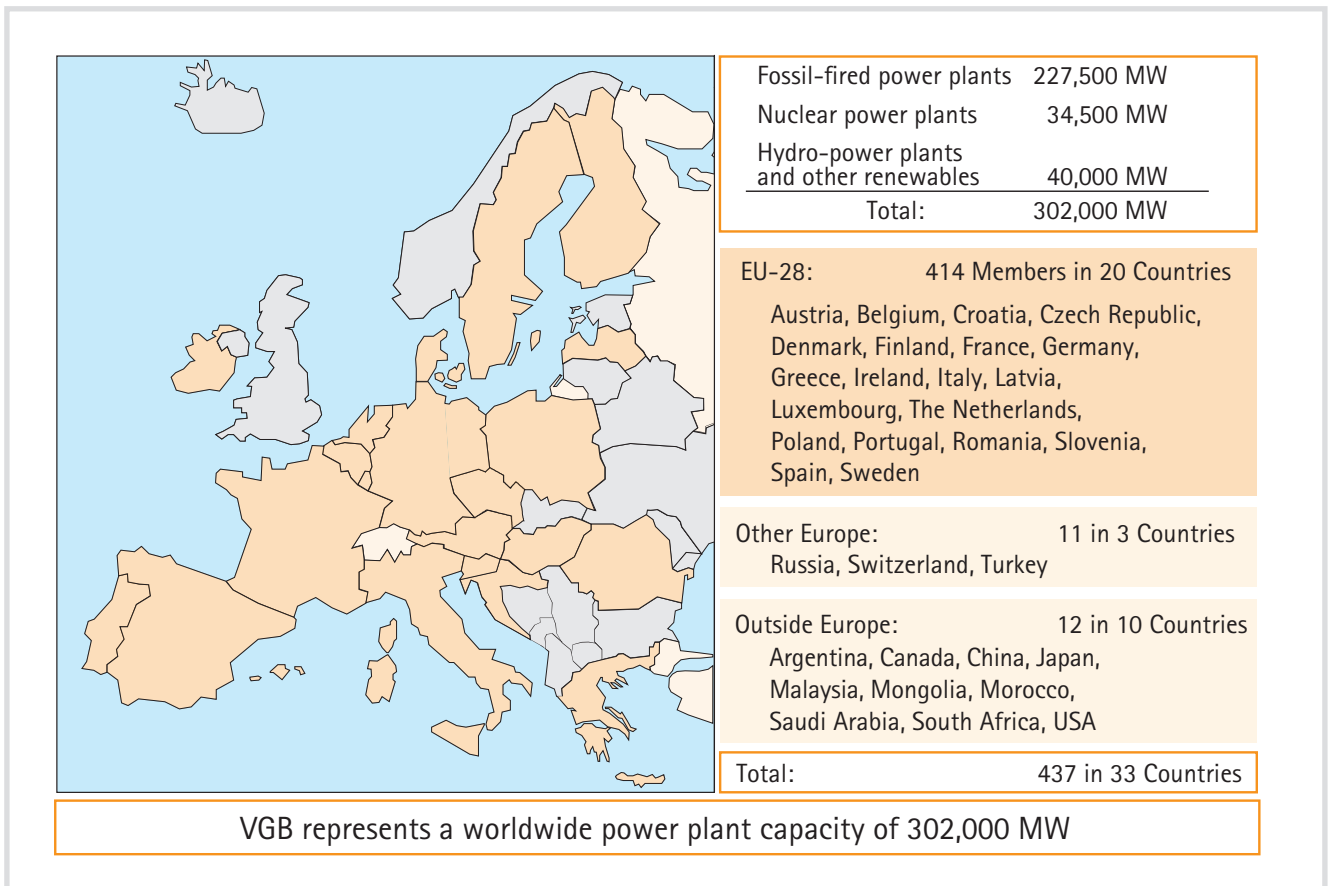


Fig. 1: VGB memberships according to European countries. Outside of Europe, another 12 companies in 10 countries are VGB members.

During the year under review, the committees, groups and forums of VGB convened at over 180 meetings (Figure 3). 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». 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.
- oil analyses.
- Creation of technical Standards (no-official standards), in detail:
 - VGB publishes Technical Guidelines termed as VGB-Standards,
 - 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.
- training and further vocational training of power plant personnel (at KWS and KSG |GfS).

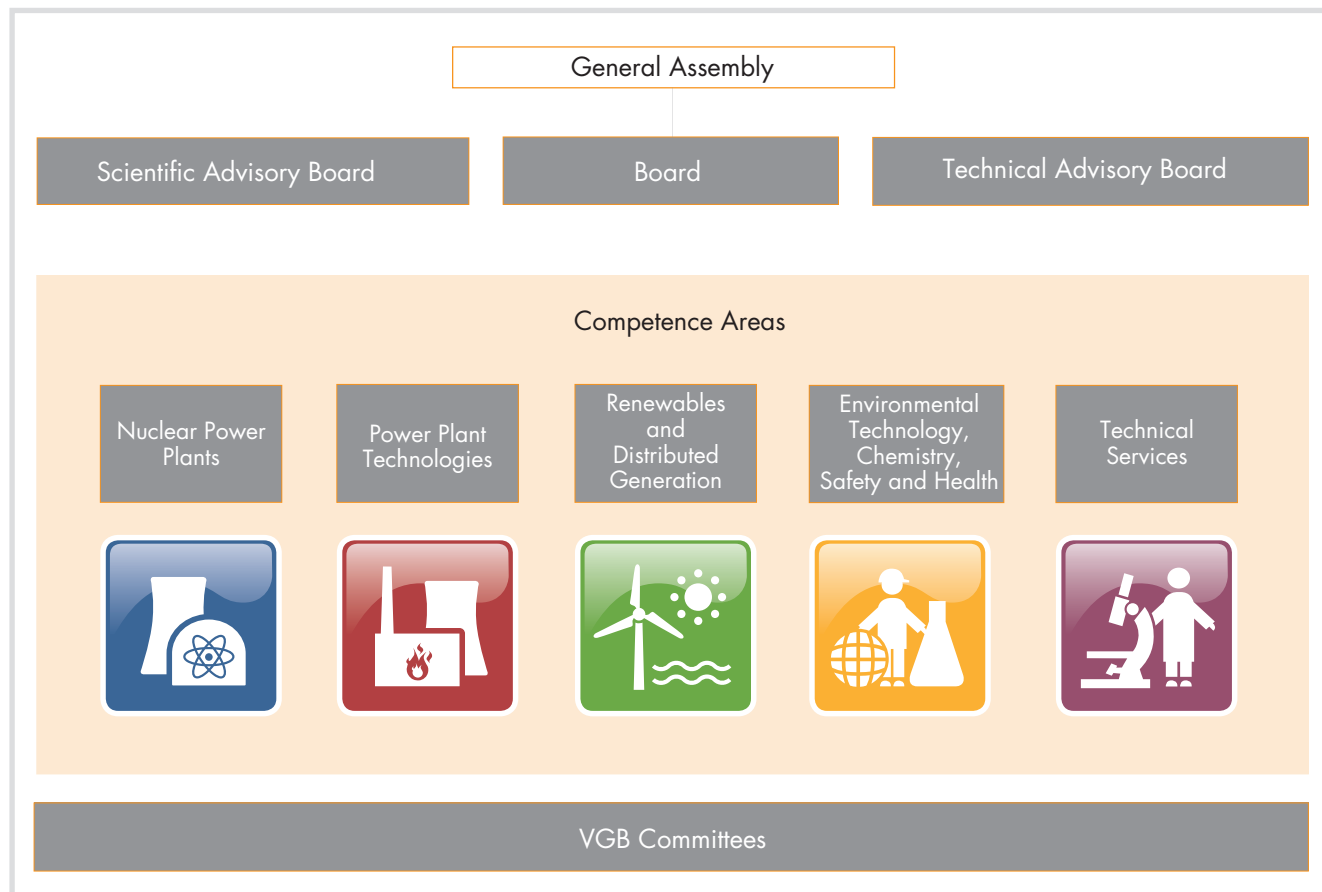


Fig. 2: Structure of VGB PowerTech e.V., the international technical association for generation and storage of power and heat.



Fig. 5: 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. 6: 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-Forschungsstiftung e.V., and VGB PowerTech Service GmbH (Figure 4). 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 5).

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 6).

VGB PowerTech Service GmbH

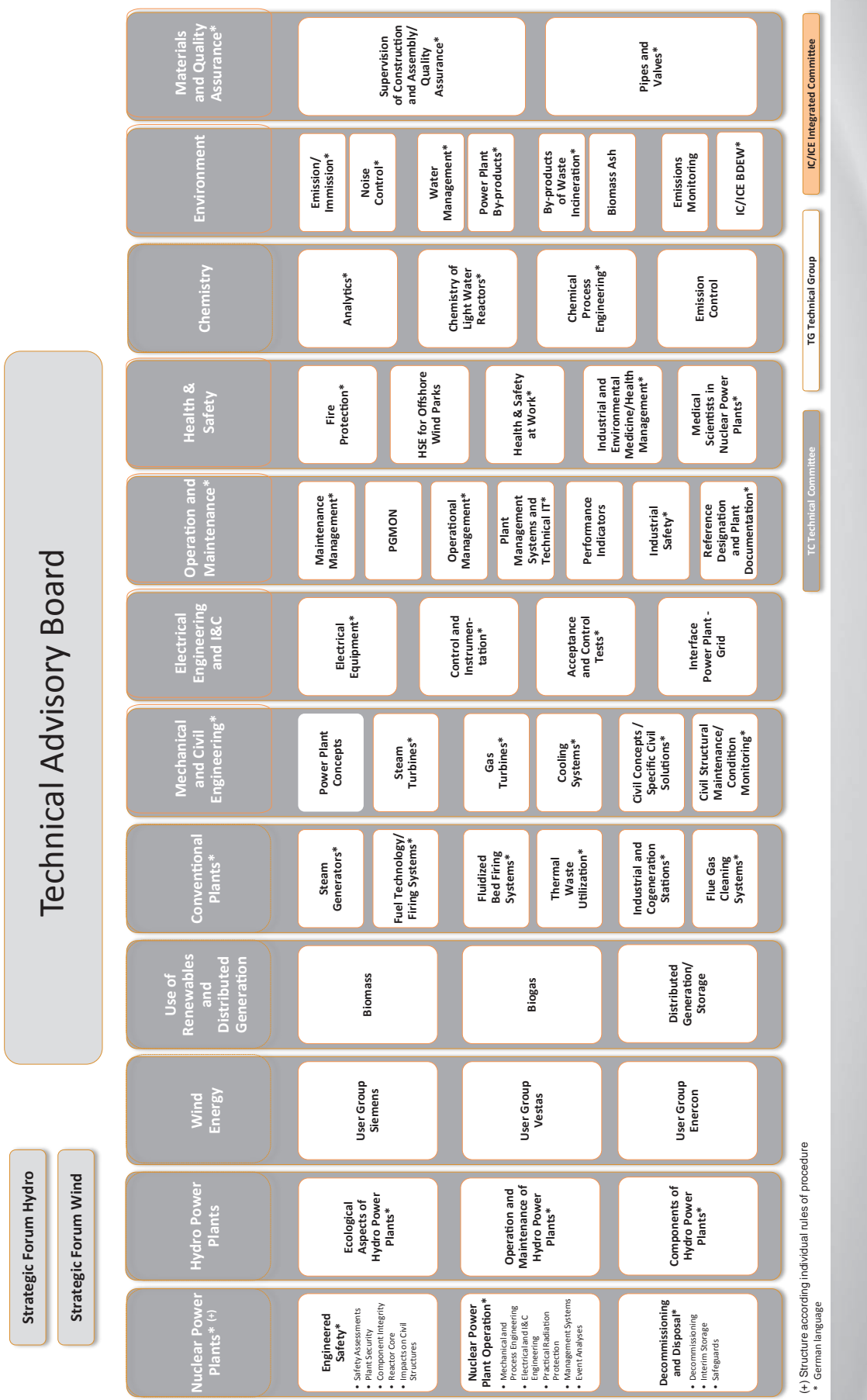
VGB PowerTech Service GmbH (PTS) is essentially responsible for collecting and distributing the existing know-how at VGB. It publishes the VGB PowerTech international journal as well as VGB-Standards guidelines, instruction sheets, conference proceedings, technical scientific reports, VGB books and brochures.

VGB FORSCHUNGSSTIFTUNG

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



Fig. 4: The VGB Group, KWS KRAFTWERKSSCHULE and KSG|Gfs – Das Simulatorzentrum.



(+) Structure according individual rules of procedure
 * German language

Fig. 3: VGB's committee structure.

Competence Area Nuclear Power Plants

GC Nuclear Power Plants	C: J. Michels A: T. Linnemann
TC Operation and Safety	C: M. Bongartz A: Dr. L. Mohrbach
WP Plant Security	C: M. Meyer A: Dr. L. Mohrbach
WP Electrical and I&C Engineering	C: M. Bresler A: J. Kaiser
WP Event Analyses	C: A. Hums A: T. Linnemann
WP Component Integrity	C: Dr. M. Widera A: J. Ganswind
WP LWR Chemistry	C: Dr. T. Stoll A: Dr. D. Rutschow
WP NPP Management Systems	C: J. Schwarzin A: J. Ganswind
WP Mechanical and Process Engineering	C: L. Schoppe A: J. Ganswind
WP Reactor Core	C: W. Schäfer A: Dr. L. Mohrbach
TC Decommissioning and Disposal	C: U. Rieger A: K. van Bevern
WP Cask Handling and Preposition	C: A. Louia A: A. Seidel
WP Safeguards	C: M. Hahn A: K. van Bevern
WP Decommissioning	C: Dr. R. Verseemann A: K. van Bevern
WP Radiation Protection	C: R. Brunner A: Dr. L. Jentjens

Nuclear Power Plants

Dr. Ludger Mohrbach

For more than forty years, the nuclear power plant operators in Germany (at present PreussenElektra AG, RWE Nuklear GmbH, EnBW Kernkraft AG and Vattenfall Energy Nuclear Europe, as well as some municipal utilities) have bundled their joint nuclear activities at VGB, fully financed by a special levy. In addition to the exchange of technical experience, the tasks include an interface function to the worldwide event reporting system, the qualification of components for nuclear applications, joint representation of interests, e.g. in standardisation and regulatory work, contractor qualification and the establishment of guidelines for the training of personnel.

As the number of nuclear power plants in Germany has fallen to seven due to the final shutdown of Gundremmingen B (Figure 1) at the end of 2017, the 11.7 % share of nuclear generation in total German electricity generation achieved in 2017 will continue to decline. Nuclear power plant operators from Switzerland, Belgium, Finland, Spain, the Netherlands and Argentina are continuing to participate in the exchange of experience.

Nuclear energy is being further expanded worldwide, especially in China, but also in over twenty other countries and – since the Fukushima accident in 2011 – eight newcomer countries. In Japan itself, as of June 2018, nine of the original 54 nuclear power plants are now connected to the grid, and 15 more applications are in progress (including two new plants), while 16 plants have been decommissioned.

With the 240 new nuclear power plant units planned to be built by 2035, China will, at a conservative estimate, be able to expand its electricity generation from nuclear energy to approximately one third of total electricity generation (Figure 2)

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».



Fig. 1: The Gundremmingen nuclear power plant in Germany.

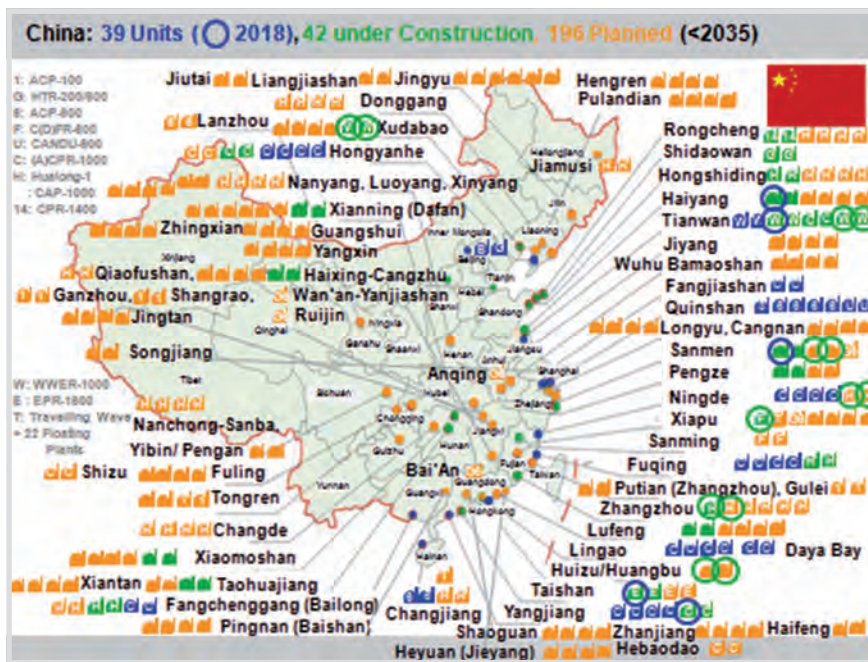


Fig. 2: Planned nuclear power plant units in China up to approx. 2035.

GC «Nuclear Power Plants»

Thomas Linnemann

In the period up to 31 December 2017, Department «N» (Nuclear) at the VGB Head Office maintained the General Committee (GC) «Nuclear Power Plants», together with three nuclear Technical Committees and 13 subordinate Working Panels. In addition, the VGB Head Office also hosted the WP «Chemistry of LWRs» (see Department «T») and the Technical Committee «Nuclear Energy» of the Federal

Association of the German Energy and Water Industries (BDEW) on behalf of the power plant operators.

In the context of the comprehensive reorganisation of responsibilities in nuclear waste management in mid-2017, the nuclear operators in Germany reviewed the scope and depth of their work in committees and in associations under the light of the remaining service lives of their nuclear power plants (up to and including 2022) and, in general, against the background of their economic situation. This review

included also all activities of the nuclear technical committees (TC) and working panels (WP) of VGB PowerTech.

In their responsibility for nuclear safety, the companies not only have to ensure the safe operation of the nuclear power plants until the legally stipulated end of their service lives, but also have to bring the decommissioning and dismantling of the nuclear power plants to a safe, efficient and economically viable conclusion.

In view of these objectives and taking into account the visible budget decline in VGB joint projects, the General Committee (GC) decided to realign the structure of the nuclear committees with two instead of three technical committees in future: Since 1 January 2018, the VGB Head Office has hosted the TCs «Operation and Safety» and «Decommissioning and Disposal» in addition to the GC (Figure 3).

With eight working panels and twelve working groups, a total of twenty committees are assigned to the TC «Operation and Safety», and with four working panels and five working groups, the TC «Decommissioning and Disposal» controls a total of nine committees.

Project Management

The subcommittees of the General Committee «Nuclear Power Plants» promote operation-related research and development projects for nuclear power plants, also known as «joint projects» with third parties. These are financed by the German nuclear power plant operators according to the cost-sharing principle, across all involved plants.

In 2017, the four leading nuclear committees commissioned 36 projects with a total funding volume of just under € 1,900,000 (Table 1).

Medium-term Budgeting

All VGB committees dealing with nuclear technology communicate their expectations for the medium-term development of their expenditure on operation-related research and development projects once each year to the VGB Secretariat, which draws up a medium-term budget (five year planning) on this basis. This five year planning is to be established each year in such a way that it is available to the nuclear power plant operators in Germany by the middle of each year.

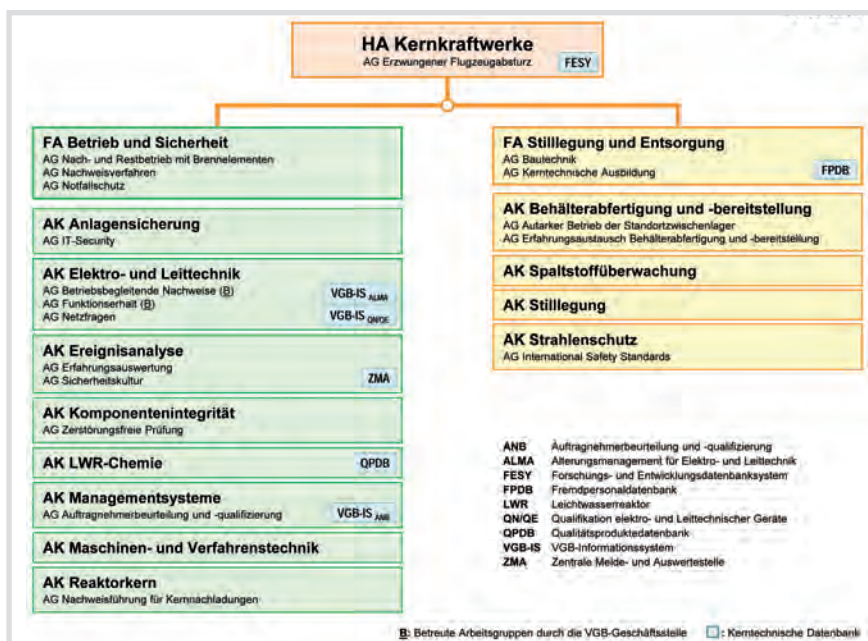


Fig. 3: Organisation chart of VGB Department «N» [Nuclear].

The VGB Secretariat submitted the medium-term budgets for 2018 to 2022 (which had been proposed by the individual nuclear committees in a «bottom up» process) to the General Committee in the middle of 2017. The 2018 budget forecasts total costs of M€ 5.6, around 57 % of which is accounted for by binding obligations from already existing (multi-year) projects.

In their previous five-year planning, the nuclear committees had forecast total annual expenditures, of which only around 60 % were actually booked as incoming invoices in the respective following year at the VGB secretariat. The GC therefore decided, in order to make planning more realistic from 2018 onwards,

- to waive lumpsum reserve items,
- to reduce the annual budgets' forecast for new projects on specific topics by 50 % across the board, and
- to establish an overarching contingency budget for unforeseeable circumstances, the allocation of which the GC is to have at its disposal in the case of urgent joint issues with well-founded applications, should TC funding no longer be possible after prioritisation.

The GC decided that this contingency budget should amount to € 0.5 m per year in the period from 2018 to 2020 and € 0.2 m per year in the period from 2021 to 2022. The GC also agreed that the TCs should control their reduced budgets by prioritising topics in such a way that no budget overruns occur.

The position adopted by the GC is documented in Figure 4, VGB medium-term budget planning, 2018 to 2022:

The committees will therefore have total funds of around M€ 1.3 available for new projects in 2018, M€ 0.5 of which are attributable to the new contingency budget.

Generally speaking, the VGB medium-term budgeting is intended as a guideline for the individual internal budgets of the operators. The next update (2019 to 2023) will be compiled in the middle of 2018.

No.	Committee	Quantity	Euros
1	GC »Nuclear Power Plants«	2	0.4 m
2	TC »Nuclear Power Plant Operation«	31	0.9 m
3	TC »Engineered Safety«	35	0.5 m
4	TC »Decommissioning and Disposal«	0	0.0
Total		36	1.9 m

Tab. 1: Nuclear projects commissioned in 2017.

(BDEW) TC «Nuclear Energy»

Thomas Linnemann

For many years, the Technical Committee «Nuclear Energy» has provided a forum for the exchange of information on the level of the associations BDEW, DAIf, VGB PowerTech and Swissnuclear. In formal terms, the committee was part of BDEW, although in recent years, the organisation of meetings and the reporting had been handled by VGB.

Together with issues on the current situation in the use of nuclear energy, the exchange of experience especially covered issues related to the (governmentally controlled) «back end» of the nuclear fuel cycle.

In the last reporting period, the legal position of the nuclear power plant operators in Germany – supported by the landmark decision of the Federal Constitutional Court on 6 December 2016 – in relation to the liability for compensation entailed

by the federal government's legislation of 2011 ordering the premature (2011 to 2022) decommissioning of all 17 units in operation at the time of the Fukushima accident, improved further. The Federal Constitutional Court instructed the German government to devise and effectively implement a compensation arrangement in 2018. The repayments of nuclear fuel tax to the nuclear power plant operators took place following the verdict by the Federal Constitutional Court in June 2017 that the Nuclear Fuel Tax Act was unconstitutional.

Another constitutional action concerned the obligation of the operators to provide for decentralised interim storage of reprocessing waste. The operators withdrew this action with the signing of the public law contract of June 2017 which reaffirms the reallocation of responsibility in nuclear waste disposal as laid down in the omnibus act. This agreement guarantees long-term legal security for both the federal government and the utilities.

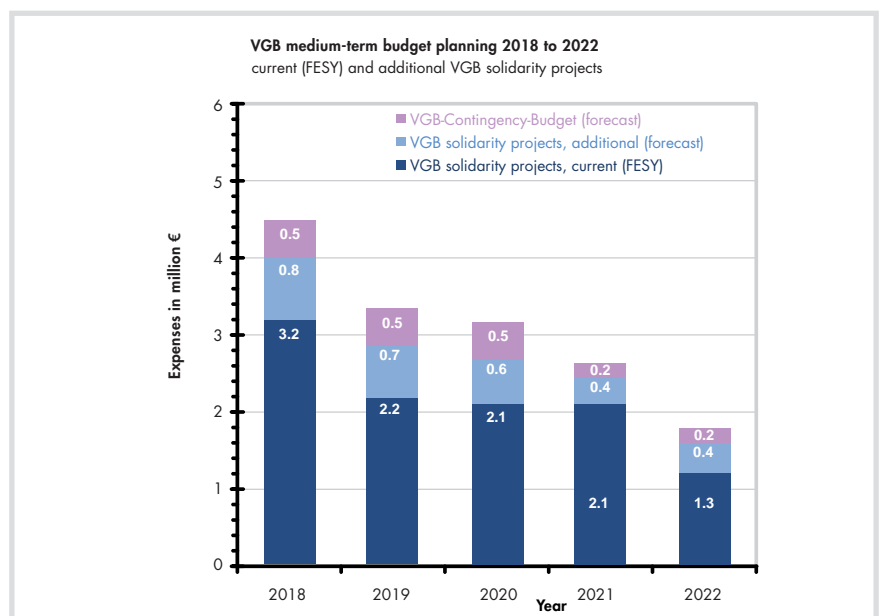


Fig. 4: VGB medium-term budget planning 2018 to 2022, (with the new General Committee contingency budget).

RSK-Committee	Subject of discussion	Date	VGB WP
RB	(Advanced) training courses for non-routine tasks (additional presentation)	07.12.2016	MUV
RB	Evaluation of effectiveness in holistic event analyses: List of questions on procedure and practice	02.06.2017	EA
AST	Status of fuel assembly deformation in PWR plants (follow-up, written report without presentation)	14.12.2016	R
DKW	Corrosion findings in waste water, distributing and discharge pipework: Studies on the cause of the damage, on its safety-related importance and on countermeasures (written reply)	03.04.2017	KOM

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».

EA: Event analysis, KOM: Component integrity, MUV: Mechanical and Process Engineering, R: Reactor core

The critical review of the industry's current common activities also included the services of the VGB Office to the TC «Nuclear Energy» and the secondment of staff of the German operators to the TC itself.

The companies came to the conclusion that the exchange of information on nuclear energy-related topics of general political importance carried out in the TC in the past had been very helpful on the one hand, but that it was not necessary to remain a member of this body in order to fulfil the tasks still incumbent upon the operators (namely operation over the individually remaining service life, as well as decommissioning and dismantling of the nuclear power plants).

The operators therefore decided by mutual agreement to leave the BDEW committee at the end of 2017. BDEW formally dissolved the committee as a result.

TC «Operation and Safety»

Ludger Mohrbach

The topics of the Technical Committee «Operation and Safety» and its predecessor committees «Engineered Safety» and «Nuclear Power Plant Operation» included not only steering of the relevant Working Panels and Working Groups, but also addressed project applications on the following:

- Qualification of electrical and I&C components,
- Impact of non-nominal water gaps on the statistical analysis of fuel rods (WP «Reactor Core»),
- HALDEN project,
- Single and two-phase grid-side phase failures.

- Examples from the extensive event reports included the following:
- RENEGADE reactions in the plants,
- Necessity of security systems in the post-operational phase,
- Accidents during crane operation,
- Transformer damage,
- Battery failures,
- Quality audits on fuel suppliers,
- Zinc dosing for boiling water reactors,
- Castor® loading strategies (Figure 5),
- Disposal options for boric acid, building rubble and plant components released for disposal,
- Primary system decontamination,
- Operating modes for load-related grid services,
- Regulatory procedures (including those for closures)
- Staffing structures, including required operator skills,
- Quality assurance for diesel engine maintenance,
- Precautions against impermissible concentrations of legionella in cooling water circuits,
- Construction of new residue treatment systems and interim storage facilities for non-heat generating waste,
- Damage to fuel assembly centring pins and hold-down springs,
- Non-transferability of crack formation in slot wedges of 60 Hz generators,
- Use of incorrect sealing screws on a Castor® secondary lid,

- Feedback effects of disturbances in the grid,
- Cracks in wheels of polar cranes.

The TC terminated the free-of-charge provision of monthly operating data to the government (via GRS, and thus to International Atomic Energy Agency – IAEA), supervised the operator contributions to the Reactor Safety Commission (RSK – Reaktor-Sicherheitskommission), organised further national peer reviews on hazard assessment and discussed the future needs for DIN/ISO/KTA standards for shut-down plants after removal of all fuel.

There has also been an increasing number of reports on experience with disturbances from the grid, presumably caused by the greater feed-in of electricity from renewable sources. Up to now, the protection facilities at the power plants have largely prevented damage, but the rising number of reports indicates that in empirical terms an increase in the probability of failure can be expected.

WP «Safety Assessments»

Thomas Linnemann

The deliberations of the Working Panel «Safety Assessments» (up to 31 December 2017) focused on coordination of answering to various RSK issues. These included e.g. operator training for non-routine tasks, evaluation of effectiveness of holistic event analyses, fuel assembly deformation and pipe corrosion issues.

As the interface between RSK and VGB Head Office, the WP coordinated four actions answering RSK requests (see Table 2) by organising four operator presentations in the period under review:

Two RSK enquiries concerning participation by an operators' representative in a new RSK Working Group on the evaluation of effectiveness in holistic event analysis and for a technical conference on damaged joint bolts were rejected by the VGB Head Office on behalf of the operators with the indication that RSK enquiries should be answered in the usual process of a hearing with an RSK operator presentation.

WP «Plant Security»

Ludger Mohrbach

The Working Panel «Plant Security» intensively discussed new official requirements for the safeguarding of nuclear facilities, with the focus on the implementation of the new guidelines on «IT security» and «transport of radioactive materials». EnKK reported on the security aspects of the transport of CASTOR casks with the rest of the spent fuel from the Obrigheim nuclear power plant via the river Neckar to Neckarwestheim in spring 2018.

Furthermore, the Working Panel developed fundamental proposals for the unbundling of the plant security facilities for the planned transfer of ownership of the on-site interim storage facilities to the new, state-run BGZ (Bundesgesellschaft für Zwischenlagerung) on 1 January 2019.

WP «Electrical and I&C Engineering in Nuclear Power Plants»

Jörg Kaiser and André Seidel

The Working Panel «Electrical and I&C Engineering in Nuclear Power Plants» 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 with regard to large electrical components such as generators and transformers, feedback effects from power electronics (e.g. also high-voltage DC transmission systems) in the transmission system on the power plant turbine generator sets, and also with regard to matters of IT-security.

The intensive exchange of experience on unusual conditions during operation and inspection, maintenance and retrofitting, plus associated research projects, build a coordinated approach for the preservation of the functionality of electrical and I&C engineering systems.

Within the Working Panel, projects are essentially handled directly by the Working Group «Functional Integrity» and the Working Group «Component Qualification for Design Basis Accident Conditions in Case of Coolant Loss».

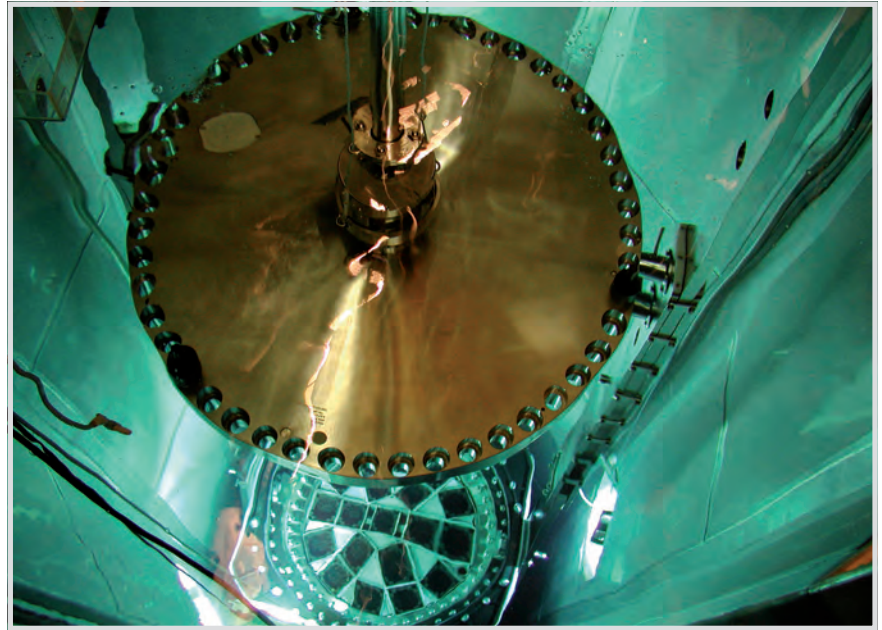


Fig. 5: Castor® underwater loading (Source: GNS).

The electrical and I&C products used in safety-relevant systems in nuclear power plants must be «suitable and qualified» in accordance with their technical specifications. The licensee is responsible for ensuring these qualification measures (in accordance with Section 7 (2) 3 and Section 11 (1) 4 of the German Atomic Energy Act and the safety standards KTA 1401 and KTA 3507). The proof of qualification of these products, documented in the «VGB Information System» database may not be called into question or invalidated in the event of subsequent or new production due to design changes, component changes or deviating manufacturing processes. A recognised basis for ensuring the validity of qualification certificates are the manufacturer inquiries to be carried out in a three-year cycle and the resulting process and product audits.

The corresponding projects are initiated and coordinated by the WG «Functional Integrity». In the reporting period, 47 projects on the preservation of functionality were processed, and 24 of these have been completed from a technical point of view.

The safety standard KTA 3706, «Ensuring the Loss-of-Coolant-Accident Resistance of Electrotechnical Components and of Components in the Instrumentation and Controls of Operating Nuclear Power Plants» defines the stipulations for electrical and I&C components which have to

fulfil their safety functions under plant incident conditions. In addition to the measures implemented independently in the plants (e.g. exchange programmes), the VGB database AUREST is used as a tool for the documentation and initial evaluation of the «coolant loss accident»-proof components used in electrical engineering and I&C technology. Taking into account the respective operational stresses, the residual service life periods of the individual components are determined. Thus, the calculation results using the AUREST database provide a basis for decision-making which components require further safety case verification.

In the period under review, the WG «In-process Demonstration of Resistance to Design Basis Accident Conditions in Case of Coolant Loss» dealt with 23 projects, 5 of which are complete in terms of technical content.

In the WP «Electrical and I&C Engineering», there is a continuous exchange of information on the topics which are relevant to the Reactor Safety Commission committee «Electrical Installations». Statements are drafted on concrete enquiries from the RSK, discussed and agreed among the group of operators, and submitted to the RSK committee where necessary. An overview of the actual topics is presented in the report from the WP «Safety Assessments».



Fig. 6: Borssele nuclear power plant in The Netherlands.

WP «Event Analyses»

Guido Vallana and Thomas Linnemann

The Working Panel «Event Analyses» 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 the annual report from the WP «NPP Management Systems»), «Human Factors» and related topics, and error avoidance techniques. Together with the German nuclear power plants, plants from the Netherlands (Borssele, Figure 6), Switzerland (Leibstadt and Mühleberg) and Spain (Trillo) are represented in the Working Panel.

Holistic event analysis

In the reporting period, 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).

Specific topics on human factors

On the basis of 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 supply utilities. The WP continues to represent the opinion that a strong safety culture and consistent application of error avoidance techniques are of great importance also in long-term off-grid operation and dismantling of plants.

Topics related to nuclear safety commissioners

In this reporting period, as before, the WP maintained an intensive exchange of experience on reportable and other events, commented on and interpreted national and international reporting criteria, evaluated experience assessments and experience reports, and interpreted reports for forwarding to the IRS (Incident Reporting System) of the International Atomic Energy Agency IAEA and to the World Association of Nuclear Operators (WANO).

WP «Component Integrity»

Jens Ganswind

The primary task of the Working Panel «Component Integrity» is to secure the integrity of mechanical components in boiling water (BWR) and pressurised water (PWR) reactors by taking into account mechanical, thermal, corrosive, radio-chemical and test-related boundary conditions.

The specific topics are raised in particular by:

- requirements from the Federal Ministry of the Environment,
- statements by the Reactor Safety Commission,
- requirements from authorities or expert organisations,
- demands resulting from the revision of the KTA standards,
- news passed on by the Gesellschaft für Anlagen- und Reaktorsicherheit – GRS,
- reportable events from VGB power plants, and
- incidents in other plants.
- As a result, the fundamental work of this WP in the year under review comprised the following:
 - Exchange of experience on current damage events with assessment of applicability to other plants, connected with (where needed) the creation of joint plans for the derivation of remedial and preventive measures,
 - Securing of component integrity by existing or newly established integrity concepts, including non-destructive testing plans, optimised test techniques and fracture mechanics calculation methods,
 - Investigation projects on clarification of damage 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, stipulating repair and remedial actions (to prevent repetition), and assessing the applicability to other BWR and PWR plants. There is also an investigation procedure of whether there may be new findings which would assist in protecting the plants.

The WP has a subsidiary Working Group on «Non-Destructive Testing». That WG is predominantly concerned with the exchange of experience on recurrent tests, but it also deals with all current issues related to testing.

WP «Management Systems»

Jens Ganswind

The Working Panel «Management Systems» addresses common issues on management systems and product-related quality assurance.

In the field of management systems, this includes the following:

- The exchange of experience on the practical implementation of existing management systems.
- The WP aims to have this regarded as a management tool and increasingly and comprehensively supported and used by managers. Deviations noted should therefore not be accepted from the very start. On the contrary, they must be corrected immediately and the self-imposed rules complied with without exception.
- The adaptation of NPP 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.
- Monitoring of international and national standards.

The WP performs standardisation work for the operators, reviews the need for revisions and, where appropriate, compiles comments on the stipulations formulated in standards.

The tasks in the field of manufacturer auditing are addressed by the (no longer from VGB administrated) WP «Contractor Assessment and Qualification» in accordance with KTA 1401, «General Requirements for the Quality Assurance» for the availability of spare parts from component suppliers, and include auditing and training courses based on the list of contractors in the VGB Information System.

WP «Mechanical and Process Engineering»

Jens Ganswind

The work of the Working Panel «Mechanical and Process Engineering» predominantly covers the exchange of experience on

- events resulting from operation, post-operation (until removal of all fuel assemblies) and shut-down-state operation,
- maintenance planning and performance,
- plant modifications and optimisations.

In addition, the WP reacts to relevant requests from the Reactor Safety Commission (e.g. on non-routine maintenance work).

In the reporting period, several reportable events and incidents - all below the reporting threshold - were presented, discussed and reviewed with regard to their transferability to other plants. These included

- dynamic plant response in irregular situations,
- leakages in pipelines, vessels and other components,
- restrictions to the function of valves, motors or pumps,
- defects of hoisting equipment, and
- incidents effecting workplace safety.

The deliberations focused on root cause analyses and mitigative consequences.

Issues concerning the transition between normal power operation and dismantling are increasing in importance. The owners of the shut-down plants have reported on their corresponding experience and have offered suggestions for improvements.

WP «Reactor Core»

Guido Vallana and Dr. Ludger Mohrbach

In the reporting period the Working Panel «Reactor Core» (Figure 7), in cooperation with the contractor AREVA (since January 1, 2018 renamed FRAMATOME GmbH), continued the long-term projects to develop «Statistical Coolant Loss Accident Analysis» and its application to PWR core designs, taking into account non-nominal water gaps. It was successfully demonstrated that no penalizations of the core design parameters (e.g. performance restrictions) are necessary.

As far as it is known, this method is a world-wide first to describe this (possibly not infrequent) phenomenon. In the meantime, the procedure has been examined and supported by the supervisory experts, accepted by the authorities and presented internationally by the authors.

Furthermore, the WP is pursuing international activities on «Operating Behaviour of Fuel Rods and Fuel Assemblies under Long-term Dry Storage Conditions».

In addition to the fuel assembly deformation and the successful remedial measures, the exchange of current operating experience also included the fractures of fuel assembly centring pins, the handling of intermediate storage containers and special corrosion effects (including crud formation) on the cladding tube surfaces. In order to clear up certain such effects, for example, the WP also initiated audits of cladding tube manufacturers.



Fig. 7: View of the upper reactor pressure vessel in the containment building during maintenance. (Photo: NPP Leibstadt, Switzerland)

TC «Decommissioning and Disposal»

Katrin van Bevern

In the reporting period, the Technical Committee «Decommissioning and Disposal» (e.g. Figure 8) met twice and also performed a telephone conference. Its activities concentrated on the exchange of experience on current operational issues from the fields of decommissioning and disposal.

The further functions of the TC were steering of the WPs on «Interim Storage», «Decommissioning» and «Safeguards» (fissile material monitoring) and, since January 2018, also the WP «Practical Radiation Protection», the WG «Civil Engineering» and the WG «Nuclear Training».

In early 2018, the TC decided to update the VGB brochure on disposal of nuclear wastes. It founded an unadministered project group with the primary aim of bringing the contents of the brochure in line with the new legal arrangements for nuclear disposal.

In addition, the TC continued its exchange of information with the Chairperson of the Federal Disposal Commission («Entsorgungskommission»), itself being an advisory body to the Federal Ministry of the Environment.

WP «Decommissioning»

Katrin van Bevern

Following the expiry of the licence for power operation of eight German nuclear power plant units with the 13th Amendment to the Atomic Energy Act (AtG) in 2011, and now that eight further decommissionings are to follow by 2022, a regular exchange of experience among both the new decommissioning projects and also with those plants which are already at the decommissioning stage is ensured at VGB. The long-established platform for this is the Working Panel on «Decommissioning», whose experience collected from the projects which have already progressed to an advanced stage provide a valuable basis for the new decommissioning projects. This also applies to (future) decommissioning projects by VGB members outside Germany

The experience of the WP shows that the technological problems of dismantling nuclear power plants while ensuring the necessary level of safety have been solved. A broad base of experience is available to operators, authorities and independent experts equally. Both the public (state-owned) decommissioning projects, such as the experimental high-temperature reactor AVR in Jülich or the nuclear power plant units in Greifswald, and those of the power supply utilities (e.g. the nuclear power plants KMK Mülheim-Kärlich, KKS Stade, KWW Würgassen and KWO Obrigheim) are well advanced and provide valuable information on technical and organisational approaches.

Almost all the nuclear power plants in Germany have submitted decommissioning and dismantling applications under the terms of Section 7, para. 3 of the Atomic Energy Act, and some of them (shutdown years 2011 to 2015) have already received approval. Two further German sites are preparing documentation for the decommissioning and dismantling applications.

In Switzerland, decommissioning and dismantling procedures are currently underway for the KKM Mühleberg nuclear power plant, and a further location (Beznau) has already initiated a preparatory decommissioning project. Further decommissioning projects are being pursued in Belgium, Spain and France.

On the national level, the WP monitors the work on transfer of the EU basic standards on radiation protection into German law and their effects on decommissioning.

WP «Cask Handling and Preparation»

André Seidel

With the planned transfer of ownership of the on-site interim storage facilities to the newly founded «Bundesgesellschaft für Zwischenlagerung» (BGZ) under the terms of the «Act on Reorganization of Responsibility for Nuclear Disposal» on 1 January 2019, the previous Working Panel «Interim Storage» was re-named in the context of the VGB committee restructuring of 1 January 2018 to the Working Panel «Cask Handling and Preparation», and its functions were adjusted accordingly.

The WP deals with generic issues relating to the loading of spent fuel in casks and their making available for interim storage.

In addition, the WP, through a specially convened working group, ensures the exchange of experience gained during the loading of transport and storage casks and interim storage between the operators and the power plant personnel at the individual nuclear power plant sites.

A focal area is the examination and improvement of the workflows and processes in the loading and use of fuel assembly casks, with a view to establishing best practices.

Apart from reporting on special issues during the loading operations and in operation of the storage facilities (including discussion of reportable events at home and abroad), the feedback from performance of periodic safety checks at all interim storage facilities constitutes a central topic.



Fig. 8: Nuclear power plants in decommissioning, NPP Stade. (Photo: PreussenElektra).

WP «Safeguards»

Katrin van Bevern

In the context of the exchange of experience on current fissile material monitoring inspection practices, the WP «Safeguards» particularly monitors events during ongoing monitoring measures by EURATOM and IAEA. In addition, the fundamental work of the WP includes the following topics:

Particular safeguards provisions for on-site interim storage facilities

After the official consultation with the operators on the site-specific drafts of the particular safeguard provisions for the on-site interim storage facilities had begun at the end of March 2017, the WP prepared a VGB statement relevant for all sites. Open questions were discussed and clarified in a special meeting in June 2017 with EURATOM – functioning here as the EU Safeguards Inspectorate – and the Federal Ministry of Economic Affairs. The «Particular Safeguard Provisions» are expected to be issued before the end of 2018.

Introduction of remote data transmission for interim storage facilities and reactors

The introduction of remote data transmission RDT for interim storage facilities is progressing further. The implementation at all on-site interim storage facilities will be completed by the end of 2018. At the nuclear power plants, remote data transmission pilot projects at the Krümmel and Neckarwestheim sites are running to the satisfaction of EURATOM and the operators. It remains to be seen which other nuclear power plants will be connected to the RDT system in the future.

Other activities of the WP include the representation of the operators' interests in the «Nuclear Material Monitoring Working Group» of the German Nuclear Fuel Cycle Association and in the Programme Council of the BMWi/IAEA Support Programme, the project for the transfer of responsibility for cask sealing to the operators and the use of digital Cerenkov viewing devices and passive gamma emissions tomography for the verification of fuel assemblies, safeguards in decommissioning and safeguarding aspects of packaged special («defective») fuel rods.

WP «Practical Radiation Protection»

Dr. Lena Jentjens

At the Working Panel «Practical Radiation Protection» meetings, which take place twice a year (October 2017/March 2018), emphasis lies on the active exchange of experience on all radiation protection issues, both from operational and shut-down units.

The implementation of the EURATOM Directive 2013/59 (EU Basic Safety Standards, Figure 9) was at the centre of interest in the standardisation work. In Germany, this EU regulation was adopted to national law in 2017 by the new «Act on Protection from the Harmful Effects of Ionizing Radiation» (Radiation Protection Act – StlSchG), which was published in the Federal Gazette on 3 July 2017.

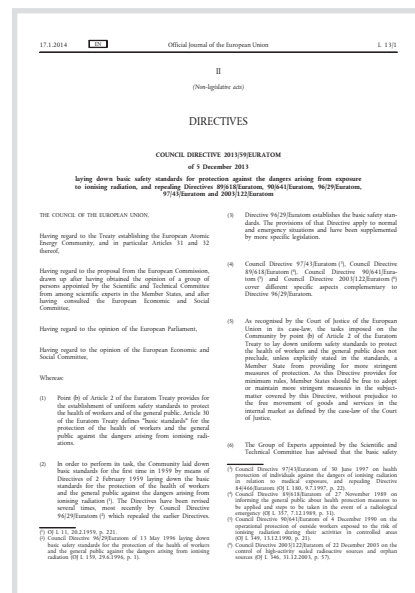


Fig. 9: EURATOM Directive 2013/59 (EU Basic Safety Standards)

With the exception of the provisions on emergency protection, which entered into force on 1 October 2017, the remaining provisions are due to come into effect on 31 December 2018. The responsible body, the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMUB) has distributed a draft (not yet agreed with the federal states) and asked for comments. As part of the «International Safety Standards» (ISS) Working Group, the operators are following the process of drafting and discussing these new regulations.

Other activities in the area of regulatory support currently include commenting on KTA safety standard 3604 «Storage, Handling and Internal Transport of Radioactive Substances (with the exception of fuel assemblies) in Nuclear Power Plants» which has currently been presented to the KTA sub-committee on Radiation Protection.

Employment in external plants or facilities requiring approval in accordance with Section 15 of the Radiation Protection Ordinance (StrlSchV)

An updated model permit has been available for this purpose since last year. In order to be able to implement uniform VGB contracts with all partners involved in the future, the WP has revised the VGB delimitation contract, and the new version is available to all members of the WP. After the Radiation Protection Ordinance will have come into force, a new revision will be necessary due to out-dated references.

Approval / clearance measurement – strategic procedure

In view of the fact that more than 95% of the material mass produced during the dismantling of nuclear power plants is not radioactive and can be released for conventional disposal, DIN has suggested that a VGB standard should be developed on this subject.

A project group has taken up the topic and prepared an extensive report. However, due to the very different approaches and regulations for clearance, it is difficult to work out common points. Although the project resulted in some action points, the WP rejected more extensive assignments such as a standardised calculation of nuclide vectors.

Qualifications in radiation protection

The admission requirements for some VGB qualification levels are to be relaxed. For some cases the WP is currently revising the relevant VGB standards, and in other cases individual arrangements are to be permitted in future.

Representation in external radiation protection committees

Furthermore, the WP is represented in other committees and working groups, including the «Fachverband für Strahlenschutz» (Professional Association for Radiation Protection), the VGB WP «Doctors in Nuclear Power Plants» and the committees A5 «Emergency Protection» and A7 «Plant Radiation Protection» of the Radiation Protection Commission and the employers' liability insurance organisation BGETEM. |

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. Titze A: Dr. T. Eck
TG Civil Structural Maintenance/ Condition Monitoring	C: A. Dorge A: Dr. 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 Instrumentation & Control	C: P. Riedijk A: J. Kaiser
TG Acceptance and Control Tests	C: A. Knieschke A: W. Czolkoss
TG Interface Power Plant-Grid	C: N. N. A: J. Kaiser
TC Operation and Maintenance	C: R. Borgmann 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. Hälbig A: O. Baumann

Competence Area Power Plant Technologies

Dr. Oliver Then

The discussion of the future role of conventional power plants in the supply of electricity and heat, with a growing share of volatile power generation based on solar and wind energy plants, increasingly focuses on aspects of an assured provision of capacity and the services for grid and system stability. Discussions about a threatening capacity shortage in Germany as of the year 2022 have now reached the political arena. The VGB Wind Study illustrates the small contribution of volatile renewable power generation to an assured provision of capacity and the need for backup systems also on a European level; an evaluation of the power plant list of the Bundesnetzagentur (Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway) additionally underscores the necessity of an open and critical discussion about the assurance of the security of supply in Germany (Figure 1). The additional power plant capacities of around 4,100 MW anticipated by 2023 compare with already foreseeable and already completed closures of plants with a capacity of about 18,600 MW. The conventional power plant capacity thus will decrease from al-

most 90,000 MW today to 75,300 MW by 2023. The Bundesnetzagentur assumes in its forecasts that the annual peak load in Germany in the early 2020s will be about 81,800 MW. Covering of peak demand can be ensured only if further power plants already scheduled for closure (about 6,800 MW) are not allowed to be taken offline, since they are classified as system-relevant for the security of supply. Additionally, it must be assumed that closure notifications will be submitted for further power plants for lack of profitability and that this development will repeat itself in our neighbouring European countries.

In the context of the flexibilisation of the entire electricity supply system, conventional power plants remain an essential element focussed on the especially important flexibility parameters

- stable minimum output,
- high load change gradients and
- short start-up times.

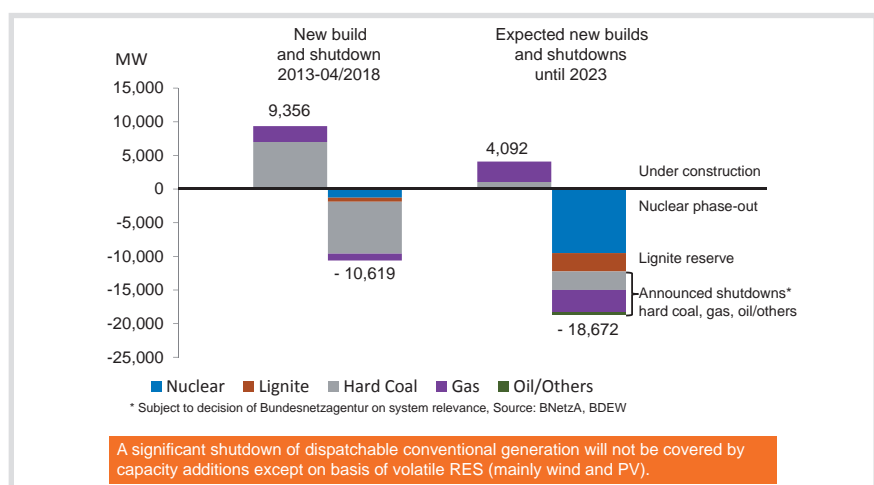


Fig. 1 Medium-term development of conventional generating capacity in Germany.

TC Technical Committee

TG Technical Group

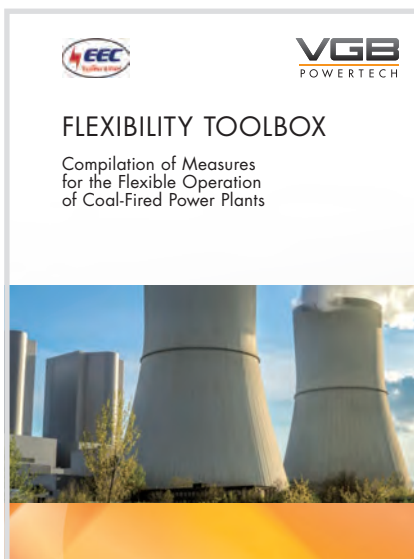


Fig. 2: *FLEXIBILITY TOOLBOX. Compilation of Measures for the Flexible Operation of Coal-Fired Power Plants.*

Further elements of a flexible supply system include, for example, storage technologies, smart grids and flexible consumers. Enquiries to VGB PowerTech in particular concerning the experience gained in Germany and its neighbouring countries with the upgrading of existing power plants to increase their flexibility and about the consequences of more flexible operation for availability, reliability and generation costs are constantly increasing. The same applies to the experience with the German regulation of the electricity market and the observance of ambitious emission standards.

Flexible power plant operation is one of the key topics of the bilateral energy partnership between India and Germany. In India the task force on «Flexible Thermal Power Plants», chaired by the national Indian power supply utility NTPC and a part of the Indo-German Energy Forum (IGEF) involving also VGB and various member companies, continued to move the overall flexibilisation project forward. The activities coordinated by VGB included

- the holding of an international workshop in New Delhi,
- the evaluation of flexibilisation options for two selected reference power plants,
- the design of a training programme for power plant personnel and
- the publication of a study entitled «Flexibility Toolbox».

The Flexibility Toolbox (Figure 2) assists operators of coal-fired power plants to change the mode of operation from base load to flexible operation. It contains information about suitable technologies, offers of further training and management-related topics. The toolbox includes, for example, 40 different flexibility enhancement measures that require a plant retrofit or major technical intervention. The measures concern different plant areas and focus on combustion, water-steam cycle, turbine, I&C system and auxiliary systems. The description of each measure includes information about the impact on flexibility, limitations, key features of the measure, required investment and time required for implementation. The toolbox can be downloaded from the VGB website free of charge using this link:

https://www.vgb.org/flexibility_toolbox.html?highlight=toolbox (German)

https://www.vgb.org/en/flexibility_toolbox.html (English)

Further stages, including the performance and evaluation of test runs on one of the reference plants, will follow in cooperation with our Indian partner organisation Excellence Enhancement Centre (EEC) for Indian Power Sector.

VGB PowerTech is after Agora Energiewende the second partner on the association side for the «Advanced Power Plant Flexibility» campaign launched by the G20 Summit/Clean Energy Ministerial. Among other things we were able to present the results of our Indian activities in several international workshops to a larger audience from the political and economic communities. More detailed information can be found using the following link:

<http://www.cleanenergyministerial.org/campaign-clean-energy-ministerial/advanced-power-plant-flexibility>

The campaign will be continued in the coming year, broadening its scope to consider the entire system of electricity supply; VGB will be glad to continue its involvement. We also supported our partner organisation TENPES (Thermal and Nuclear Power Engineering Society) in Japan with a lecture programme.

In Germany, in cooperation with BDEW, the Federal Association of the German Energy and Water Industries, various proposed laws and regulations in the area of emissions reduction and minimum generation were discussed, participation in the DENA project System Services 2030 was concluded, and the national implementation of the Network Code «Requirements

for Generators» through the FNN in the VDE was actively supported. In addition, we were heavily involved in drawing up the 42nd Ordinance to the German Pollution Control Act (42. BImSchV; Ordinance on evaporative cooling systems, cooling towers and wet separators) and now actively support its implementation. At the European level, together with Eurelectric we particularly supported the specification and national implementation of the various Network Codes and the adoption of the BREF LCP. We continue to monitor the BREF process for waste incineration. Details on all topics and the corresponding documents can be found at the VGB website.

Digitisation in the field of electricity supply received increasing attention in technical discussions. At the 2017 «VGB Congress» in Essen and KELI2018 in Potsdam, VGB presented the «Power Plant 4.0» concept. Power Plant 4.0 is based on aspects of Industry 4.0 relevant to electricity and heat generation. These include, for example, Big Data and cloud services, monitoring and diagnosis for condition-based or anticipative maintenance, optimising of operation with intelligent modelling and artificial intelligence, process digitisation and IT security. VGB took up this topic in an initially internal working group in order to get a picture of the activities going on within the VGB committees, to identify the need for action and to develop concrete activities and research projects. At the same time, within the scope of a digitisation offensive the development of VGB into a digital association that organises a more effective exchange of experience with the aid of up-to-date internal and external communication platforms and has efficient internal processes is being expedited.

TC «Conventional Plants»

Werner Hartwig

As the country continues to be governed by a Grand Coalition, the perhaps most important decision for the coming decades in the area of energy policy may be even longer in coming. Neither of the two major parties has shown any particular desire for reform to date where the controversial topic «exit from coal» is concerned.

The exit from coal has been on operators' minds for quite some time. Scenarios are being created and feasibilities checked. Some operators have already drawn up completed concepts and are beginning to implement them. At the same time, more and more coal-fired power plants are being taken offline, and so the Bundesnetzagentur takes on an important role in regard to grid stability.

The phasing out of coal is being planned even for power plants that produce district heating or process heat in addition to electricity. Since low prices appear to be the long-term trend in electricity prices, more and more heat generators and hot-water boilers are being ordered and installed.

New boiler materials

The newly constructed plants with the boiler materials T24 and HR3C have taken up their intended operation after special heat treatment methods were applied in accordance with the manufacturers' instructions. This was supported by an intensive exchange of experience with the VGB ad hoc working group. In particular, the different procedures for heat treatment of the new materials were discussed. All operators were then able to devise measures appropriate to their specific cases.

Nonetheless, in the very recent past the boiler plants have again suffered damage, making costly repair work and inspection cycles on existing seams unavoidable.

Boiler circulating pumps

Fossil-fired power plants increasingly are under pressure from renewables in part-load and minimum-load operation or in overnight shutdown mode. This necessarily raises new challenges for conventional power plants and in particular places burdens on specific power plant components. In combination with unfavourable designs or as yet undiscovered defects in workmanship that make themselves evident only after lengthier periods of power plant operation, massive damage can ensue. The bursting of a boiler circulating pump during the operation of the Staudinger power plant posed a new challenge to the engineering world in May 2014.

At the time, VGB set up a working committee to deal with this together with the operator and manufacturers.

Operator and manufacturer reported on temperature measurements made on a converted boiler circulating pump in parallel flow operation. The analysis with the «Areva Fatigue Concept» (AFC) system and the possible conclusions to be drawn had already shown that, with the pump at a standstill, in spite of preheating a pool of cold water (20 K up to 90 K) forms at the bottom of the casing. The ad hoc working group «Process Engineering» will develop a technical draft incorporating the experience with the two circulating systems, parallel flow and counterflow. These findings are to be included in the revision of VGB-Standard VGB-S-506 (Figure 3).

Mercury

The Technical Committee discussed the topic of mercury emissions always in great detail in recent meetings. Interest centred especially on the anticipated standards, the calculation methods and the measuring methods. New are the retention systems (filters).

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 the BREF LCP range for hard coal-fired furnaces.

Upshot of the discussion was that an Hg annual average of $4 \mu\text{g}/\text{m}^3$ for hard coal firing is considered feasible; daily or half-hour averages would have to be about 10 or $20 \mu\text{g}/\text{m}^3$, respectively.

Legionella

The members supported the development process for implementing the 2nd Federal Pollution Control Ordinance in practical legionella monitoring and for meeting the requirements.

To this end, among other things a project group for the microbiology of cooling systems was set up.

The VDI Standard 2047 Parts 2 and 3 «Open recoler systems – Securing hygienically sound operation of evaporative cooling systems (VDI Cooling Tower Code of Practice)» was prepared between 2014 and 2017. This standard describes the technical demands on the design, manufacture and operation of open recoler systems, including the requirements for technical hygiene. It defines threshold limit values for legionella concentrations in cooling water for the purpose of performing legionella control measures.

TG «Steam Generators»

Werner Hartwig

General

After serving for many years as head of the Technical Group (TG) «Steam Generators», Mr. Udo Gade retired. Mr. Gade was a member of this body for more than 20 years and chaired it since 2008. With his outstanding experience in steam-raising boiler construction for brown coal and hard coal-fired plants, and as Technical Director Construction at the Moorburg power plant, he greatly enriched the work of the group.

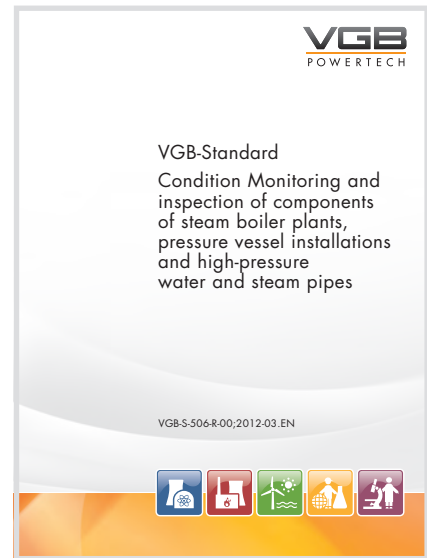


Fig. 3: Under revision: VGB-Standard «Condition Monitoring and inspection of components of steam boiler plants, pressure vessel installations and high-pressure water and steam pipes».

The TG will now devote its efforts towards efficiency enhancement, flexible operating regime and effective reduction of emissions. This can only be achieved with improved technology, and it requires the creation as soon as possible of a stable legal framework for emission limits in order to permit the continuing safe, and at the same time cost-effective, operation of power plants as well as their adaptation to future more stringent requirements. In conventional power plants, the currently good condition of the existing plants is attributable also to a stable environment which has been maintained for decades.

In addition to the technical aspects, considerations of economic efficiency and specific requirements of the regulations, standards, codes and directives beyond the state of the art must be taken into account.

Some older power plants must continue to be operated or maintained as reserve power plants, partly for reasons of grid stability. This requires intensive plant inspection and appropriate technical, operational and organisational measures. Furthermore, the financeability and economic viability of this reserve is a challenging, time-consuming issue with often unsatisfactory results for the power plant owners. The accompanying negotiations with the Federal Network Agency are lengthy and difficult, and are still in progress.

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. Unfortunately, there are also exceptions which currently are the subject of intense study to determine their causes.

In particular the handling of greater stress problems with thick-walled components occupied our group in recent meetings. The initiatives of individual operators who look into the replacement of these components well in advance are interesting. Specifically, the components are designed in such a way that they can be used in several systems on different heating surfaces. As a result, at the planning stage tenders are invited 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 shorter inspection and overhaul outage. This saves a considerable amount of planning time and cost.

A further approach was pursued by TÜV Nord at the Rostock power plant with funds from the Federation of German Industries, 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 with steady load cases (zero, partial and full load) and with 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 were not considered at all.

The result is the stipulation of test intervals for thick-walled power plant components by means of damage tolerance analysis.

Boiler circulating pumps

The topic of circulating pumps in once-through boilers and the reworking of the spherical parts is complete. The background to this work had been serious damage at one power plant, which required considerable efforts on the part of the manufacturer, the operators and VGB.

The findings, including the research results, were bundled by the manufacturer and integrated in the production of new units. The re-equipped plants therefore now have circulating pumps which are state-of-the-art in terms of flow mechanics, structural design and metrology.

The findings are to be incorporated in the revision of VGB-Standard VGB-S-506. In a further VGB initiative, a new VGB-Standard dealing with the process of preheating of the circulating pump in different plant states now is to be created. We can expect to gain some interesting knowledge in this area.

Mercury

The members of the Technical Committee dealt with the topic of mercury emissions in much detail in their last meetings. They are particularly interested in mercury measuring techniques.

Due to the legal requirements for «measurement of total Hg», in-situ measurements are not possible. The latest equipment for continuous Hg measurement can cover a measuring range up to 10 µg/m³. In consequence, only a limit of 4 µg/m³ can be verified for power plants, approximately corresponding to the upper limit of the BREF LCP range for hard coal-fired furnaces. A comparison of suitability tests in the USA and the EU shows that the EU provides for more extensive testing and quality assurance in advance. The verification of low limits around 2 µg/m³ could only be performed at present using sorbent traps (see USA).

Upshot of the discussion was that an Hg annual average of 4 µg/m³ for hard coal firing is considered feasible; daily or half-hour averages would have to be about 10 or 20 µg/m³, respectively.

A further discussion took place with regard to Hg emissions into waste water. At most plants, the analysis value is <1 µg/L (detection limit). The BREF LCP states a range of 0.2 µg/L to 3 µg/L. There should be no problems if special attention is paid to the operation of the FGD waste water scrubbing plant.

Exhalations from new insulation after first heat-up of plants

Emissions of harmful substances, specifically so-called isocyanates, from the new or re-insulation of boilers have been measured.

These substances are used as binders in the manufacture of mineral wool. Upon first heating of the plants these substances then outgas. This is unpleasant and possibly also a health hazard.

Consequently, the VGB Department «Health», in agreement with the employers' liability insurance association (bgetem), operators and manufacturers, suggested that measurements be made in power plants with new insulation. Measurements were made in the power plants of RWE (Neurath Unit E) and Vattenfall Berlin (Lichterfelde plant). Tangible results could not be obtained. An evaluation of isocyanic acid (ICA) is not possible due to an unstable standard. The first measurements therefore did not yield any significant results in Germany.

In Germany an exposure guideline level of 0.018 mg NCO/m³ is prescribed (similar to Sweden). Currently, no method for the determination of monoisocyanates exists.

The further course of action is that the operators now are to be informed by VGB about possible outgassing of new insulation. At the same time, in joint discussion between the employers' liability insurance associations, operators and manufacturers further field tests are to be organised. If possible, autoclave tests should be carried out in order to analyse exact values for the products of different manufacturers. Newly insulated surfaces should be well ventilated and workers should keep clear until final results are presented. At least this applies to the first days of commissioning.

TG «Fuel Technology/ Firing Systems»

Christian Stolzenberger

The Technical Group «Fuel Technology/ Firing Systems» had two main topics on its agenda: mercury reduction and CO₂ emission monitoring. On the first point, reports were delivered on the current status of the VGB initiative Hgcap(ture) and in particular on possible future emission limits along with reduction measures and measurement techniques. As to current activities, at a hard coal-fired power plant a DeNO_x layer in the catalytic converter was replaced by a special layer for mercury oxidation on a trial basis, so as to achieve an Hg oxidation degree of at least 95% upstream of the flue gas desulphurisation system. The gypsum continues to fulfil the requirements for marketing. At a lignite-fired power plant, the mercury content of the lignite was determined over a lengthier period, since the content can

vary depending on the coal field from which the lignite comes, to serve as a basis for decision-making on further action. The second focal topic was put on the agenda since the determination of CO₂ emissions in flue gas naturally is not free of error. Generally speaking, for more exact determination of the quantities of CO₂ an adjustment and correction are made taking the feeder speed, a stockpile calculation or deposit model. Depending on plant, either an additional calculation is made by sampling in combination with weighing on rail or on belt conveyor, or by using the data of the delivery papers.

In the Netherlands, a large hard coal-fired power plant currently is being converted for co-combustion of heavy fuel oil, bio-propane and wood pellets. What makes this a special challenge is that no additional burner is to be installed for this. For the first fuels, both positive and negative experience has been gained in the process of commissioning.

At three plants, coal fires were detected and could be brought under control with nitrogen or light extinguishing foam.

At an opening for a superheater through the membrane wall a dust leak occurred. As first measure, boxes were fitted to prevent dust from escaping. The damage might have been caused by vibrations; the cause will be identified before repairs are made.

The Technical Group initiated a research project (KORINNA) for quantitative online measurement of furnace corrosion for flexible plant operation with the aim of bringing onto the market a sensor for quantitative online detection of the corrosion rate of membrane walls in the area of the evaporative system of power plants.

TG «Fluidised Bed Firing Systems»

Christian Stolzenberger

The topic addressed by the Technical Group «Fluidised Bed Firing Systems» was the protection of critical infrastructures (KRITIS). It was discussed even though the majority of the plants are below the threshold levels – 420 MW and more for electricity supply and from 2,300 GWh for district heating – as sooner or later it can be expected that the requirements for plants falling under KRITIS will be extended in a milder form to smaller plants. An expert from RWE gave a lecture on the subject.

The members reported slightly increasing negligence on the part of external companies with regard to workplace safety or difficulties in communication. In order to ensure safety at work, more training is being carried out and monitoring teams are being set up. To overcome communication difficulties, the external companies will designate a German-speaking employee, who must be identified by a differently coloured helmet or vest. Operational tests to prevent or reduce chlorine corrosion have shown that they prove their worth, both through reduction of the use of RDF or application of a ceramic coating. The shutdown of fluidised bed furnaces leads to a lack of bed ash in the market, which means that when switching to sand (F34) as bed material, the microscopic structure of the sand must be taken into account. It must be round instead of angular and have a low sodium content to avoid the formation of «popcorn ash» with hardness values such as for corundum, which lead to increased wear of the pipe walls. Damage to the refractory of boiler and cyclone repeatedly occurs as a result of material ageing, inadequate care for joints, or gaps that are too narrow. Refractory in the area of the cyclone repeatedly falls off, the main cause being faulty refractory anchorage. Anchors bent in the thermal barrier coating are weak points and cause cracks to grow in these areas. This can be remedied by avoiding anchor bends in the thermal barrier coating and choosing a higher-quality anchor material. In two power plants, the boiler had to be shut down or start-ups postponed because not enough qualified personnel were on hand due to illness, early retirement, reduction of overtime, etc. In one plant, after successful testing of a phosphorus recycling process this technology is being implemented on an industrial scale. In another plant, the water from the planned sewage sludge drying plant is treated to produce boiler feedwater. A patent has been applied for. The search for alternative fuels due to an envisaged phase-out of coal showed that even after considering the three best options wood chips, olive cake and sewage sludge, a fuel change is not recommended for economic reasons.

TG «Thermal Waste Utilisation»

Dr. 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 drafted their comments together and fed them into the process through EURELECTRIC. Meanwhile the last meeting of the Technical Working Group «Thermal Waste Utilisation» has taken place, at the end of April 2018. No substantial changes to the BAT-associated emission ranges (BAT-AEL) for airborne emissions as stated in the draft were made at that meeting (Figure 4). As was to be expected, the discussion on the topic of mercury was highly controversial. Whereas the environmental associations advocated appreciably lower ranges and the additional introduction of an annual average, there was considerable resistance against further reductions not only from the industry, but from several member states as well. They concerned especially the topic of mercury peaks. As compromise the alternative of applying a BAT-AEL long-term sampling average of 1 to 10 µg/m³_N was restricted to such cases in which low and stable mercury contents are found in waste input or to cases involving the use of mercury-specific reduction techniques. In general a BAT-AEL as daily average of <5 to 20 µg/m³_N now is going to apply both to new and existing plants. This means that the upper emission level of 25 to 20 µg/m³_N originally planned for existing waste incineration plants will be reduced.

The final report of the research project «Ammonia Masking», in which the ultimate disposal of ammonia upon further tightening of the NO_x emission limits for SNCR technologies was to be examined, has been completed. It was shown that a further reduction in the legally stipulated NO_x limit at the stack runs up against technical limits if the installed SNCR technology is retained. The type of grate, the type of gas routing, the boiler design and the employed SNCR technology have no influence. The age and quality of the technical equipment, however, may impact compliance with reduced limits. The effectiveness of the reduction agent drops significantly as the limits become more stringent, so that appreciably more has to be used than would correspond to the stoichiometrically necessary quantity. The ammonium content in the residues then accordingly increases strongly.

Specimen	mg/Nm ³	New mg/Nm ³	Existing mg/Nm ³	17. BlmschV mg/Nm ³	Measurement period	Footnote
Dust	2-5 (1)			5	DA	No bag filter 7 mg/m ³
Cd, Tl	0.01-0.02			0.05	MVS	
Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V	0.05-0.3			0.5	MVS	
HCl		2-6 (1)	2-6 (1)	10	DA	With washer lower value, with drying-process upper value
HF		< 1	< 1	1	DA or MVS	
SO ₂		5-30	5-40	50	DA	
NO ₂		50-120 (1)	50-150 (1) (2)	150	DA	Lower value with SCR
N ₂ O						Upper value 180 mg/Nm ³ without SCR
CO	10-50			50	DA	
NH ₃		2-10 (1)	2-10 (1) (3)	10	DA	Upper value 15 mg/Nm ³ with SNCR and without washer
C(org)		3-10	3-10	10	DA	
		µg/Nm ³	µg/Nm ³	µg/Nm ³		
Hg		5-20 (2)	5-25 (2)	30	DA or MVS	Lower value if const. low Hg input or special technology (washer), upper value if dry absorption process available
		15-35	15-40	50	DA	
		1-10	1-10	10	Long-term	Short-term or long-term
		ng I-TEQ/Nm ³	ng I-TEQ/Nm ³	ng I-TEQ/Nm ³		
(A) PCDD/F (1)		< 0.01-0.04	< 0.01-0.06	0.1		A or B
		< 0.01-0.06	< 0.01-0.08		Long-term	Short-term or long-term
		ng WHO-TEQ/Nm ³	ng WHO-TEQ/Nm ³			
(B) PCDD/F + dioxin-like PCBs (1)		< 0.01-0.06	< 0.01-0.08			A or B
		< 0.01-0.08	< 0.01-0.1		Long-term	Short-term or long-term

Fig. 4: BAT-associated emission bands in the revised first draft of the BAT conclusions for waste incineration plants of February 2018.

In some plants, crane and gantry rail rehabilitation will be necessary owing to advanced age. For this purpose a separate exchange of experience was organised where, along with the topics

- mode of operation and wear and tear,
- rail shape, rail quality and design and
- automation,

the handling and the verification concept also were discussed.

The VGB Instruction Sheet 205 «Maßnahmen zur Verminderung von Heizflächenabzehrungen in abfallgefeuerten Dampferzeugern» (Measures to reduce erosion of heating surfaces in waste-fired steam generators) was completely revised and expanded to include biomass combustion plants. It will be published as VGB-Standard VGB-S-205 in the second half of 2018. Other VGB-Standards that are being prepared:

- Pressure discharge of solid materials from silo vehicles.
- Reduction of mercury emissions from thermal waste utilisation plants.

The next expert meeting will be held in March 2019 together with the Technical Group Fluidised Bed Firing Systems.

TG «Industrial and Cogeneration Stations»

Werner Hartwig

Since the economic situation in Europe is still developing favourably and all signs point to further growth, the PG on «Unit-type CHP» is forced to act. A reason for this is the new German Law on Cogeneration and, as consequence, the fact that power generation plants, despite frequent optimisation, now have less reserve capacity, and frequently even reserve plants are used for normal generation. Moreover, it is foreseeable that generation of significant income through the sale of electricity cannot be expected in the long term. All of this has the result that investments increasingly are made in new plant forms.

Parallel to this, the Technical Group «Industrial and Cogeneration Stations, Unit-type CHP» has now established its new Unit-type CHP group as an independent unit. This newly installed committee is enjoying success with topics of its own and a workshop. The membership is growing. This now puts us in the position to address the increasingly broader range of topics in a meaningful manner and, above all, to delve more deeply into the technology so as to be able to better support the members.

On account of the variety of plant types and the different technical issues, the members of the Technical Group are primarily engaged in exchanging details of their experience.

The members are currently dealing in particular with the planning and building of new generation plants. These are often hot-water boilers, so-called fire-tube boiler plants. Recent experience teaches us that even today there is still a wealth of topics in connection with these plants – in many cases they concern quality problems and problems arising in normal operation.

The petrochemicals, paper and automotive industries, and municipal utilities as well, place particular emphasis on the requirement that contaminants and residues 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 meantime have met. At present, we expect the standard to be completed within the first quarter of 2019.

- 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.
- In cooperation with the Federation of German Heating Industry (BDH) a standard for improved internal inspection of fire-tube boilers is being compiled.

Standardisation of the manhole sizes is taking considerable effort. Here the requirements of the German Ordinance on Industrial Safety and Health (BetrSichV) and the DGUV Standard 113 published by the German Statutory Accident Insurance (DGUV) are in sharp contradiction to the interests of the manufacturers, as the latter must provide the safety equipment for the high-pressure boilers.

PG «Engine Heating Power Plants»

The Project Group «Engine Heating Power Plants» formed in 2017 under the auspices of the Technical Group «Industrial and Cogeneration Stations» regularly meets twice a year to exchange experience and views. The rapid growth of the sector dealing with electricity and heat generation by means of internal combustion engines is reflected also in the membership of the project group. A number of new members could be recruited.

Sparkplug lives and sparkplug parts that spontaneously come loose continue to occupy the operators' attention on a larger scale. Some manufacturers urge the operators to have the engines retrofitted with cylinder head covers (sparkplug retaining plate). On the part of the operators a risk assessment is urgently needed in this area.

The cylinder head replacement intervals for bigger engines are far smaller than what the OEM specifies owing to the engines' high power density. Economical operation of the plant is additionally made difficult by the large effort required for installation and the long downtime this entails. With smaller engines, the economic disadvantage of cylinder head replacement is smaller, as installation usually is simpler.

The tightening of the NO_x emission limits in the amendment to the Technical Instructions on Air Quality Control (TA Luft) from currently 60 mg/m³ to 20 mg/m³ for existing plants makes an SCR emission control system necessary in future.

Operation of gas engines – which usually are optimised for operation with natural gas – presents a problem if alternative fuels are used.

TG «Flue Gas Cleaning Systems»

Andreas Wecker

Following publication of the BAT conclusions for large combustion plants in August 2017, attention now centres on the implementation and necessary adaptation of the flue gas cleaning technology. The anticipated low limits for mercury and NO_x are especially deserving of mention. Since at this time nothing definitive can be said about the emission limit values that will be set in the national implementation, various case studies are being discussed.

The technique for continuous mercury measurement presents a further problem. Given the present emission limits and actual values measured at the lower end, calibration of the measuring instruments by the standard reference method has a major influence on the ascertained values. This influence is a subject of intense discussion.

The 42nd Ordinance to the German Pollution Control Act (legionella ordinance) published in July 2017 affects not only cooling towers, but in some cases also FGD systems. Guidelines were drawn up and the necessary measures discussed.

Since the behaviour of mercury in the FGD system has not yet been fully explained, the Technical Group is supporting a research project of the Institute of Energy and the Environment and TU Dresden in which

- the transition of mercury compounds between gaseous phase and liquid phase is described in greater detail, in particular taking the individual droplet, to gain a better understanding of the absorption and re-emission processes,
- the specific influence of the sulphur compounds (dissolved and solid) in gypsum scrubbers on the resultant redox reactions with the mercury dissolved in the scrubbing solution will be revealed as a function of the relevant operating parameters.

TC «Mechanical & Civil Engineering»

Peter Richter

The Technical Committee «Mechanical & Civil Engineering» with its five Technical Groups organises a regular exchange of experience to deal with issues of the day.

Due to the variety of requirements involved, 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 topics 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.
- Consolidated reports to TABCOM (summary of important findings, results, positions, need for action, assistance needs, etc. of TC and TGs) with particular emphasis on operator interests.
- 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.).
- Current projects in the area of waste incineration plants.
- SSTI sub-synchronous torsional interaction.
- Damage in the inlet section of two IP turbines of identical design.
- Coal bunker fire in a power plant of the chemicals industry.
- Retrofit measures on low pressure rotors.

The committees and groups assigned to the TC provide 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.

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

The problems occurring on ultra-supercritical (USC) steam turbines were and are 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 and the manufacturer of the USC steam turbines concerned in regard to the various technical problems occurring at the different locations and the methods of solving them.

This included, for example, a complete identification of the issues, clarification of misunderstandings, establishing consensus on root cause analysis (RCA) and on the implemented 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 in 2016 was discussed with the manufacturer and reports on experience were exchanged.

More and more salt damage – with various causes – has been noted in the recent past (Figure 5).

With regard to the revision of the VGB-Standard «Internal Pipework of Turbine Systems», consultations with VDMA were conducted on the draft completed by VGB. The standard meanwhile has been published.

A new VGB-Standard (VGB-S-133 «Recommendation for the Inspection of Turbo Gear Units Mounted on Plain Bearings») was prepared and is now in the final discussion phase prior to printing.

In addition, the Technical Group provides reports on past and future conferences and workshops, and on the status of the VGB standards currently undergoing revision.

Standards

- VGB-S-115-EN published: Recommendations for the Inspection and Overhaul of Steam Turbines.
- VGB-S-503 published: Standard for the Internal Pipework of Turbine Systems.
- VGB-S-133 Recommendation for the Inspection of Turbo Gear Units Mounted on Plain Bearings.

TG «Gas Turbines»

Andreas Böser and Dr. Manfred Freimark

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

Structured status reports for all gas turbines operated by members of the VGB-TG «Gas Turbines», downloadable from the user group as advance information for each meeting, are the basis of the semi-annual exchange.

As a result of changed market requirements, manufacturers, in close cooperation with operators, have achieved impressive results in extending the effective out-

put 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 of the 200 and 300 MW class, minimum gas turbine outputs of around 25 %, and of the 2+1 plant system of approx. 12 %, 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 to components – especially in the hot gas system of the gas turbine – has been noted. It 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 that have problems with the premature 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.

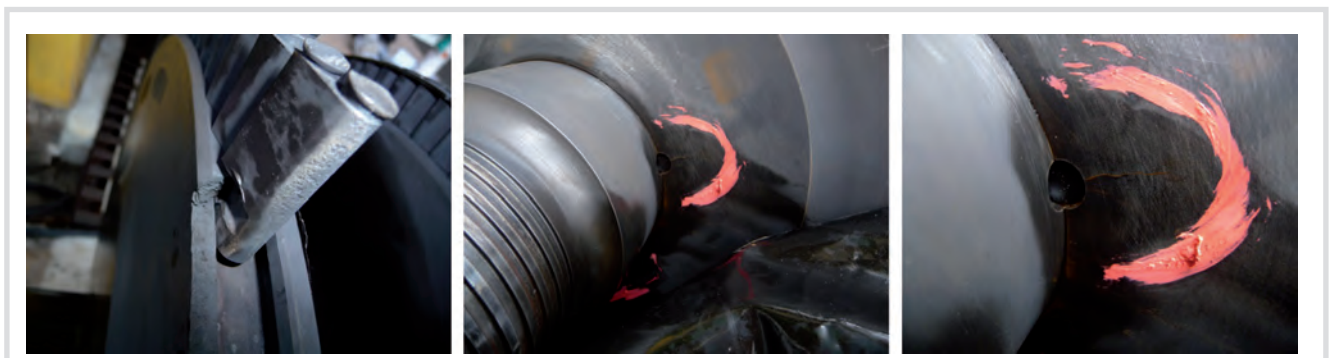


Fig. 5: Stress corrosion cracking caused by salt deposits.

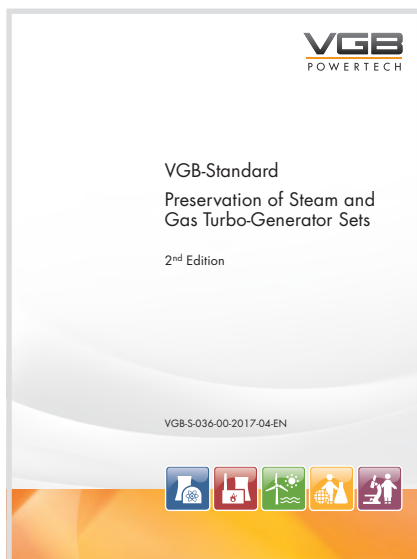


Fig. 6: VGB-S-036 «Preservation of Steam and Gas Turbo-Generator Sets», 2nd edition

For additive manufacturing, laser deposition welding with powder or wire as well as 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 function-integrated 3D prints.

Renewal of I&C systems integrated in LTE measures has led, in cases where I&C interfaces received insufficient attention in advance, to an increase in false trips and increased expenditure of time and fuel 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 controls of the gas turbine firing system. The use of gas chromatography has been considered in this connection.

Discussion of the final report on the BAT conclusions of the EU-IED BREF project regarding emissions in large combustion plants, with an eye to gas turbine plants, with the responsible department of BDEW.

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 its 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 challenges of the energy transition, favoured compliance with the BAT conclusions with indicative monitoring of this pollutant.

VGB-Standards

The VGB-S-036 «Preservation of Steam and Gas Turbo-Generator Sets», 2nd edition, was completed (Figure 6).

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 the operation and maintenance of power plant and industrial cooling systems, taking account especially of the changes to operation brought about by the changing background conditions, with increasing low-load and outage periods. In that context, the hygienic requirements for the operation of evaporative cooling systems and cooling towers play an important role.

Members of the Technical Group and the Project Group «Microbiology in Cooling Systems», comprising members of the TG Cooling Systems in Power Plants and the TG Chemical Process Engineering, made a major contribution to the shaping of VDI Standard 2047, Part 2 and Part 3, and the ordinance based thereon governing the operation of evaporative cooling systems, cooling towers and wet separators (42nd Federal Pollution Control Ordinance), which entered into force on 19 July 2017. The ordinance gives rise to extensive new legal obligations and requirements for the operators of evaporative cooling systems. A «VGB Expert Forum on the Implementation of the 42nd Federal Pollution Control Ordinance» was organised in which the new duties of the operators and the consequences for the operation of systems were explained and suitable options shown for meeting the hygienic requirements. Both the first event in November 2017 in Düsseldorf and the repetition in February 2018 in Berlin were sold out. The operators will continue to be informed and counselled by the Technical Group and the Project Group through articles in VGB PowerTech, on the VGB website or upon individual request.

For the VGB research project on legionella emissions from cooling towers, which is supervised by the PG Microbiology in Cooling Systems, cooling water samples and

deposits from various cooling systems were microbiologically analysed and the actual legionella emissions in the vapours examined. The comprehensive measurements and analyses have been completed and a final summary report is in preparation. The objective is to develop improved strategies for ensuring hygienically safe operation of evaporative cooling systems, wherever possible without the use of biocides.

Topics in the meetings of the TG «Cooling Systems in Power Plants» included the production and range of application of various cooling components (tour of EN-EXIO Water Technologies GmbH), special features of the cooling systems of nuclear power plants (tour of NPP Grohnde), new methods of cleaning cooling fills and drift eliminators, condition assessment of supporting structures in ongoing operation (wood, metal, CFRP and concrete constructions) and the performance of dispersion calculations for cooling tower plumes.

An essential concern of the semi-annual meetings of the TG «Cooling Systems» is the exchange of experience among the participants, which included reports on the use of a thermographic camera in a cooling tower during operation for the purpose of pinpointing cold air bypasses; on the shutdown and inspection of power plant cooling systems at temperatures well below freezing; on air-cooled condensers in a waste-to-energy plant that were designed too small; on damage to clean gas ducts in cooling towers and to supporting structures made of wood and concrete; on experience with different biocide treatments and on new fish protection requirements at water extraction points.

TG «Power Plant Concepts»

Dr. Oliver Then

This Technical Group «Power Plant Concepts», whose members are from European countries, concerns itself with the optimising of existing processes and systems for the generation and storage of electricity and heat, and to an increasing extent with the evaluation and further development of innovative technologies, for example Power-2-x or heat and electricity storage devices.

The group visited the facilities of the DLR Institute of Solar Research in Jülich, including the new Synlight facility, the largest artificial sun in the world. On 23 March 2017, DLR put a unique system into operation at the Synlight facility. Each of its individually adjustable 149 xenon short-arc lamps has the output of a large cinema projector. Together they produce

a light intensity that corresponds to more than 10,000 times the incident solar radiation on Earth's surface. This enables solar radiation outputs of up to 240 or 380 kilowatts in three separately usable radiation chambers, in which a maximum flux density of more than 11 megawatts per square metre can be achieved. Two of the three test chambers were specially developed for the requirements of solar-chemical process development and provide direct access to gas scrubbers and neutralisers. An intensive discussion was held on the opportunities and challenges of CSP technology.

Experience gained with the thermal shock method of eliminating the microorganisms in the open-loop cooling system of a hard coal-fired power plant was presented. The twin-unit plant is located on shore of the Dutch Wadden Sea, and the use of biocides is thus strictly prohibited. After a few improvements, the successful implementation of this thermal treatment method could be demonstrated in more than 140 applications, and fully automatic operation was achieved. As side effect, the modification of the extraction system resulted in enhanced thermal efficiency at the plant.

In addition, the topics Power-2-x and sector coupling were made the focus of one meeting. Various technologies for Power-2-Gas, Power-2-Fuel and Power-2-Chem basically are known mainly from the chemical process industry. The challenges consist in the industrial-scale adaptation to the specific requirements of energy supply with respect to service life, cost and flexible application for the anticipated use of temporarily available «excess electricity» from renewable sources. Apart from the electrification of further sectors, sector cou-

pling can help to enhance the profitability of power plant operation if, at times when electricity prices are below the marginal costs, chemical products (e.g. methane, methanol) are produced instead of power and heat. The production of hydrogen, methane or methanol and their respective use involve specific advantages and disadvantages that currently are the subject of critical discussion. Arguments in favour of the use of hydrogen are, for example, the lowest costs and efficiency losses, with the drawback being a more complex and separate infrastructure. Methane, in comparison, is easier to transport, store and use, but requires an additional cost-intensive, high-efficiency methanation that can be done in two ways: biologically (demonstration) or catalytically (commercially available). Different technologies are used in the catalytic methanation process. They were developed primarily for the methanation of CO from gasification plants, but can be upgraded for CO₂ methanation through an additional water gas shift reaction. Commercially available are fixed bed reactors (either adiabatic or isothermal). Fluidised bed reactors or three-phase reactors are under development. An argument in favour of the use of methanol is its competitiveness in the current market environment, for example.

TG «Pipes & Valves»

Christian Stolzenberger

At its autumn meeting the Technical Group «Pipes & Valves» visited Siekmann Econosto GmbH & Co. KG GmbH in Zwenkau. This company offers solutions to meet the valve and gasket requirements of the operators of power plants. One focus of

this manufacturer theme day, apart from the discussion of the product portfolio, was a triple offset valve that executes a rotary movement instead of a lifting movement. At the spring meeting, the group inspected one of the six simulators for fossil-fired power plants at the PowerTech Training Center in Essen to get first-hand information about the safe use of the control system as link between humans and machine.

The exchange of experience without manufacturers showed that there are good developments, for example, in gasket technology, but that there are also unsatisfactory situations, for example the circumstance that known effects are not adequately taken into account in the planning and execution of pipes and valves. A detailed report was presented on the extension of the life of a feedwater pump mechanical seal from two to eight years by switching to diamond coating. Further flow-accelerated corrosion on the interior walls of a direct-contact heater could be avoided by the dosage of hydrogen peroxide. The stirrup of a stirrup clamp of a constant support hanger broke. Striations and an overload fracture were identified. The cone and cage of an HP steam bypass system showed traces of erosion that were caused by entrained water during start-up. A repair was carried out and the boiler operating regime was adjusted to avoid renewed damage. Cavitation in condensate piping reduced the wall thickness to such an extent that the wall finally ruptured. A changed operating regime was identified as cause, as the plant had been changed over to primary control operation. A new pipe made of a higher-quality material should prevent the damage in future, and an additional structure-



Fig. 7: Cooling tower of the thermal power plant Rostock under revision, KNG.



Fig. 8: Cooling tower of the thermal power plant Rostock under revision, detail, KNG.

borne sound measurement will enable early detection of cavitation. A turbine valve seat was replaced due to radial cracks between base material and hard-facing material.

This last instance of damage prompted the members to launch the VGB research project «Hard-facing of Valves». The objective is to clarify the failure behaviour of deposition-welded wear protection layers in thermostatic and thermal-cyclic age-hardening tests over up to 10,000 h with different hard-facing materials, with and without buffering.

VGB-Standard VGB-S-107 «Ordering and Designing of Fittings in Thermal Power Plants» was completely revised and coordinated with the Association of Steam Boiler, Pressure Vessel and Piping Manufacturers (FDBR).

TG «Civil Concepts/ Specific Civil Solutions»

TG «Civil Structural Maintenance/ Condition Monitoring»

Dr. Thomas Eck

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

Work on the VGB-Standards VGB-S-610 «Structural Design of Cooling Towers» (formerly R 610) and two new standards, VGB-S-039 «Lifetime Management for Footings, Foundations and Towers of Onshore Wind Turbines» and VGB-S-044 on the subject of «Lifetime Management of Structures in Industrial Plants and Power Plants» is in progress. All three standards are scheduled for completion in 2018.

The contents of the exchange of experience increasingly come from the area of lifetime management and maintenance of structural works. Maintenance and dismantling concepts play an essential role here also under the aspects of changing residual service life as well as subsequent use and conversion. These aspects pose a variety of requirements to structural maintenance. During the autumn meeting of the TG Civil Structural Maintenance/Condition Monitoring it was possible to inspect the construction site for the rehabilitation of the cooling tower at the Rostock power plant (Figure 7 and Figure 8).

On the topic of dismantling, on 19 June a first VGB Workshop «Decommissioning and Renaturation of Conventional Power Plants» took place in Essen. In addition to renaturation concepts and renaturation processes, among the important topics covered at the event were demolition technologies, occupational safety and health protection, handling of pollutants (pollutants survey), waste legislation as well as logistics and disposal or use of dismantled materials. The workshop focussed on presenting the experience gained by power plant operators and enterprises active in the energy sector, the aim being to handle future challenges more safely and efficiently.

The VGB committees in the field of civil engineering will in future devote more attention to the topic of dismantling, as well as to the topic of refractory construction. A further focal topic for the future is digitisation in the areas of design, construction and especially operation of building structures, subsumed under the heading «BIM – Building Information Modelling».

In the renewable energy sector as well, topics such as dismantling and partial dismantling meanwhile also need to be addressed. The disposal of rotor blades of wind turbines, for example, will present a major challenge in future, especially in view of the beginning discontinuation of remuneration under the Renewable Energy Act (EEG). VGB is dealing with this topic in an internationally staffed Project Group newly set up in autumn 2017 for the VGB-Standard «Disposal of Rotor Blades».

TC «Materials and Quality Assurance»

Olaf Baumann

In the past year, the work of the Technical Committee «Materials and Quality Assurance» concentrated 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 welded 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». The TG «Online Monitoring and Testing» is revising VGB-S-506, updating the requirements for tests of pressure systems, and describing new methods of online monitoring. For this purpose a workshop «Online monitoring and testing of pressure systems requiring inspection» is being prepared in Essen for 15 January 2019.

The activities of the Working Group on T24/HR3C were discussed. The procedure for performing repairs on T24 and the latest test results on the material HR3C as well as the non-destructive testing of welded joints also were topics of discussion.

The Working Group «Calculation Methods» is focussing 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,

close attention was paid to damage on boiler circulating pumps. A publication on this topic can be found in VGB POW-ERTECH 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 FeLoSeFI research project (Fatigue Life Load Sequences effects and Failure-probability driven Inspection) and
- standardisation of welded joints in wind turbines.



Fig. 9: System Services 2030» project organised by the German Energy Agency (Dena). Deutsche Energie-Agentur GmbH (dena), Berlin, Carolin Schenuit.

TG «Supervision of Construction and Assembly/Quality Assurance»

Christian Stolzenberger

The Technical Group «Supervision of Construction and Assembly/Quality Assurance» dealt with two main topics: creation and assessment of replica impressions, and inspection periods for conventional thermal power plants. The first topic was presented by a staff member of the VGB Materials Laboratory and accompanied by small practical exercises such as the creation and evaluation of replica impressions. The aim was to improve the members' skills in the proper preparation and correct assessment of such impressions. This was achieved, in the opinion of the members, by the lecturer, who demonstrated a high level of technical competence. The second topic will accompany the Technical Group over a longer period of time. The aim is to harmonise the extension of inspection periods (external, internal, pressure resistance) to enable the power plant operators to obtain an extension of the periods more easily, based on an existing inspection concept, if additional measures and monitoring systems such as boiler diagnosis systems, steam leak monitoring systems, state-of-the-art online and offline lifetime monitoring systems or expansion monitoring systems are implemented. Preliminary talks on this subject currently are taking place with an approved inspection body.

During the exchange of experience it was reported that with lifetime monitoring systems the power plants can better adapt the requirements to the scope of inspections, optimise the inspection procedures or extend the inspection periods, or make better use of existing flexibility reserves in the plants. The current situation regarding the creep-resistant boiler materials 7Cr-MoVTiB10-10 (T24) and the austenitic materials like HR3C was discussed off the record. A research project to determine the residual life of HR3C and Super 304 H welds after heat treatment is being planned.

A Project Group of the Technical Group, in collaboration with the Federal Waterways Engineering and Research Institute (BAW), has been dealing for some time with the topic of corrosion protection for offshore wind power plants, and to date has brought out three sets of rules as VGB/BAW Standard VGB-S-021 «Corrosion Protection for Offshore Wind Structures», covering coating systems. The German Maritime and Hydrographic Agency (BSH) has declared these three sets of rules to be mandatory. To keep pace with ongoing developments, publication of a third edition in spring 2018 became necessary. Further parts covering cathodic corrosion protection, repair of coating systems, or thermal spraying are either being published, prepared or planned.

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, requirements at the plant-grid interface and benefits of digitisation, are processed and work is performed on standards for the field of electrical engineering and I&C.

Research projects

VGB participated in the «System Services 2030» project organised by the German Energy Agency (Dena, Figure 9).

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 in 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 in the generating mix are under consideration. This includes balancing power, instant availability standby, provision of 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 instant availability standby and provision of reactive power and their appropriate remuneration as a service contributing to the safe operation of the system as a whole are of special importance. The study was officially completed in spring 2018 with an «Innovation Report System Services 2030».

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

New technologies in the transmission system change the familiar system interrelationships and can have an adverse influence on the power plant components, e.g. due to 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 (high-voltage direct current) 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 (below and above the grid frequency of 50 Hertz) 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.

In a research project the University of Rostock described the fundamental interrelations in a clear and understandable way and explained the premises applicable to a concrete study.

To prepare a guide, a core team was formed which, on the initiative of the VGB TC Electrical Engineering and I&C, has brought together operators of the transmission systems, the HVDC systems (Figure 10) and the power plants with university academics and manufacturers.

In 4 work packages the members will specifically deal with:

- Overview grid restructuring/grid modification owing to HVDC.
- Necessary exchange of information between grid, HVDC systems and power plants.
- Necessary analyses and simulations.
- Specifications for HVDC regulation and for protection systems (HVDC system, possibly power plant).

In the context of the core team's work, VGB actively participated in the consultations on VDE AR 4131 «Technical requirements for grid connection of high voltage direct current systems and direct current-connected power park modules».

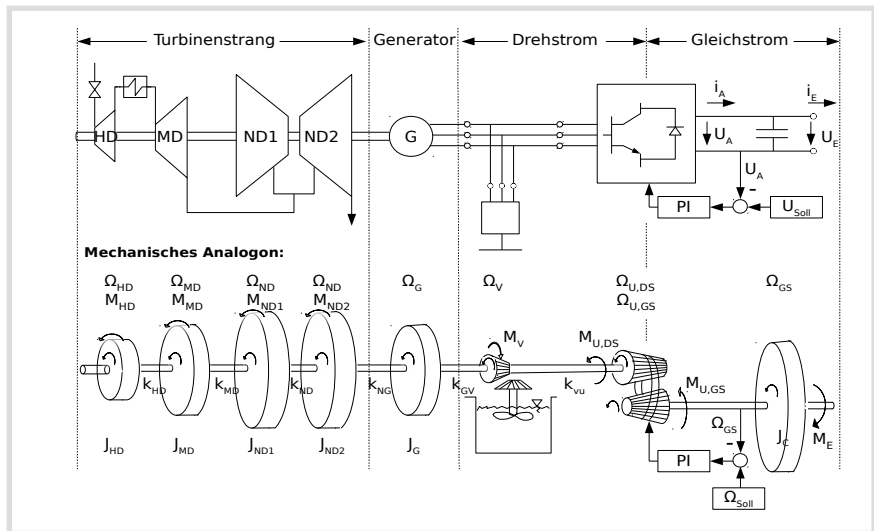


Fig. 10: Fundamental relationship, interaction HVDC-grid-power plant (electrical and as mechanical analogue) – Source: University of Rostock.

TG «Electrical Equipment»

Jörg Kaiser

Work was 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 for 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 jointly identify optimum solutions for further improvements in the operation and long-term stability of the generators. The operators demand a simple, robust design that ensures fault-free operation in the required operating period even under high thermal cyclic stresses.

The sub-group «Thermal/Mechanical Generator Protection» 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, 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 high-rating transformers, monitoring options and methods 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) has revised the AGI Data Sheet «Fire Protection on Transformer Systems» (J21-1). The PG «Transformers» nominated representatives to assist in the

revision, coordinate interim results with the PG Transformers and safeguard the interests of the operating companies. The work was completed at the beginning of 2018.

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.

Electrical Generating Unit Protection

The activities necessary to begin project group work on the revision of the existing VGB-Standard were initiated.

Work currently is in progress on a study by Professor Kulig which examines the thermal behaviour of the slot wedges of a generator in the event of an asymmetrical fault. This study should deliver important input for the work of the PG. The intention is to start concrete project work in autumn 2018.

TG «Instrumentation and Control»

Jörg Kaiser

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

On the other hand, for economic reasons 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.

A further challenge is posed by the GE I&C system Alspa, for which a similar situation can be seen emerging.

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.

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. Publication (initially in German) took place in early 2018.

Information security (IT security) for I&C systems

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 in 2018. In the form of the standard VGB-S-175 on IT security, VGB has created a basis on which I&C systems in the past were already specified in terms of IT security and operated accordingly. This VGB-Standard has been incorporated into said draft of the IT Security Catalogue.

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 the assessment of its influence on I&C systems as well as the actions necessary for implementation.

TG «Interface Power Plant – Grid»

Jörg Kaiser

Active membership in the Technical Group «Interface Power Plant – Grid» (TG IPPG) unfortunately could not be maintained. Retirement, changes in duties and more stringent internal rules resulted in:

- the absence of a chairperson and a deputy chairperson,
- a decreasing number of participants, and
- a lack of active contributions at the meetings.

The TC «Electrical Engineering and I&C» then decided to request the Technical Advisory Board (TAB) to assist in enlisting active memberships and to direct a final appeal to the remaining members in regard to the chair.

The TAB supported the proposed activities, which did not, however, result in the preservation of the TG IPPG.

As result of the discussion at the last meeting of the TC Electrical Engineering and I&C, the participants consented to concentrating the activities of the TG «Interface Power Plant – Grid» and PG «Network Codes» in a single committee in order to conserve resources. The effort for preparing the meetings, reporting, etc., is to be kept as small as possible.

As next step, the PG «Network Codes» will be requested to review the topic lists of the two committees for the purpose of adopting/integrating the topics based on their importance and in accordance with the Project Group's capacity for work. VGB will ensure support for the 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 and Guidelines from Entso-E, in close cooperation 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 two years. It is apparent that an intensive European exchange of experience will also be necessary in the PG Network Codes 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 national implementation of the Network Codes and Guidelines. VGB as an independent stakeholder has two seats on each of the stakeholder committees «Grid Connection» and «System Operation».

Further Network Codes and Guidelines are in the resolution phase and require continuous monitoring and the exertion of influence by the responsible PG «Network Codes».

Technical Aspects of German Regulation

The PG «Technical Aspects of German Regulation» is responsible for coordinated reactions to German requirements resulting from laws and regulations, for instance the consultation and stipulation proceedings of the Federal Network Agency (BNetzA), 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 balancing group contract, 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 new plants and after retrofitting and modernisation of existing plants, as well as in ongoing operation, in terms of cost-effectiveness and environmental compatibility is one of the major aspects of power plant operation. Requirements for acceptance inspection to verify guarantees after completion of the work are laid down in specifications and contracts; these are generally verified by specialist measurement teams. For reliable checking of plants and processes in normal operation, minimum standards must be set for the operational measuring activities. The Technical Group «Acceptance and Control Tests» creates a common basis of understanding between operators and manufacturers for this purpose and makes recommendations for selecting metrological instruments and on assessment and evaluation methods.

The new standards VGB-S-020, «Determination of Measuring Uncertainty in Acceptance and Control Tests» and VGB-S-012 «Process Quality in Power Engineering» define the fundamentals of these topics and provide concrete pointers for their practical application. These standards now are available in German and English versions.

The revised standards VGB-S-130 and VGB-S-131 on acceptance and control tests on water and air cooled turbine condensers likewise were published in German and English. VGB-S-130 contains a calculation program (PC software tool) for evaluating water-cooled turbine condensers.

The PG Pulverised Coal Measurement has performed first test measurements combining isokinetic extraction and laser optical measurement of particle size and PC mass flow in the pneumatic fuel feed lines of hard coal and lignite-fired plant units. The results to date are promising. The possibilities for direct measurement of the fuel mass flow in the combustion of biomass also are going to be investigated.

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 performed on new plants, after conversion to biomass combustion, and after emission reduction measures; experience with wireless measured value transmission, the use of process quality monitoring systems for the optimisation of operation, experience with laser optical techniques for flow metering, and more.

A number of members of the Technical Group and its Project Groups are actively involved in international standardisation committees on test and acceptance measurements (VDI 2048, VDI 3921, ISO 1888, ISO 2314, IEC 60953) 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 that are of especial interest in the technical management of the generation facilities, and manages the activities of the associated Technical Groups.

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 deployed personnel and for the need for IT support are subjects of 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 and of other emission limits.

The initial and further training of power plant personnel, knowledge management (preservation of know-how) within the companies and the development of a new generation of skilled workers also are important issues in ensuring the long-term competitiveness of businesses. The demands on and expectations of one's own personnel must be discussed in close connection with the changes in the human resources situation of manufacturers and service providers.

In an enlarged expert meeting of the TC «Operation & Maintenance» in June 2018, the links that exist between the committees of the TC Operation & Maintenance and between them and other committees from other «pillars» of the VGB structure were discussed and proposals for still better networking and communication were coordinated. This includes the optimisation of external presentation as well as, for all VGB members, the awareness of, and simple usability of, the results of the work of individual VGB committees. In view of the new and increasingly more complex topics such as digitisation, flexibilisation and regulation, it became clear that new processes and tools have to be integrated in the work of the VGB.

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 are the basis of activities throughout the industry. VGB provides support for effective work in the form of various tools such as VGB-Standards and databases for events and damage.

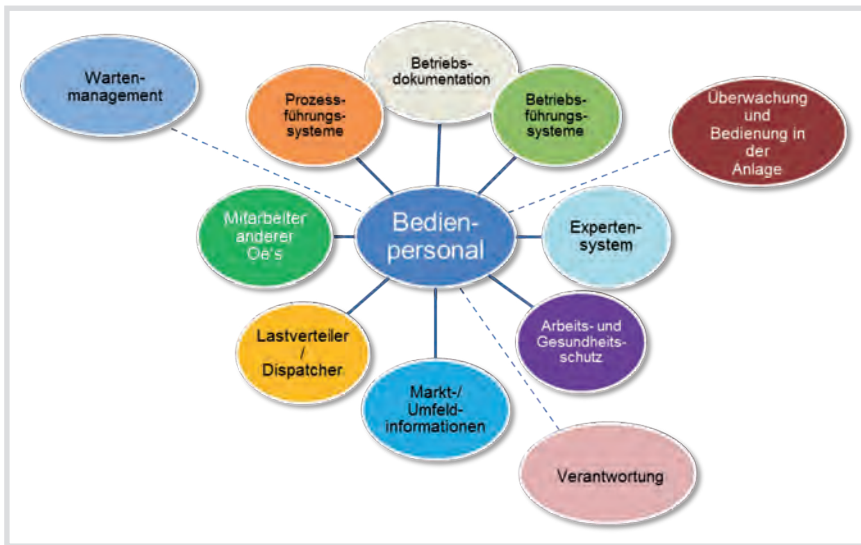


Fig. 11: Contents of workshop «Operations Management in Production»

TG «Operational Management»

Kerstin Kofink

Since the last annual report, meetings of the Technical Group «Operational Management» have been held in Münster, on 26 and 27 September 2017, and in Karlsruhe on 25 and 26 April 2018.

On a positive note, it can be said that despite the growing workloads and the resultant increase in cancellations of attendance at TG meetings at short notice, individual members of the Technical Group are able to realise even very time-intensive projects, like the planning and design of a workshop, with exceptional commitment.

On the one hand, certain topics such as digitisation in control room operations or the VGB-Standard for preservation of technical qualification could not be deepened or completed as planned in the past year; on the other hand, feedback and reports are presented to the group by telephone or video conference whenever possible, despite absences. The experience gained handling, for example, editorial meetings where Technical Group meetings are prepared via telephone conference is also very good. The discipline required for this speaks for the great interest and motivation of the members, who are strongly interested in a more efficient exchange of information on electronic platforms, e.g. a VGB cloud or a chat level that is simple and intuitive to use, like WhatsApp, but which also meet the requirements of data protection. With an extended keyword list and a revision of the page of the TG Operational Management, the focus is on the future in order to address a larger group of people and to gain further impulses and perspectives with additional members.

WG «Central Control Stations»

Since the central control station Berlin-Mitte was visited in November 2017, new questions have arisen for the working group, e.g. what has to be observed organisationally and legally in the remote operation of plants. Furthermore, the way in which the control room is staffed must be clarified, since the option of using the same personnel for «plant monitoring» and «fault clearing on site» apparently can lead to considerable understaffing of the control room, depending, on the one hand, on the type and duration of the fault and, on the other hand, on the distance between the central control station and the place of operation.

WG «Operational Management»

On 17 April 2018 for the first time a workshop on the topic «Operations Management in Production» (Figure 11) was held where the results obtained to date by the key groups that provide the foundation of the Working Group were summed up, presented and discussed in more depth. In terms of content, the workshop focussed on the topics responsibility, operating personnel, control room management and in-plant monitoring and operation and was rated very highly by the participants. In particular, contents like responsibility and law are of great interest. Production managers, power plant managers and persons holding similar responsibility appear to have a need for pragmatic information and solutions in this area.

Outlook

The members of the Technical Group «Operational Management» are tackling their projects with great verve. The unresolved items are being finalised in a concentrated manner.

The focal points of work in 2018/2019 are «digitisation in control room operation» and «leadership in times of generational change». The Technical Group «Operational Management» strives to provide practicable recommendations that will be of great benefit to many members of VGB.

TG «Plant Management Systems and Technical IT»

Jörg Kaiser

The Technical Group «Plant Management Systems and Technical IT» pursues activities to support the integration of human beings, data and information systems for the purpose of using information technology as a management tool. The activities are carried out with the aim of implementing the added value-creating 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 examined.

In that context, requirements/criteria are developed for plant management systems and other IT systems for process support. The work of the Technical Group focuses on the exchange of technical experience and know-how regarding all aspects of IT support for the business processes of plants that generate electricity and heat, over the entire lifetime of the plants.

For the topic Digitisation/Industry 4.0, which has been actively addressed as a topic of work since 2017, an overview of the definitions used at the companies has been prepared (glossary). The exchange of experience concerning planned and implemented applications (projects) was begun.

Information Security (IT Security)

In the wake of the German IT Security Act, in summer 2015 lawmakers stipulated in Section 11 Para. 1 of the Energy Industry Act (EnWG) that energy systems (power plants) that are defined as critical infrastructure in accordance with the Ordinance on the Definition of Critical Infrastructure (BSI-KritisV) must observe a catalogue of security requirements, to be pub-

lished by the Federal Network Agency, for appropriate protection of their information technology systems. Energy systems are defined by Section 3 No. 15 EnWG as systems for the production, storage, transport or distribution of electricity and gas. Said regulation applies to energy systems which reach or exceed the threshold levels of the BSI-KritisV. For power generation plants the threshold level is an installed net nominal capacity (electrical) of 420 MW or more; for gas storage facilities, an extracted output of 5,190 GWh/year or more.

The central requirement of the IT Security Catalogue for energy systems is the introduction of an Information Security Management System (ISMS) to DIN/ISO IEC 27001 and its certification based on a conformity assessment program that has yet to be developed by the Federal Network Agency (BNetzA) and the German Accreditation Body (DAkkS). For generation plants and gas storage facilities the catalogue contains requirements for concretisation; for instance, parts of the VGB-Standard «IT Security for Generating Plants» (VGB-S-175) and the standards DIN ISO/IEC 27002 and ISO/IEC 27019 must be taken into account. For nuclear facilities, special provisions are applicable in accordance with the SEWD (Disruptive action or other interference by third parties) IT Directive; here the IT Security Catalogue additionally provides for taking into account specific protection objectives.

BNetzA provided the opportunity to make written comments by 28 February 2018, and a statement from BDEW/VGB was sent to BNetzA within the deadline. As agreed in the committees, VGB sent an additional separate letter to BNetzA emphasising the priorities from the point of view of VGB. The IT Security Catalogue is expected to be published shortly.

At the suggestion of the PG VGB Coordination of IT-SiG, VGB has become a member of UP KRITIS (German CIP Implementation Plan). Collaboration in the Sectoral Working Group on Electricity also was approved. All relevant proceedings and information from the Sectoral Working Group on Electricity will be communicated actively in the relevant committees. Ad hoc activities will be scheduled as needed.

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.

Restructuring of the online guideline on implementation of the Ordinance on Industrial Safety and Health in power plants, VGB-S-104 (Figure 12), 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).

Examples of the topics addressed by the TG Industrial Safety in the most recent past:

- agreement with VDMA on generators, in particular regarding the definition of zones and the application of the Pressure Equipment Directive,
- classification of boiler circulating pumps in reference to the BetrSichV,
- non-compliance permits for lift systems and retrofit requirements,
- removal of scaffolding,
- hazard assessment in the event of damage,
- test recommendation for explosion protection and
- use of work equipment during power failures.

TG «Performance Indicators»

Stefan Probst

The main activities of the Technical Group «Performance Indicators» in the period under review were:

- the revision and publication of guidelines for definitions of indicators in German, English and French,
- further development of the power plant information system database KISSY,
- establishment of interplant statistics for power plants using renewable sources of energy,
- contact and consultation with other international associations and groups like the World Energy Council.

The VGB-standards of the VGB-S-002-ff. series such as «Technical and Commercial Indicators for Power Plants» (VGB-S-002-03) and the exercise booklet to the series (VGB-S-002-33) have been updated. Most of the booklets are available for downloading in the languages German, English and French, free of charge.

In the course of development of the VGB power plant information system database KISSY, a system analysis of the database will be performed for the purpose of using up-to-date, cost-effective technology to improve the future functionality of the database. After 15 years of successful use, attention also will be paid to the user friendliness of the web interface. KISSY thus also makes a contribution to the digitisation initiative in the VGB Offices.

The pilot project «Wind Turbines – Major Failure Statistic», undertaken by international members, presented the results to the VGB «Strategic Forum Wind». In the pilot project the complete replacement of the gearboxes of a total of 1,292 wind turbines was analysed. The aim was to

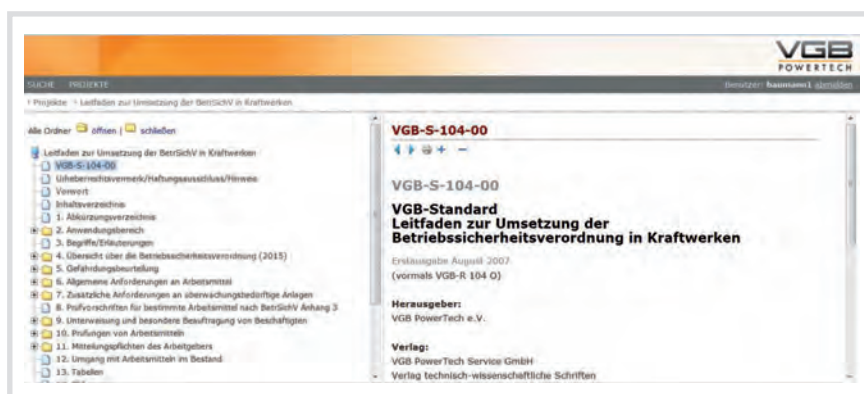


Fig. 12: Industrial safety. VGB-S-104-0, On-line-Standard.

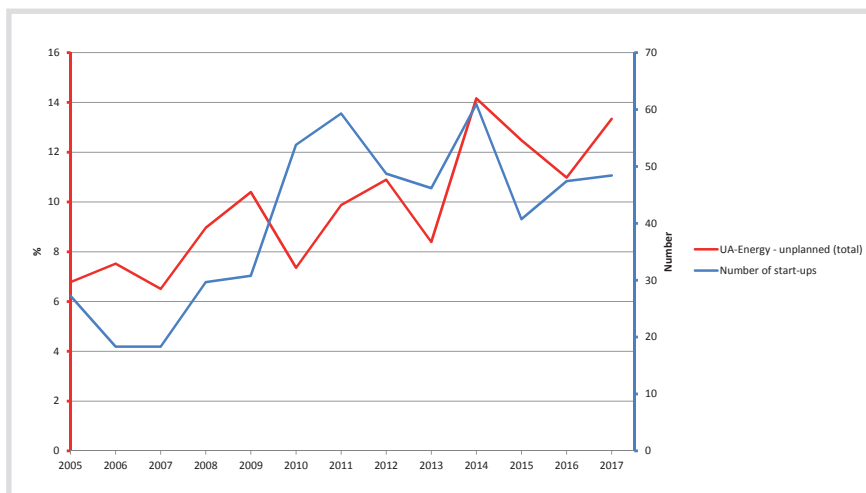


Fig. 13: Trend of the number of starts compared with the unplanned unavailable energy from hard coal-fired power plants in Germany.

analyse the systematic recording of the unavailabilities of the members, to agree on a common understanding and, if possible, establish first reliability indicators.

Cooperation with the VGB committees TG «Reference Designation and Plant Documentation» and TC «Materials and Quality Assurance» was deepened or newly initiated:

- A solution was devised for automated conversion of the KKS codes used in KISSY into RDS-PP® (Reference Designation System for Power Plants) to enable future application of RDS-PP®, the leading plant identification system, in KISSY.
- The TC Materials and Quality Assurance investigates possibilities of making analyses in KISSY of the more flexible use of power plant units, if at all possible on the basis of the existing data pool. The aim is to quantify the changes and effects, such as increased wear and tear on power plant components, caused by intermittent operation. The joint Project Group was staffed with experienced members of the two committees.

Based on special analyses, among other things the number of starts was compared with the unplanned unavailable energy. The trend for the collective of hard coal-fired power plants (Figure 13 and Figure 14) shows a constant increase of the parameters. This continuous increase can be explained by, among other things, the more flexible operating regime of the power plants as a result of the priority given to feed-in from renewable power plants in Germany.

In future, these and other new data analyses relating to the increase of unplanned unavailable energy are to be intensified and explanations sought. The increase in unplanned unavailable energy might be explained by the reduction of effort for maintenance, since the planned unavailable energy has declined steadily over the years. These and other factors will be investigated in a pilot project jointly with the TC Materials and Quality Assurance.

The technical-scientific reports «Availability» and «Analysis of Unavailability» of power plants were drawn up. 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 – technical-scientific report for the period from 2008 to 2017 – were compiled in cooperation with 67 German and international VGB members with, at present, 653 power plant units and 173 machine sets at storage and pumped storage power plants, with a total net installed capacity of approximately 275,000 MW.

TG «Reference Designation and Plant Documentation»

Andreas Böser

The VGB 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.

A network of national and international committees (e.g. DIN, ISO, IEC, CEN, DKE, eCl@ss, etc.) is used to achieve uniformity of the requirements for reference designations and documentation.

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.

The Technical Group likewise was actively involved in transposing DIN SPEC 91303 to DIN 77005-1, Lifecycle record of technical objects - Part 1: Terms and structure, for the purpose of including the technical documentation of plants covered by VGB S-831. Publication of the standard is scheduled for 2018.

Two new RDS-PP® application guidelines are currently being compiled:

- VGB-S-823-xx Systems for Distributed Energy Supply with Combustion Engines,
- and
- RDS-PP® application guidelines on «Grid Connection» in cooperation with IG-EVU.

For the revision of the wind guideline VGB-S-823-32 a Project Group was formed with the aim of completing work on the technical end of the application guidelines in 2018.

Work on the application guidelines for Photovoltaic Power Plants (VGB-S-823-33) and for Power to Gas Plants (VGB-S-823-41) could be successfully concluded in 2018.

TG «Maintenance Management»

Heinrich Grimmelt

The Technical Group «Maintenance Management» had adopted the following focal topics for its work:

VGB-Standard «Recommendations for the Introduction of Risk-Based Maintenance»

The aging VGB standard should be revised. For this purpose a project group was formed with representatives of EnBW, GKM, LEAG, NUON, PreussenElektra and Vattenfall.

As a first measure, the title was changed to «Recommendation for the introduction and establishment of value-based maintenance using a risk-based maintenance strategy».

In value-oriented maintenance, not only the costs of maintenance are considered, but maintenance is examined as part of the value chain. The aim of value-oriented maintenance is to optimise maintenance expenses over the entire lifecycle of the plant. This means that the difference between revenues and expenses, including maintenance costs, should be maximised.

In addition to extrapolating the risk for risk-based maintenance, value-oriented maintenance uses iterative feedback of the forecast revenues (market-dependent) to assess the risk.

This means that if unavailability were to lead to high revenue losses, it would make sense to increase availability through higher maintenance expenses, so that the overall economic optimum is achieved.

Value-based maintenance is based essentially on the risk-based maintenance strategy. This in turn is usually based on an existing maintenance program with the priorities described above (failure-oriented, condition-oriented, time-based).

In this situation, attempts are often made to reassess (high-priced) measures of the existing maintenance programme as a whole, with a stronger focus on financial aspects. In this context, it must not be forgotten that measures based on legal requirements, official requirements or safety-related considerations cannot generally be omitted.

By varying the company's willingness to take risks, the maintenance strategy can be controlled by risk-based maintenance (in the classic sense as described above). If a company is prepared to set the risk (product of probability of occurrence and extent of damage) very high, this comes close to failure-oriented maintenance. If a small willingness to take risks is the more likely preference, more preventive maintenance measures take place.

In order to define willingness to take risks, economic analyses and evaluations of the generation plant concerned must be made beforehand. The expected contribution margins are determined on the basis of forecast revenues (operating times x obtainable revenues) less the costs incurred (personnel, maintenance...). The only costs considered influenceable here are the maintenance costs of an individual plant (personnel costs and portfolio effects are not taken into account). Furthermore, it is assumed that sufficient contribution margin is generated to ensure plant operation in compliance with legal and regulatory requirements.

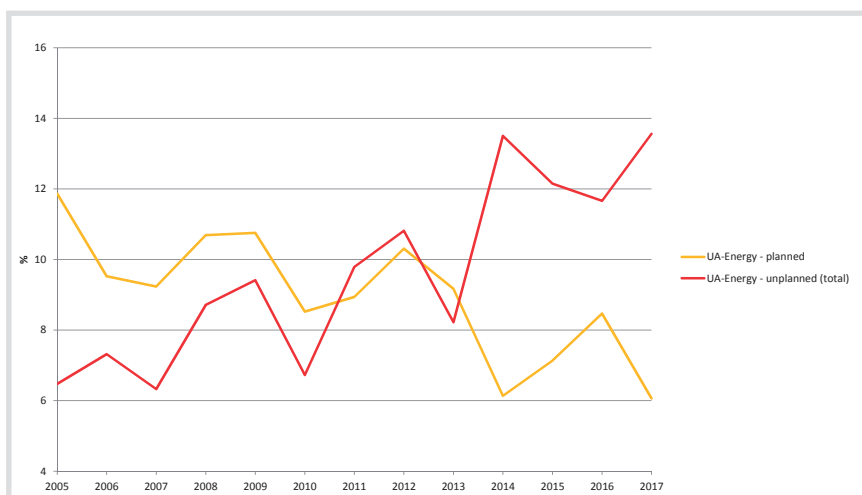


Fig. 14: Trend of planned versus unplanned unavailable energy from hard coal-fired power plants in Germany.

TG «Power Generation Maintenance Optimisation Network (PGMON)»

Sven Göhring

In the reporting time two meetings of the Technical Group «Power Generation Maintenance Optimisation Network (PGMON)» were held.

The autumn meeting took place at Grosskraftwerk Mannheim and showed again a broad variety of presentations.

ČEZ reported about their philosophy regarding the asset management in the conventional power division and the condition monitoring of main electrical components – especially the generator.

Dekra presented some methods for the condition assessment of boilers and the about data on the condition of several components in general.

The presentation held by Latvenergo dealt with data acquisition, mathematical processing and equipment condition prognostic.

It was shown how the needed data is extracted from the control system and what mathematical procedures are needed to gain a good input for the condition prognostic. This was also shown by some examples and case studies that have been performed.

The spring meeting 2018 was held at Nuon in Amsterdam. The main topic was condition monitoring with the focus on risk management.

ESB presented about the condition monitoring at the coal mills vs. the performance and the usage of HFO. They informed about their experience with wet coal and impact of the machines and increase of HFO burn to be able to sustain at the dispatched loads. Another part of the presentation dealt with the development of a web-based application for risk management in generation. The objective of the current risk project is development of a single asset/risk register which encompasses all business risks into a single dynamic source. The outputs to include (i) Risk Reports and (ii) Risk-based evaluation of investment decisions.

NUON gave a presentation on the handling of risk at power plants. They have developed an integrated asset management system and process safety system that balances risk, performance and cost that was explained to the participants. One of the observations is that the risk assessments that are done by the technical specialists for similar parts in the plants are showing differences, this will be further investigated.

Competence Area

Renewables and Distributed Generation

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 specific issues, with technical and environmental topics in the field of renewables and distributed generation. Capitalizing on the intensive exchange of experience, it offers its members an ideal international platform with the goal of achieving further improvements in efficiency, safety, environmental friendliness, economy and operation. Along with aspects of the optimization of plants already in operation, the detailed investigations and in-depth analyses focus on the formulation of technical requirements for the construction 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, 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 division 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>.

During the period under review, the activities and cooperation in particular with Eurelectric in Brussels, BDEW (Bundesverband der Energie- und Wasserwirtschaft/German Association of Energy and Water Industries) and Energie in Austria were extremely intensive due to a large number of initiatives, directives, laws and ordinances had to be revised or introduced for the first time on national and European level.

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 (Figure 1). 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% is expected for the electricity sector, 21.3% for heating and cooling and 11.3% for the transport sector.

In 2016, the share of renewables in gross final energy consumption in the European Union reached a level of 17%, and was twice as high as in 2004 (8.5%), the first year for which data are available.

At more than half (53.8%), the share of energy from renewable energy sources was by far the highest in Sweden in 2016. Of the 28 EU Member States, eleven have already achieved the levels necessary to meet their national targets for 2020: Bulgaria (18.8%), the Czech Republic (14.9%), Denmark (32.2%), Estonia (28.8%), Croatia (28.3%), Italy (17.4%), Lithuania (25.6%), Hungary (14.2%), Romania (25.0%), Finland (38.7%) and Sweden (53.8%). Moreover, Austria is less than 1 percentage point short of its 2020 target. On the other hand, the lowest shares for the use of renewable energy sources were registered in Luxembourg (5.4%), Malta and the Netherlands (both 6.0%).

At the end of 2016, 29.2% of the EU's electricity generation was from renewable energy sources, with fluctuating renewables

SF Strategic Forum
TC Technical Committee
TG Technical Group

– wind and solar energy – accounting for 43.5% of total renewables electricity generation in the EU (Figure 2). Wind power generation in the EU (Figure 2). Wind power generation more than quadrupled between 2004 and 2016. After hydro power, which accounts for more than 36.9%, it now makes the second largest contribution to renewable electricity generation. With a share of 18.9% in 2016, electricity generation from biomass also reached a corresponding increase. Also noteworthy is the use of solar energy, which rose from 2.5 TWh in 2006 to 110.8 TWh in 2016 over a period of 10 years.

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 1,267 GW generated around 4,185 TWh of electricity in 2017. 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 as compared to the previous year, and has set itself the aims of

- being the collective European platform 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). The hydro power-related media catalogue, for example, contains 35 VGB-Standards, some of which are

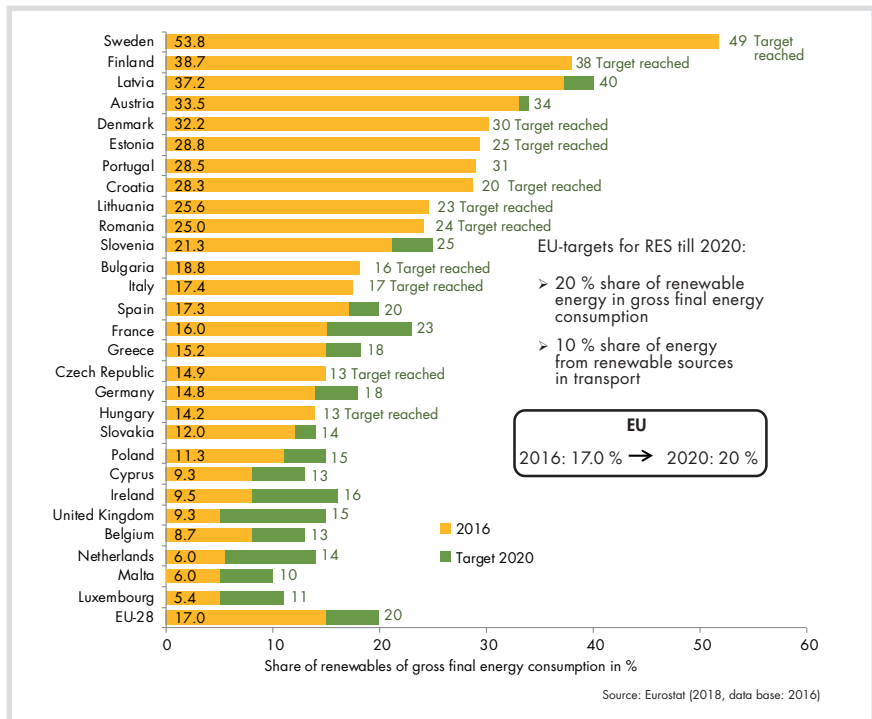


Fig. 1: Share in renewables according to member state (in % of the gross final energy consumption).

in German, English and French, created in close cooperation with operators and manufacturers. For better clarity as to the area of application, the VGB-Standards are assigned to specific fields. The hydro power events diary for 2017/2018, published jointly by VGB and Eurelectric, with its numerous references to conferences, symposiums, seminars, workshops and committee meetings in Europe has also met with an excellent response.

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 countries actively address a variety of technical and environmental topics relating to hydro power and engage in an intensive exchange of experience.

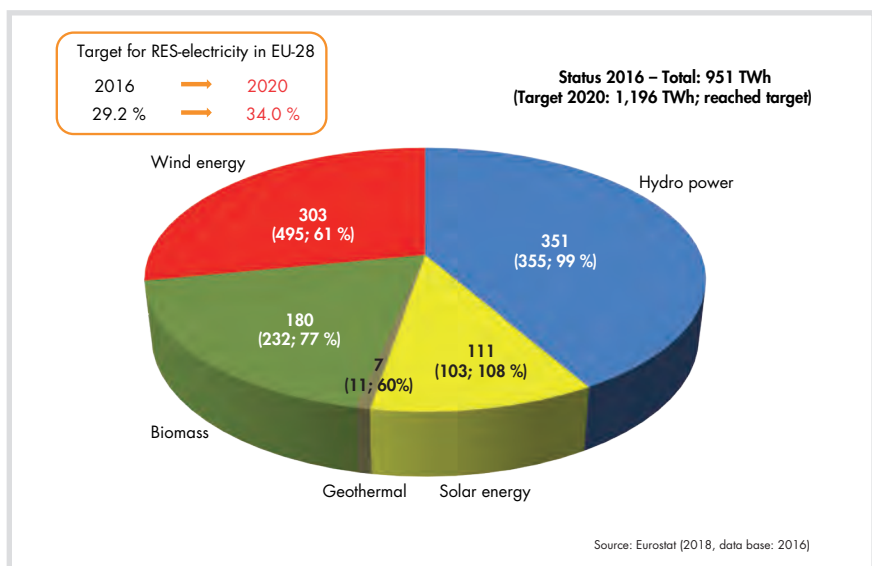


Fig. 2: Shares of renewables in the electricity sector in the EU-28.

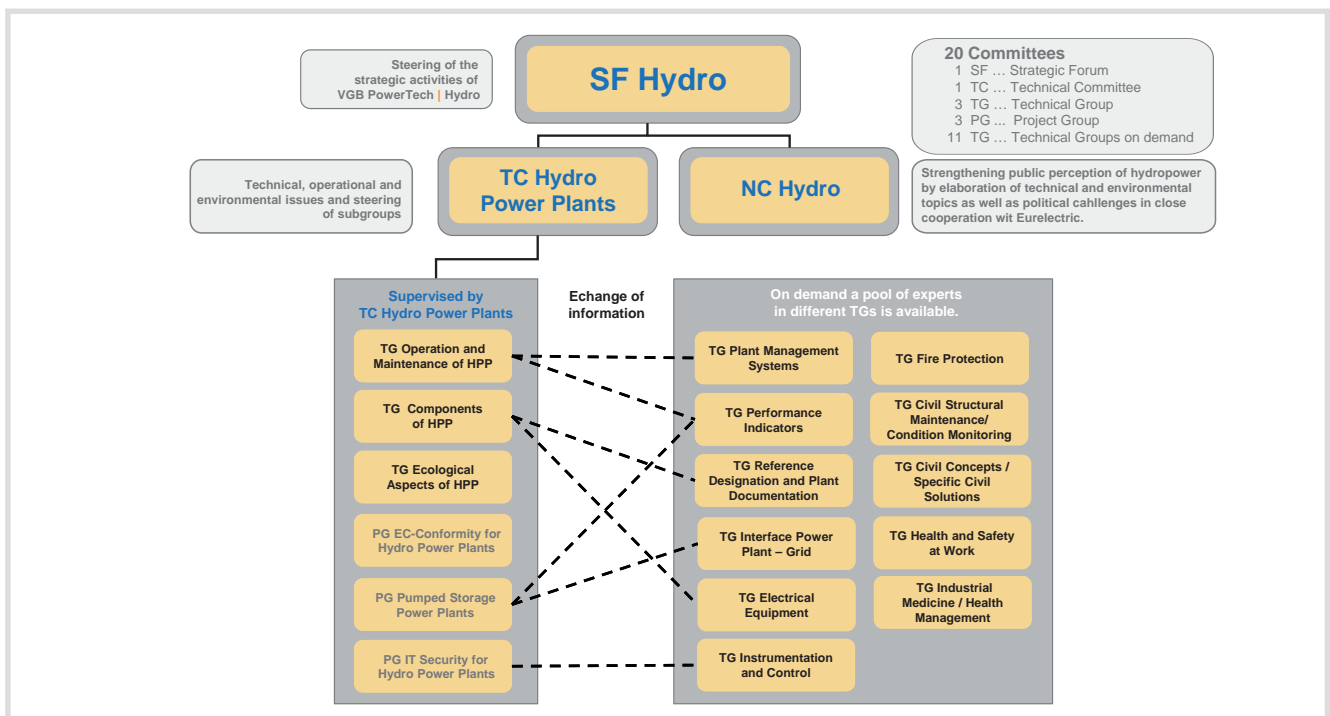


Fig. 3: Committee structure of VGB PowerTech | Hydro.

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 the political and strategic work on the EU level concerning all matters of power generation.

SF «Hydro»

Mario Bachhiesl

The Strategic Forum (SF) «Hydro» comprises top management members of European hydro power operators and manufacturers, 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 energy 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 organizations, and coordinates the work of the Technical Committee (TC) on «Hydro Power Plants».

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 organizations, and in particular stronger representation of hydro power by VGB at the European level. VGB and its committees forms an interface to Eurelectric for the European operators of hydro power plants when dealing with technical, economic, ecological and strategic issues.

A Network Committee (NC) has also been established in order to enhance the importance of hydro power in Europe. The work performed by the members of the NC, who come from both operators and manufacturers, will include the compilation of position papers and fact-based documents, and the development of communications strategies.

TC «Hydro Power Plants»

Mario Bachhiesl and Wolfgang Czolkoss

The functions of the various Technical Groups and Project Groups dealing with hydro power are coordinated in the Technical Committee on «Hydro Power Plants». There is an intensive exchange of technical experience (Figure 4 and Figure 5) between the members, development projects are coordinated, and liaison and cooperation with other organizations in the field of hydro power such as BDEW (Bundesverband der Energie- und Wasserwirtschaft/German Association of Energy and Water Industries), DWA (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall/German Association for Water, Wastewater and Waste), AGAW (Arbeitsgemeinschaft Alpine Wasserkraft/Alpine Hydro Consortium), etc.) take place.

The current market situation for hydro power is characterized by low achievable earnings for electricity, coupled with a lack of subsidies for hydro power as a renewable source of energy. As a result, the existence of many current plants is threatened.



Fig. 4: Hydro power plants, Sohlstufe Lehen (Photo: VGB, Czolkoss)

The expansion of hydro power, desirable from an ecological viewpoint, is not economically feasible under such conditions. The additional services provided, for flood control or shipping, for example, thus are also in jeopardy. They would have to be provided by other means if the decommissioning of hydro power plants threatens. In general, hydro power 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. The ecological requirements, for instance concerning the design of grilles for fish protection, are becoming more and more stringent although their benefit to the fish population is questionable. The coming Natura 2000 directive is leading to even lengthier 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 is continuing to lead to reductions in expenditure on servicing and maintenance. Maintenance intervals are extended and the expected service life of components is increasingly utilized to the limit. The two TGs, «Operation and Maintenance of Hydro Power Plants» and «Components of Hydro Power Plants», deal with these problems. 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 modernization and replacement. Assistance in this area is provided by the VGB-Standard VGB-S-033, «Interaction of Conformity Assess-

ment and Industrial Safety in Hydro Power Plants», which has been updated by the Project Group (PG) «Conformity Assessment».

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». Based on the VGB-Standard VGB-S-175, «IT Security for Generating Plants» the project group is identifying the security risks and consequences to be drawn for the equipping 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.

TG «Ecological Aspects of Hydro Power Plants»

Wolfgang Czolkoss

The Technical Group «Ecological Aspects of Hydro Power», established jointly with 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 organized by the German environmental protection agency Umweltbundesamt – UBA and in other national and international events and committees, representing and explaining the positions of the hydro power plant operators. Members of the TG are also actively engaged in other associations and organizations, providing a constructive dialogue with other stakeholder groups, such as fishing, shipping, flood defence and conservation.

A workshop on «Ecology and Large-Scale Hydro Power» is being prepared on the basis of the collated results of existing research and monitoring studies, and practical experience. The purpose of the workshop is to discuss outstanding questions relevant to the objectives of the European Water Framework Directive with scientists, authorities, hydro power operators and various associations. The aim is to present appropriate requirements and suitable solutions for achieving the objectives, and to define the research that is still necessary. The results are to be published in a position paper.



Fig. 5: Hydro power plants, Kaprun hydro power plant (Photo: VGB, Czolkoss)

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 studies on fish protection and monitoring projects.

In the demonstration project on dam restoration with ecological improvement of the bank areas (INADAR - Innovative and ecological approach for dam restoration), the construction phase at the two trial areas of the Danube at Oberelchingen and Offlingen has now been completed. The development of the ecological situation at the banks is now being monitored.

TG «Operation and Maintenance of Hydro Power Plants»

Wolfgang Czolkoss

The Technical Group «Operation and Maintenance of Hydro Power Plants» provides for an 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. In view of the economic constraints that lead to extended maintenance intervals and greater use of the calculated life, 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 in 2018, and it is planned to use it as a training document for a workshop.

For this purpose, working 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),
- Digitization of workforce management (exchange of experience).

In connection with operation by remote control, it is necessary to deal with individual issues related to particular plants. Therefore it is not possible to establish a generally applicable guideline. Information on the subject of remote control is exchanged with the VGB PG «IT Security for Hydro Power Plants». A VGB workshop took place in Vienna on 4 April 2017 in cooperation with Verbund on the subject of «Digitalization in Hydro Power», and

	Installed capacity end 2015 [MW]	Installed capacity end 2016 [MW]	Installed capacity end 2017 [MW]
Germany	44,946	50,019	56,132
Spain	23,025	23,075	23,170
France	10,358	12,065	13,759
United Kingdom	8,958	14,542	18,872
Italy	8,144	9,257	9,479
Sweden	6,025	6,519	6,691
Portugal	5,079	5,316	5,316
Denmark	5,064	5,227	5,476
Turkey	4,694	6,081	6,857
Netherlands	3,431	4,328	4,341
Poland	2,497	5,782	5,848
Ireland	2,486	2,830	3,127
Austria	2,412	2,632	2,828
Belgium	2,229	2,386	2,843
Greece	2,152	2,374	2,651
Finland	1,001	1,539	2,071
Norway	837	838	1,162
Remaining Europe	6,311	6,520	6,883
Europe	141,726	161,330	177,506

Tab. 1: Installed wind power plant capacity in Europe in 2015, 2016 and 2017 (Source: WindEurope 2018).

was attended by over 100 participants from 12 different countries. The focal areas were those of «Digital Workforce Management» and «Digital Hydro Power Plant».

During an unscheduled meeting between members of the TG and representatives of EDF, there was an exchange of information and experience on maintenance issues and the organizational structure of small hydro power plants (<10 MW).

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 the influence on component quality which they give rise to in all project phases, from tendering, drafting of contracts and design through production and installation to commissioning and operation. 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.

The result is a document on «Measures to Improve Quality for Components in Hydro Power Plants» with 6 self-contained chapters, which is being made available to VGB members. A summary is to be published in VGB PowerTech.

Wind Energy

Mario Bachhiesl and Ulrich Langnickel

The use of wind energy 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 by 2020. However, extensions should be purposefully selected at very favourable «wind sites» taking account of power plant-related criteria. In order to optimize the actions required for this, operators of wind power plants exchange information on their experience with technical and environmentally relevant topics at an expert level within VGB. At the end of 2017, about 29,844 wind power plants with an output of 56,132 MW were in operation in Germany. At that time the installed capacity in Europe amounted to 177,506 MW (Table 1) and worldwide 539,123 MW.

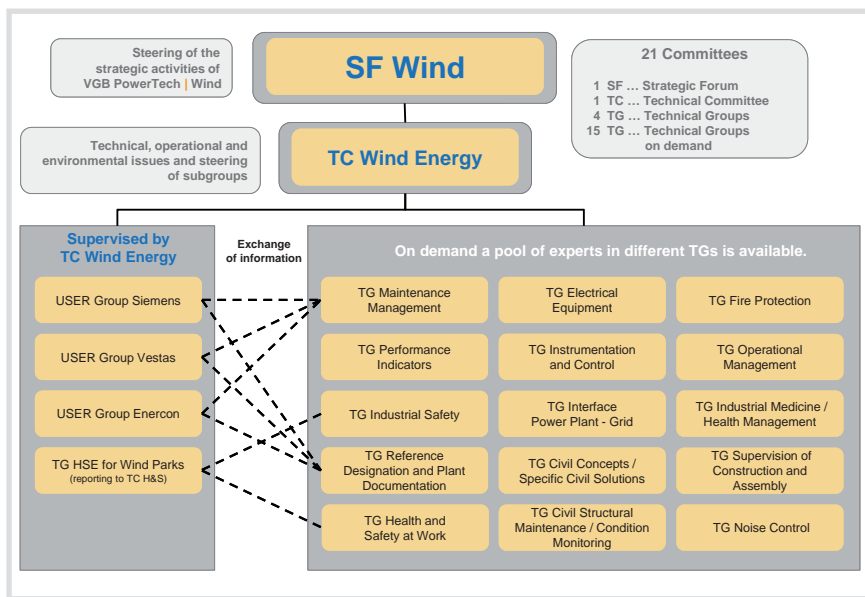


Fig. 6: Committee structure of VGB PowerTech | Wind.

For over 17 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 standardization (best practice) and strengthening of the common interests of the operators, above all in various User Groups.

VGB PowerTech | 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 Europe. Further intensive initiatives have been developed and implemented for this purpose, and can be reviewed on 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. The wind energy-related VGB-Standards are listed in a dedicated media directory. This comprises more than 25 standards, seven of which are undergoing final drafting or revision. 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 power plants with a total capacity of more than 38,000 MW, corresponding to around 23% of the capacity installed in the EU 28. In the VGB committees and groups, over 140 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. Further committees and groups can be activated as required (Figure 6).

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 Verbund, pool their interests under the roof of VGB. Apart from exchanging information and experience, the participating companies seek mainly to advance standardization (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 coordinated and joint analysis of operating experience. The findings and knowledge obtained provide the basis for the establishment of construction and operating standards (VGB-Standards). In the SF «Wind», the strategic requirements for the utilization 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 various User Groups are coordinated. These bodies deal mainly with operating experience and requirements, and initiate and support relevant research projects.

The VGB member companies in the SF «Wind» have set themselves the aim of intensifying the exchange of information and experience in the committees. For that purpose, appropriate products are being offered by VGB in the context of progressive digitization. In this connection, VGB has already developed an Online Information Portal, which is being tested in the Vestas User Group.

One fundamental topic belongs to the plant designation requirements. In this connection, more attention is to be paid by VGB to the implementation of the VGB-Standard on «Reference Designation System for Power Plants - RDS-PP® for Wind Power Plants». The expectation behind this attention is that the wind turbines from the various manufacturers will in future be designated in a uniform way.

TC «Wind Energy»

Ulrich Langnickel

The primary objective of the members of the Technical Committee (TC) «Wind Energy» is to jointly cut the costs of servicing and maintenance of the wind turbines. Together with an intensive exchange of information and experience, the committee coordinates the further development of standardization, initiates corresponding research projects, and assists in designing the contents of VGB events. In addition, the requirements of the operators are regularly discussed with the manufacturers of the wind power plants. In the period under review, there were meetings with Vensys Energy AG and Nordex Energy GmbH. In this context, fundamental issues for discussion were related to the reference designation systems and the provision of the necessary documentation.

To optimize the maintenance strategies in the wind energy field, further standardization is an absolute necessity. Similarly to the recommendations for conventional power plants, therefore, various VGB-Standards contain requirements and necessary measures for the installation and operation of onshore and offshore wind farms. In total, the newly compiled media directory for the field of wind energy comprises 25 VGB-Standards, 9 of which are exclusively concerned with the challenges in the area of wind energy. These include the following documents:

- 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 a revised form in 2014. The stipulations of RDS-PP®, based on

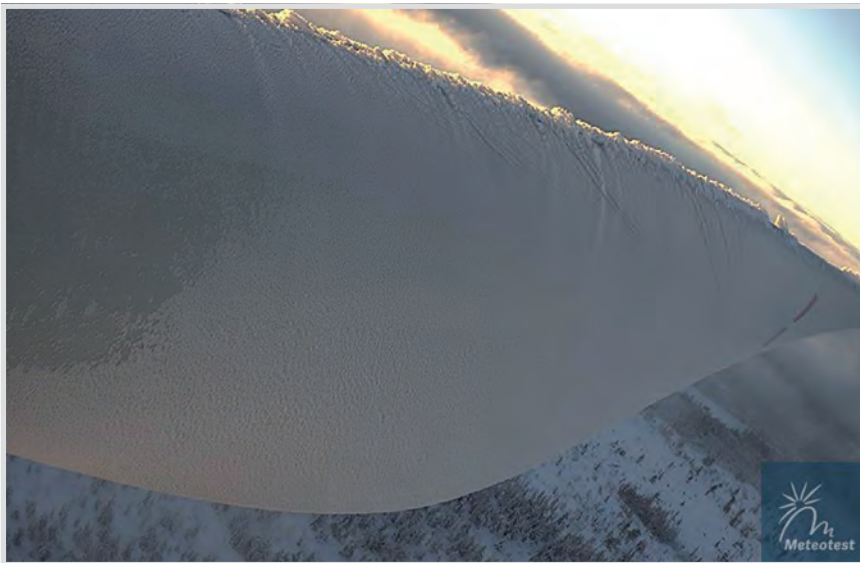


Fig. 7: Camera for documentation of ice formation on a rotor blade, Photo: MeteoTest AG.

international designation standards, make an unequivocal digital exchange of data on the components of a wind turbine possible, and by doing so produce 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. At present, the VGB-Standard is being extended to also cover further plant components, such as those in off-shore transformer platforms.

- Specific information requirement lists for wind turbines have been integrated in VGB-Standard VGB-S-831-00-2015-05, «Provision of Technical Documentation (Technical Plant Data, Documents) for Energy Supply Units» 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 harmonize the definitions and indicators, members of the TG «Performance Indicators» have compiled such terms for the wind energy sector and coordinated them with the members of the TC «Wind Energy». They are published in the VGB-Standard «Wind Turbines – Definitions and Indicators» (VGB-S-002-05). This VGB-Standard is being continuously expanded and adapted. 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, and with preventive measures to avoid damages. These components are made of steel, reinforced concrete and other materials as well as combinations of these. This document also deals with building materials such as mortar or coatings which are part of the basic package or are used for repair. However, electrical or electrically conducting components are not considered. This VGB-Standard will be published in 2018.
- 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» is being drawn up in consultation with specialist associations. This standard was declared 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 onshore 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 action required to protect human life is also explained. The relevant VGB-Standard will be published in 2018.

- 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 will describe details of oil analysis, oil filtering and the correct procedure for flushing and filling. The VGB-Standard is to be published in 2019.
- A standardized acceptance 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 constituent meeting on this VGB-Standard took place on 20 November 2017. The structure and the main issues of the document have been discussed.
- The disposal of rotor blades will represent a major challenge in future. On 31 December 2020, the remuneration system under the terms of the Renewable Energy Act (EEG) in Germany will end for around 5,500 wind turbines with a total capacity of approx. 4,000 MW. In case of complete dismantling of the wind power plants, there will be a need to dispose 16,500 rotor blades. The constituent meeting on the VGB-Standard «Disposal of Rotor Blades» took place on 13 November 2017. In that meeting, and in the following meetings of the working panel, the structure of the document was defined.

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. 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. To date, three ice detection systems have been installed on a Vestas V90 wind turbine at the Swedish wind farm Stor Rotliden, which is operated by Vattenfall Vind AB. The fourth sensor will be installed in the summer of 2018. In an extensive programme, the behaviour of these systems is being tested, evaluated and compared.

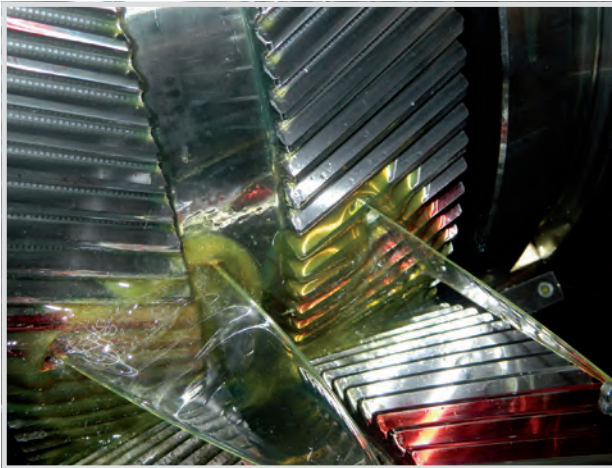


Fig. 8: Oil feed in a gearbox, Multigear GmbH

The formation of ice is additionally documented by a camera (Figure 7). The VGB member companies which have provided financial support for the implementation of this highly innovative research project have access to the test results since January 2018. With the conclusion of the research project in 2019, 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 Economic Zone (EEZ) have to be checked every four years and the foundations of transformer platforms every year. On the basis of experience gained and evidence collected by testing of the condition, deviations from the fixed annual test intervals are possible in agreement with the inspection and testing officer and the BSH. In order to reduce the high costs associated with recurrent testing, the operators are aiming at prolonging the testing intervals. In a first step, the actual stresses on the materials used, including the welded joints, were 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 previously used. In the course of the research project, extensive analyses and measurements were conducted on existing offshore foundations under various loads. In addition, various trials were performed on a laboratory scale. The favourable results of the research project have been available to the companies involved in the financing of the project since the end of 2017. The results obtained from the research could

have an impact on possible adjustments of the testing intervals for the recurrent tests. VGB will support and monitor the discussion process which is necessary in that context.

As wind turbines are highly dynamically stressed structures with high numbers of stress loads, stringent demands are placed on the lubrication of the gearbox bearings and gear teeth. The correct performance of oil changes and oil analysis are essential. With

support from Ørsted Wind Power A/S and the Project Group dealing with the corresponding VGB-Standard, a two-day event on «Oil Monitoring for Wind Power Plants» took place in Copenhagen on 7/8 November 2017. The topics dealt with the development of new oils, their ageing processes and the corresponding monitoring, and also with the use of additives and the oil change (Figure 8). As a result of the positive feedback, a further VGB event on this topic will follow in 2019.

With support from Allianz Global Corporate & Speciality SE and the TC «Wind Energy», the annual technical conference «Maintenance of Wind Power Plants» took place in Munich on 7/8 May 2018. Over 80 participants from 13 countries addressed issues related to the operation, servicing and maintenance of wind turbines. One of the main topics of this event concerned the operation and maintenance strategies of the various market players. Both the owners and the manufacturers of the wind turbines presented their different concepts in this regard. This set of topics was rounded off by the contributions of the manufacturer independent service provider. The process of progressive digitization will also have a significant impact on the orientation of future operation and maintenance strategies. This was illustrated in a corresponding thematic block. The presentations and intensive discussions at the conference showed that the process of optimizing servicing and maintenance strategies has to be continued. The next technical conference will take place in Bremen, Germany, on 26/27 March 2019.

User Groups «Siemens» and «Vestas»

Ulrich Langnickel

There is 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 optimize the servicing and maintenance measures for the respective systems. The requirements and suggestions for improvements established jointly are being discussed with the manufacturers. These include in particular the use of the RDS-PP® reference designation system and the provision of the necessary documentation by the manufacturers. Access to the IT systems after handover of the wind turbine, however, also plays an important role.

The committee members intensively discussed the use of the RDS-PP® reference designation system with a representative of the wind turbine manufacturer Vestas. Vestas is already making corresponding designation marking available for particular types of turbine. This dialogue is to be continued in order to intensify the exchange of the different requirements on this topic.

In order to ensure a continuous exchange of information and experience, the members of the Vestas User Group are testing an Online Information Platform installed by VGB. If the feedback is favourable, this tool will also be used by other working groups to intensify the committee work.

TG «HSE for Offshore Wind Parks»

Guido Schwabe

The evaluation and communication of accidents are the main topics of the Technical Group «HSE for Offshore Wind Parks». This also 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».

A number of medical issues have also been addressed. Examples include the AWMF guideline on medical fitness for offshore workers and the DGUV information on first aid. Further topics are e.g. drinking water quality, hazardous substances and microorganisms.



Fig. 9: New ships for offshore wind power operation
Source: Knut Gerdes, EMS Offshore GmbH, Emden VGB Workshop 2016.

Development of the «Offshore Wind Rescue Chain» is supported. This includes questions concerning the use of helicopters and ships (Figure 9) for rescue work, and telemedicine.

The «Emden Workshop on Occupational Health and Safety» has become a regular event. In the reporting period, the workshop took place on 1/2 September 2017 and the next will take place on 7/8 September 2018.

TG «Distributed Generation/Storage»

Doreen Kückelmann

Within the framework of the TG, the technical and commercial developments of small combined heat and power (CHP) plants, which are mostly based on the classic piston engine process, and storage technologies are considered. The committee's work also focuses on the system integration of fuel cell technology, micro gas turbines and Stirling engines. These technologies are capable of enabling the use of CHP technology even for units with a very small output range, for example for applications in domestic and local heating supply, and also in the commercial sector. Developments in the electricity grid, progress in grid expansion, demand management, virtual power plants, smart grids, smart cities and IT security/communication are monitored in both grid-dependent and stand-alone operation, and used as a basis for discussion of further business models. The technical developments of storage technologies in the complex system of distributed energy supply consisting of generation, transmission, distribution and consumption are becoming increasingly important.

Batteries, compressed air, heat storage, hydrogen and methane are increasingly contributing services to the electricity grid and energy system and facilitating more flexibility in a low-carbon energy system. Both distributed and centralized power generation from renewables will be further expanded. This increases the demands relating to the integration of variable renewables. Energy integration could provide further flexibility that would permit better incorporation of renewables in the electricity system. The use of energy storages is confronted by numerous regulatory frameworks in the individual EU member states that lead to ineffective market integration as a result of that fragmentation. Reducing the administrative burden and allowing non-discriminatory access to the grid for energy storage facilities would reduce the overall cost of the electricity system.

The VGB workshop «Storage — Flexibility in a Low-Carbon Energy System» took place for the first time on 20 February

2018 in Herne in cooperation between the TG «Distributed Generation/Storage» and STEAG Technischer Service. The use of storage batteries, compressed air systems, thermal storage systems as well as the opportunities and risks of integrated energy were discussed in several presentations. The event was rounded off by a tour of the STEAG large-scale battery systems at the power plant site in Herne (Figure 10).

In the past business year, the topics of storage technologies and flexibility were discussed.

In the Paris Climate Agreement of December 2015, the international community has set itself the goal of limiting the rise in global temperature below 2°C. A further reduction in current CO₂ emissions will be necessary to meet the two-degree target. Further expansion of energy from renewables is expected. Energy Storages as well as sector coupling will become increasingly important to ensure the reliable supplies in the energy grid. The most important driver for this is the integration of energy from volatile renewables from wind and PV in the public grid. Power-to-X is attracting more and more interest. At present, a number of pilot projects are still underway with regard to Power-to-Gas. Hydrogen as an energy fuelling vehicles already works without problems.

At present, the use of switched-off power from wind turbines for other uses, e.g. in Power-to-Gas, is prevented by regulation. This is another reason why there is a fundamental need for a discussion of storage technologies. Storage developments and applications are dynamic and have to be concerted. So far, however, there is no uniform and economically viable legislation. There is also the demand to reduce the current market uncertainty with regard to CHP.



Fig. 10: STEAG large-scale storage battery Source: STEAG

Balancing of the residual load must also be guaranteed in the future. The number of coal and nuclear power plants will be reduced. Then, flexible power plant capacities, storage technologies and Demand side Management (DSM) will increasingly be used.

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 committees and groups which intensively discuss technical, operational and environmentally relevant topics (Figure 11). 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 (Figure 12). 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 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 utilization, 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, smouldering fires in large storage piles are only detected at a very late stage. On the same subject, a research project sponsored by the German Federation of Industrial Research Associations (AiF) entitled «Analysis

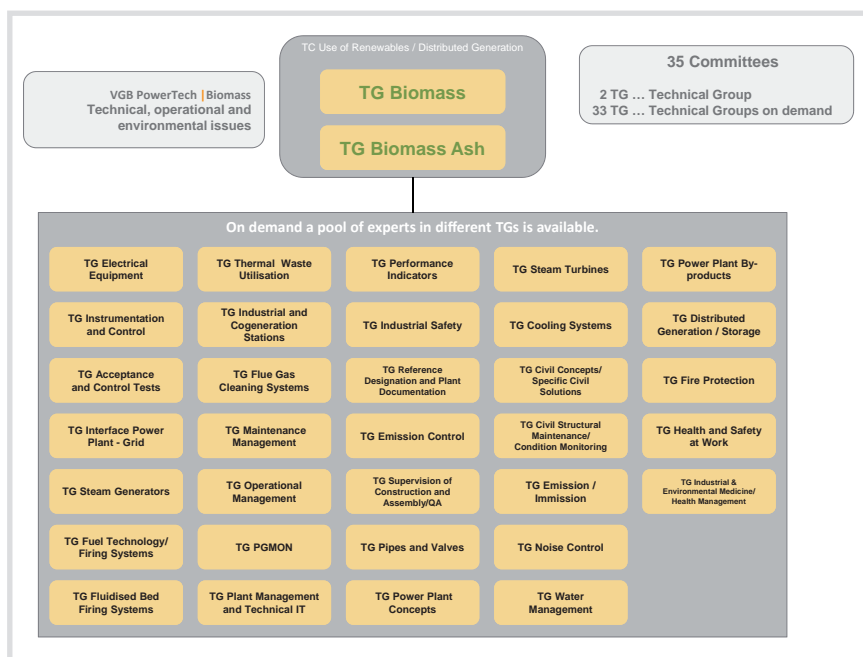


Fig. 11: Committee structure of VGB PowerTech | Biomass.

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.

A presentation was given at the TG Biomass on operating experience with the new ChlorOut system at the Boehringer Ingelheim power plant. In 2004, the site, which went into operation in 1983, was converted from hard coal to waste wood of categories I to IV. The live steam temperature of 540 °C required on the production side in connection with high chlorine contents in the fuel led to strong corrosion phenomena on the first superheater tube bundle, which were countered by the injection of ammonium sulphate solution (ChlorOut process). However, this process did not make it possible to comply with the limit values for ammonia slip introduced in 2016 by the 17th Pollution Control Ordinance (17. BImSchV). The problem was discussed intensively at an earlier meeting of the TG and the solution of replacing part of the ammonium sulphate with iron sulphate was jointly developed. Following



Fig. 12: Fuel bunker at the Märkisches Viertel power plant. Source: Vattenfall Europe Wärme



Fig. 13: Pine needles without (left) and with (right) biomass ash fertilizer application (Source: ecolan/FIN)

implementation and the first inspection cycles, a final, detailed evaluation of the process has now been provided. It was possible both to comply with the limit values and to keep the corrosion to a minimum. As an alternative to the use of additives, newly developed superheater materials and composite tubes from Sandvik were presented.

The Dalkia power plant in Biganos (France) was integrated into the existing paper production site as a purely biomass-fuelled fluidized bed furnace. The installation made it possible to shut down an old inefficient power plant for combustion of bark and natural gas. The pressure of the live steam produced at 120 bar and 520 °C is first reduced in a turbine to produce electricity. A partially expanded steam flow (12 bar) is used in paper production. The residual heat from the condensation is used for hot water and heating. The fuel supply comprises on the one hand bark and residues from paper production, and on the other hand residues from local forestry. The entire project from planning and approval to reliable supply for production was completed in just 21 months. A tour of the plant was conducted, with special attention to biomass logistics and storage.

TG «Biomass Ash»

Dr. Hans-Joachim Feuerborn

The European Technical Group «Biomass Ash» deals with all topics related to the production, characteristics and use of biomass ash. The work in the year under review was predominantly related to its application as a fertilizer. Attention was directed to practical experience and in particular to impending changes in the regulatory environment.

In 2016, the European Commission adopted a proposal to simplify the existing Fertilizer Regulation (No. 2003/2003). This is intended to simplify the fertilizer market and extend the stipulations to products previously only governed by national standards by introducing general quality and safety criteria. It is assumed that, in addition to the requirements for nutrients relevant to fertilizers, limit values for trace elements will also be introduced. So far, these have only been regulated nationally. This means that restrictions to current practice are foreseeable in some European countries.

The European Fertilizer Regulation is being revised by a working group of representatives of the member states, the fertilizer industry, non-governmental organizations and academic institutions. For the development of process and product criteria for struvites (magnesium ammonium phosphates), biochar and ash-based products, a STRUBIAS (STRUvit, Blocoal and ASH) working group was established. Product criteria are defined for the STRUBIAS products in order to ensure nutrient supply in a form available to plants and to preclude risks for humans and the environment. The phosphorus content is of particular importance here as phosphates are classified as critical raw materials in the EU and are of particular importance in terms of cost-effectiveness and availability. The report from the STRUBIAS working group will be completed in autumn 2018.

In addition, the results of fundamental and application-oriented research projects are evaluated and the developments leading to use in accordance with regulations are closely monitored, particularly with regard to the use as an aggregate in road construction, as a component of fertilizers and for forest liming. Aspects of homogeneity and composition must be taken into account as far as possible in such a way that subsequent use or safe disposal is possible without further processing or treatment. In the current Bioefficiency research project (funded as No. 72761 in Horizon 2020), aspects of fuel

treatment and process control are examined not only for the specific aspects of efficiency, emissions and durability of the plant systems, but also for the quality and options for utilization of the residues (<https://www.bioefficiency.voeu/>).

The latest findings are discussed with interested experts at workshops. At the last VGB Biomass Ash Workshop on 6 June 2018, discussions with experts and interested parties from industry and research focused in particular on developments in fertilizer law, the production of fertilizers and the treatment of ash, and practical experience in the use of wood ash for forest fertilization (see Figure 13). The findings will be incorporated into the further work of the group.

In the technical applications of biomass ash, the regulations for earthworks and road construction are of especial importance. When the relevant standards for aggregates are revised, the lists of aggregates (including biomass ash) from the standards are to be transferred into a technical report. The potential applications will therefore no longer be directly apparent from the standards. In the field of earthworks, a new technical report is also to be prepared in which the national experiences with secondary raw materials are described in detail. Environmentally relevant requirements in the place of use will then also have to be taken into account.

These rules and regulations are subject to continuous further development in order to take account of the findings which are made. However, it must be considered that in some countries biomass ash is also produced by the incineration of contaminated waste wood, and that these ashes can not be utilised, but has to be disposed of safely. Due to the comparatively limited opportunities for use and disposal of the ash, the focus has shifted to improvement of quality by conditioning. Both mechanical and mineralogical and chemical processes are used to process the ash. Either a specific type of metal species is extracted or depleted, or the surface quality is influenced in such a way that, among other things, the leaching behaviour of certain metals or compounds decreases. The possibilities of phosphorus recovery are also important. During co-incineration in biomass combustion, the chemical composition and in particular the uniformity of the ash are positively influenced.



Fig. 14: Barby Biomethane Plant. Source: MVV

Biogas

Sebastian Zimmerling

Biogenic methane mixtures can be used for electricity and heat generation in small combined heat and power (CHP) 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. According to the 2012 amendments of the German Renewable Energy Act (EEG), at least 60% of the waste heat has to be utilized.

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 utilizing 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 an extremely broad range of topics relating to biogas generation and cultivate an intensive exchange of experience.

TG «Biogas»

The optimisation and operation and maintenance of existing plants is the current core topic of the TG «Biogas», and consequently the biogas plant of a member of the Technical Group was visited and its special technical features discussed in detail. In addition, there was a tour of a Power-to-Gas plant, where the hydrogen produced is methanized with the lean gas from a biogas conditioning system and can therefore be temporarily stored in the natural gas network without limitation.

The Barby Biomethane Plant (Figure 14) went into operation at the end of 2014 and feeds conditioned biogas into the local natural gas network. Biomethane can be used to supply electricity or heat. A broad range of plants from regional agriculture is used as the fuel input, including maize silage, grass, sugar beet, whole crop silage and farm manure. The technical peculiarities of the plant, especially in the field of feeding agitator technology and the associated operating experience were intensively discussed during the plant inspection. The Barby Biomethane Plant is part of the Saxony-Anhalt biomethane cluster, which consists of 5 biomethane plants.

The Ibbenbüren pilot power-to-gas plant converts excess electricity from renewable energy sources into hydrogen, which can be temporarily stored up to a certain concentration in the natural gas network. By combining the hydrogen from electrolysis with CO₂ from the lean gas flow from biogas treatment, methane can be produced which can then be stored in the natural gas network without limiting the concentration. At the Ibbenbüren site, only the hydrogen production is initially thoroughly tested in practical operation. Particular attention is paid to the accumulation of operating experience with the use of an electrolyser in the context of energy generation from renewables, and especially the consideration of fluctuating and intermittent operating modes instead of «conveyor belt operation» and the study of reliability and efficiency developments over a period of several years are decisive.

Initial operating experience after more than 5,500 operating hours shows that the electrolyser fulfils all contractually agreed performance characteristics, that it is possible to follow predefined profiles (wind and PV generation profiles) without any problems and that the system is generally suitable for use under normal practical conditions. |

Competence Area

Environmental Technology, Chemistry, Safety and Health

TC Environment	C: P. van Zijl A: S. Göhring
TG Emissions/Imissions	C: Dr. F. Söllnböhrer 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 Dr. T. Eck
TG By-products of Waste Incineration	C: W. Schmidt A: Dr. T. 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. A. Wiesel 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: M. van Schaik A: G. Schwabe
TG Fire Protection	C: S. Schwenker A: S. Zimmerling
TG Health & Safety at Work	C: Dr. R. Wieder A: G. Schwabe
TG Industrial and Environment Medicine/ Health Management	C: Dr. T. Schnabel A: Dr. L. Jentjens
TG Medical Scientists in Nuclear Power Plants	C: Dr. N. Behrens A: Dr. L. Jentjens
TG Health & Safety for Offshore Wind Parks	C: N. N. A: G. Schwabe
IC Climate and Environmental Protection *)	C: Dr. B. Viertel A: Dr. A. Wecker
ICE Climate Protection	C: A. Nolden A: S. Göhring
ICE Immission Control	C: Dr. J. Altenburg A: S. Göhring
ICE Systems Planning and Licensing	C: Dr. A. Bala A: Dr. A. Wecker
ICE Water and Soil Conservation	C: M. Käser A: Dr. D. Rutschow
ICE Waste and By-products	C: K. Fetsch A: Dr. T. Eck
ICE Dangerous Goods/ Chemical Agents	C: F. Stypa-Geiger A: G. Schwabe 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».

The committees in the Competence Area «Environmental Technology, Chemistry, Safety and Health» deal with existing and in particular emerging issues of environmental and health protection in all types of energy and heat generation. The general topics of occupational safety, health and fire protection, in-process chemical issues and emissions into the air, water and soil are described in the reports by the working groups. The issues are influenced by increasingly strict regulations that influence plant operation through economic and political conditions.

In the period under review, the effects of Best Available Techniques (BATs) for fossil fuelled plants and new requirements for the use of power plant by-products in Germany were dealt with in special projects, which are described separately here.

Best Available Techniques (BATs)

The European requirements for emissions from power plants were adopted by the member states on 28 April 2017 on the proposal of the EU Commission as part of the LCP-BREF (Large Combustion Plants – Best Available Techniques Reference Document, Figure 1) review process. On 17 August 2017, the BAT conclusions for large combustion plants were published in the Official Journal of the EU. This updates the previous BREF from 2006 and redefines the state of the art. All large combustion plants with a firing thermal output of at least 50 MW are affected. The deadline for publication of the conclusions marked the beginning of the four-year transposition period for EU Member States, after which all large combustion plants must comply with the new BAT conclusions.

The revision process for the BREF LCP began with a kick-off meeting in October 2011, but the technical part of the document had already been revised by the VGB committees and made available to the European IPPC Bureau (EIPPCB). The first draft of the new document published by the EIPPCB in June 2013 was intensively examined and commented on by the VGB/BDEW working committees. Members' comments and sugges-

tions for changes were forwarded to the Seville office. It took the EIPPCB almost two years (till the end of March 2015) to analyse and evaluate the 8,500 comments received. The background papers made available for the final meeting of the TWG have also been commented on by the VGB/BDEW committees. Despite the intensive preparatory work and the technically sensible amendments proposed by the power industry, the results in the final document are disappointing, both in the ranges for emissions and in the definition of the state of the art. In the latter case, the findings from the industry on dedusting, denitrification and desulphurisation were taken into account. However, new technologies for mercury capture have been included which are neither technically tried and tested in Europe, nor can be described as state of the art technology in power plant operation. In particular, the influences on the quality of the residues or by-products were not taken into account.

Following the publication of the conclusions, the VGB committees will perform a detailed discussion of the implementation proposals in the member states.



Fig. 1: Best Available Techniques (BAT) Reference Document for Large Combustion Plants.

VGB Initiative on Hg^(capture)

Germany already has strict mercury emission limits and is one of the pioneers within the EU and globally. At present, the requirements for mercury, last reviewed in 2013 (13th Federal Pollution Control Ordinance (BlmSchV)), are 30 µg/Nm³ in the flue gas (daily average). From 2019 onwards, an additional annual average value of 10 µg/Nm³ must be complied with. The low bandwidths for mercury emissions stipulated in the process of determining the best available techniques present a major challenge to the power industry. In 2016, the VGB initiative Hg^(capture) was formed to objectify the very emotional discussion, conducted especially by the environmental associations (Figure 2). With this initiative, VGB, together with the power plant operators, aims to contribute to objectifying the debate and to achieve an appropriate implementation of the emission bandwidths from the BAT process. In this context, a background paper was prepared, in which the opportunities and risks of special mercury reduction techniques were illustrated and the research activities of the member companies were presented. VGB presented and discussed this topic at various events. Various joint research projects were also initiated and implemented.

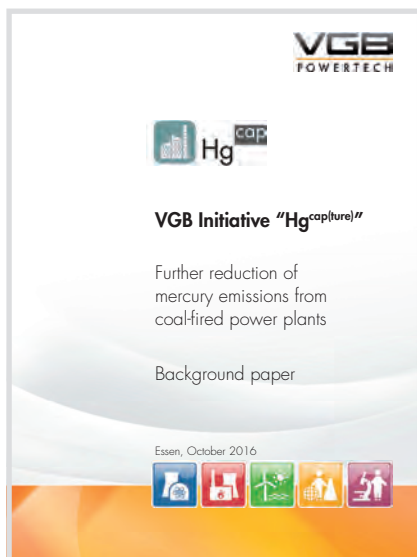


Fig. 2: Hg^{capture}, Background Paper.

Administrative Regulation on Technical Construction Regulations (VV-TB)

In the field of the use of power plant by-products there were also changes in the area of environmental regulations. With the introduction of the European Construction Products Ordinance on 1 July 2013, new environmental, health and hygiene requirements (Basic Work Requirement BWR3) and sustainability (BWR7) for construction products according to harmonised product standards (e.g. EN 450 for fly ash for concrete) must be followed. These are normally only to be taken into account when revising product standards. However, a judgement by the European Court of Justice against the Federal Republic of Germany in October 2014 regarding additional technical requirements for construction products according to harmonised standards required far-reaching changes in German construction law.

The model administrative regulation on technical construction regulations (VV-TB) and the requirements for structural installations with regard to effects on soil and water (ABuG) contained therein now specify requirements for structural installations with regard to environmental protection that were previously regulated in general building supervisory approvals (in particular environmental certificates). These are to be complied with as soon as the regulations are implemented in state law in the individual federal states. Prior to publication, intensive coordination was necessary to ensure that the by-products could continue to be used as construction materials.

For construction materials according to harmonised product standards (e.g. fly ash for concrete according to EN 450-1 or bottom ash as a lightweight aggregate according to EN 13055), existing national requirements must be included in the European standards. During the transitional period, existing approvals may be used as technical evidence of environmental compatibility. For the implementation of the ABuG requirements, a guideline is being drawn up by the German Committee for Reinforced Concrete (DAfStb).

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 «Environment». 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 were adopted by the member states in 2017 and their possible implementation in the individual countries constituted a major topic at recent meetings. It became clear in this context 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. In order to facilitate a closer examination and pursuit of these circumstances, the Technical Committee has drafted a questionnaire, which is now to be completed and continuously updated by all the members. Using the responses from various member countries collected there, the individual members will better be able to prepare and support their arguments in the national discussions.

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 «Emissions/Immissions» was the implementation of the BREF LCP conclusions as published by the Seville office in German law. One of the issues 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 «Emissions/Immissions» 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 VGB workshop on «Emission Monitoring», Essen, 18 September 2018, was prepared. It is also organised and coordinated by the members of this Technical Group. Further information on the event and the topics to be addressed can be



Fig. 3: VGB workshop on «Emission Monitoring», Essen, 18 September 2018.

found on the VGB homepage (Figure 3).

TG «Noise Control»

Sven Göhring

A focal area in the committee's «Noise Control» discussions was the subject of construction noise. Discussions included a more detailed consideration of the General Administrative Regulations on Construction Noise (AVV Baulärm) and their application in the context of the required immission forecasts for brief noise peaks during the day. As an alternative, TA Lärm is also used as a basis, and increases the guideline value for noise peaks by 30 dB (A).

A further important topic was the amendment to the Sixth General Administrative Regulation on the Federal Pollution Control Act (Technical Instructions on Protection against Noise – TA Lärm, Figure 4), which was published in June 2017.

The amendment to the TA Lärm 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 old version of the TA Lärm did not contain any guideline values for this new territorial category.

TG «Emissions Monitoring»

Sven Göhring

The Technical Group «Emissions Monitoring» deals among other things with the development of research projects in the field of emissions monitoring. The research project «Benchmark E-PRTR emission reporting» was completed in 2017. A new project was then launched, and is currently being finalised under the title of «Statistical Guidelines for Emission Compliance Evaluation». The aim of this research project is, among other things, to compare the uncertainty requirements with the performance of emission monitoring. The project is expected to be completed and the results published in the third quarter of 2018.

Another important focal topic in the Group was the implementation of the adopted BAT conclusions and their requirements for emission monitoring. This was also analysed and discussed in the Technical Group for the implementation of the MCP Directive.

The members of the Technical Group continue to work intensively on CEN standardisation work, usually through the cooperation of the corresponding members in the CEN working groups (WGs). The liaison between the VGB office and CEN makes it possible to appoint employees from member companies as members of the WGs. This provides an important opportunity to make European standardisation practically oriented and to bring it in line with the conditions in the industry.

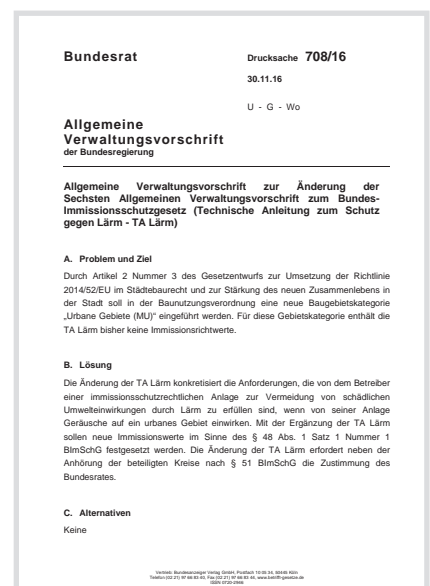


Fig. 4: Submission of the «TA Lärm» to the German Bundesrat.

TG «Power Plant By-products»

Dr. Hans-Joachim Feuerborn and Dr. Thomas Eck

The Technical Committee on «Power Plant By-products» deals with ensuring the use of the power plant by-products resulting from the combustion of coal in pulverised coal and fluidised bed furnaces. Power plant by-products from hard coal firing are mainly used in the construction industry, while most of the by-products from lignite firing are used as backfill material in open cast mining. FGD gypsum (Figure 5) from lignite-fired power plants is used as a raw material in the cement and plaster industry, as is that from hard coal fired power plants.

The use of by-products largely depends on their quality and thus, in particular, on uniformity and compliance with the physical and chemical requirements specified in standards and regulations. In addition to the requirements of construction regulations, criteria from environmental legislation are also important in this respect.

In the period under review, the national requirements for construction products were dealt with by implementing the administrative regulation on technical building regulations (VV TB) and, in particular, the requirements for structures with regard to their effects on soil and water (ABuG) which are contained therein. These concern the environmental requirements for fly ash for concrete according to DIN EN 450-1 and bottom ash according to DIN EN 13055, which were previously taken into account in the form of general build-

ing authority approvals. The existing approvals are still regarded as sufficient technical evidence until the requirements have been transferred to the standard. For the implementation of the ABuG requirements, a guideline is being drafted by the German Committee for Reinforced Concrete.

In addition, the developments and effects of the Ordinance on Substitute Construction Materials with specifications for the use of secondary raw materials in unbound earthworks and road construction were discussed. The Upper House of the German Parliament (Bundesrat) postponed discussion of the Ordinance on Substitute Construction Materials until the new Federal Government decides on how to proceed. When the regulations are introduced, power plant by-products will only be able to be used under difficult conditions, or their unbound use will no longer be possible. Studies on the eluate behaviour were commissioned with regard to the further use of power plant auxiliary products. The results will be incorporated into further work.

Furthermore, qualitative aspects of changing the way power plants operate and, where appropriate, of the accommodation of the lower emission limit values of the BAT conclusions for large combustion plants published in the Official Journal of the EU on 17 August 2017 and to be implemented by 17 August 2021 were addressed. Numerous trials are underway to reduce Hg emissions. Influences on the quality of the by-products are to be expected.

In addition, European and national regulations on this application were discussed:

- The introduction of environmental, health and hygiene requirements (BWR3) into the European product standard EN 450-1 for fly ash for concrete.
- The preparation of a generic and verified environmental product declaration (EPD) for fly ash for concrete to prove sustainability (BWR7).
- Revision of aggregate standards. The lists of initial materials (natural and secondary raw materials, and also ashes) are being converted into a technical specification.
- The preparation of a report on European experience with secondary raw materials in earthworks and road construction.



Fig. 5: Gypsum store at the Moorburg combined heating and power plant.

- The regulations of the Road and Transport Research Association (FGSV) in the field of rural roads regarding the use of bottom ash.
- The preparation of terms of delivery for fly ash for road construction at FGSV.
- The registrations pursuant to the European chemicals regulation (REACH) including dossier updates.

Within the framework of application-oriented research, the projects for durability testing of fly ash concrete are being supported and new research projects on its use in heat-treated railway sleepers and on environmental impact assessments are being commissioned.

TG «By-products from Waste Incineration»

Dr. Thomas Eck

The Technical Group «By-products from Waste Incineration» worked on the following focal topics in the period under review:

- Support in and critical assessment of the development of standards for the recycling/disposal of mineral waste, especially the German Framework Ordinance Introducing the Substitute Building Materials Ordinance.
- Further support for the revision of the BREF for Waste Treatment and Waste Incineration.

- Classification and review of the classification of bottom ash from incineration of municipal waste in accordance with the Waste Catalogue Ordinance, taking special account of the «H» (hazard) criteria and the legislation on chemicals.
- Handling of incineration residues in Germany and Europe – the market for bottom ash from incineration of municipal waste.
- Waste incineration against the background of closed-loop waste management and conservation of resources.
- Current research projects in the field of waste incineration, with particular reference to the incineration of municipal waste.
- New processes in the conditioning of bottom ash and flue gas treatment residues, for instance wet treatment processes.

In the course of the 2018 spring meeting, the thermal waste recycling plant of EEW Energy from Waste at the waste recycling centre in the Lahe district of Hanover was toured (Figure 6).



Fig. 6: Thermal waste recycling plant of EEW Energy from Waste in Hanover.

At the spring meeting, the topics, location and date in autumn for the 17th Workshop on «Products from Waste Incineration» were decided. In the course of the workshop in Magdeburg on 12/13 November 2018, aspects of recycling will be examined and supplemented by current issues. The aspects of resource conservation and the recycling economy are also to receive attention. Together with the professional presentations and discussion forums at the workshop, a tour of the MDSU Mitteldeutsche Schlacken Union wet conditioning system will be offered as part of the background programme.

TC «Chemistry»

Dr. Andreas Wecker

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 further focal area is the mode of operation of the water-steam cycle in conditions of frequent load changes.

A new VGB-Standard on metering systems in the water-steam cycle has been completed and is shortly to be published. It provides recommendations for the correct positioning, design, instrumentation and servicing of metering systems and represents a supplement to the existing VGB Standards for the water-steam cycle:

- VGB-S-010, «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».

The last conference, «Chemistry in Power Plants 2017», took place in Koblenz. The topics covered the fields of the water-steam cycle, flue gas treatment, water treatment and analytics. The number of presentations from the field of nuclear chemistry continues to decline.

TG «Analytics»

Dr. Andreas Wecker

The Technical Group «Analytics» is currently working on the completion of a VGB Standard on analytical procedures 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. 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 302 on the standardisation of conditions for activity testing of DeNOx catalysts, a new VGB Standard is currently being compiled for mercury oxidation catalysts.

As a result of the increased use of modern analysis techniques, VGB Instruction Sheet VGB-M 701, «Analysis of FGD Gypsum» has to be revised. In this context, the current analysis methods will first be discussed and the evaluation limits determined.

TG «Chemistry of Light Water Reactors»

Dr. Dittmar Rutschow

Restructuring at VGB

The Technical Group «Chemistry of Light Water Reactors» is in future to be managed in the Nuclear Power Competence Area as the Working Panel on Chemistry of Light Water Reactors under the Technical Committee on Operation and Safety.

Up to now, the TG «Chemistry of Light Water Reactors» was subordinate to the TC «Chemistry» and had an intensive exchange of experience with the conventional power plants.

The General Committee on «Nuclear Power Plants» has resolved that the WP «Chemistry of Light Water Reactors» should now be subordinated to the TC «Operation and Safety» and supported by VGB for one year from 1 January 2018.

Election of the Representative

Mr. Krumpholz of the Gundremmingen nuclear power plant left the Working Panel to pursue other activities. Dr. Böttcher of the Neckarwestheim nuclear power plant was unanimously elected by the committee as the Representative.

Mr Klein of the Gundremmingen nuclear power plant was appointed to the committee as Mr. Krumpholz's successor.

Hydrogen concentration in the primary circuit

Based on a finding in a power plant of increased oxide layer thicknesses on M5 cladding tubes in the upper plenum of fuel elements, the question was raised as to how the hydrogen concentration in the primary coolant can be related to the findings. The WP sees no reason to change the permitted concentration range of hydrogen in the primary coolant, since the results of investigations and recommendations to date on this topic are also covered by the applicable concentration range. Standard VGB-R 401, which is currently under revision, therefore remains unchanged on this point.

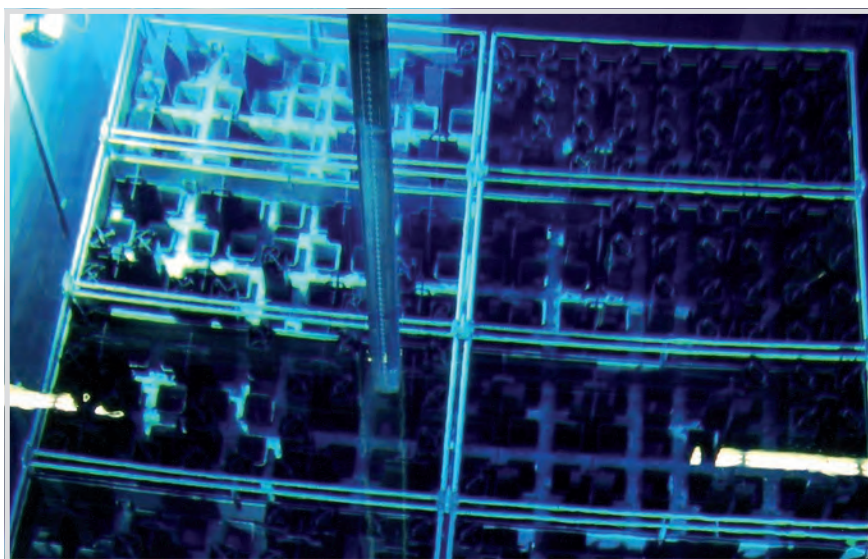


Fig. 7: Fuel element storage pools in a nuclear power plant.

Prevention of the formation of microorganisms in wet storage pool in nuclear power plants

Microorganisms form in fuel element storage pools (Figure 7) and other wet storage basins in nuclear power plants. Especially in the fuel element pool, this is not initially the case as long as the dose rate of the stored fuel elements counteracts biological growth. Experience from the plants has shown that the formation of microorganisms can severely restrict vision and form deposits of different colours. There are various approaches to microbiological control in wet storage pools, which are used by the members. Examples of this are the continuous or batch metering of hydrogen peroxide and the dosing of ozone via a generator with downstream metering system.

Revision of VGB Standard VGB-S-401

The former VGB Guideline VGB-R 401 J «Guideline for water in nuclear power plants with light water reactors», which consists of a PWR section and a BWR section, is currently being revised. The BWR part has been revised, and some passages have been adapted to reflect the current state of the art. This part of the guideline is therefore complete and has yet to be transferred into the VGB Standard. The PWR part is currently being revised and is to be transferred into the VGB-S-401 standard together with the BWR part. Afterwards, the VGB Standard VGB-S 401 can be printed.

Background paper on the BWR section of Standard VGB-S-401:

A project application by the WP which concerns a background paper from the plant manufacturer for Standard VGB-S-401 was approved. The section of the background paper for the primary circuit has been completed.

QP Database

The database is maintained in cooperation between the users in the power plants and the VGB database administrator. Older products that are no longer to be used remain in the database, but are marked as «undefined». This means that operators can also access substances that are no longer used.

It was discussed how entries are to be made and what should be entered into the database (identifier, description and notes). The renaming of attached documents and pdf files is possible for every administrator. The data sheets (product/safety data sheets) should be headed with a year date. Older data should remain stored so that it can be used during dismantling.

The WP has upheld the decision that the initial qualification of new products must be carried out by an accredited or certified laboratory. Requalification can be carried out by in-house or other analytical laboratories (VGB also has a laboratory in which samples are analysed according to DIN standards, but the laboratory has no accreditation).

A manual for the QP database still has to be created.

After the restructuring of VGB, VGB WG «QP-Database» will continue to be managed by VGB.

In addition to an extensive exchange of experience, further information was provided on the topics of cooling towers in winter (Figure 8), WANO peer reviews and Molycote D321 as a replacement for Molycote D21, and queries are currently underway in the individual plants for the disposal of waste water containing hydrazine, on pollutant registers and on the handling of wash water in the cooling basin.

TG «Chemical Process Engineering»

Dr. Dittmar Rutschow

The members of the Technical Group «Chemical Process Engineering» unanimously elected Mr. Woizick of RheinEnergie AG as Representative.

PG Microbiology in Cooling Towers

In autumn and spring, VGB already organised VGB expert forums on the legionella issue. Ten lectures were presented and there were extensive discussions on the legionella problem and legislation.

A new rapid test for the detection of legionella which could provide results within one day was discussed in the TG. The rapid tests should be relatively precise compared to the UBA method and provide similar results. Two measuring instruments are required for the evaluation of the samples. In one instrument the sample is enriched and in the second instrument the sample is measured. Experience to be gained in a plant is still outstanding.



Fig. 8: Cooling tower in winter.

Furthermore, it was reported that there are many discussions with representatives of authorities on the topic of microbiology, as they wish to implement the 42nd Pollution Control Ordinance (BlmSchV) point by point, without taking into account the type of plant. The representatives of the authorities often also require the operator to carry out a hazard assessment, which is not particularly easy to implement. In addition, the costs for small plants are so high for operators that the operation of these plants may no longer be worthwhile.

In a hazard assessment, the authorities want to exclude not only the risk of legionella within the plant, but also outside the plant and thus in the population. The wind direction and the environment around the plant must be taken into account and a propagation calculation submitted.

There are as yet no independent experts who are familiar with the subject of microbiology. These must first be trained and pass an examination before they can act as experts for the implementation of the 42nd BlmSchV.

PG «Cooling Water Standard»

The latest version of the revised Cooling Water Standard was sent to the members of the PG «Cooling Water Standard» well ahead of the meeting on 12 April. Mr. Woizick and Dr. Wecker were accepted as new members of the project group. The tasks involved in revising the standard have been divided into sections. Each section of the standard developed by them will be revised by a small group of members from the PG. There is a coordinator in each group. Subsequently, the individual sections are to be incorporated in a common standard.

VGB Standard VGB-S-042 on Metering Systems

Members of the TG are also participating in the revision of Standard VGB-S-042 (former metering guideline). The standard concerns the water-steam cycle and is also suitable for fire-tube boilers. The standard refers to the purity of the chemicals used (delivery concentrations) and to some chemicals used in the water-steam cycle. It was also possible to use the revised solidification curve for NaOH from the new

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 2017 (based on input from all members).

standard VGB-S-405 in VGB-S-042.

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

The TG has revised the former Instruction Sheet VGB-M 405 G «Water Demineralization by Ion Exchangers» and converted it into the new form of VGB Standard VGB-S-405. The final version of the standard is being edited. It will soon be available for ordering from VGB Service GmbH.

TG «Emission Control»

Dr. Andreas Wecker

The interpretation of the BAT conclusions was discussed in the European Technical Group. It was found that various emission reduction methods recommended there can be used, but are not absolutely necessary if the emission bandwidths are complied with.

In the national implementation of BAT conclusions, most countries are likely to follow the upper values of the emission ranges. In this context, the techniques for achieving these values were discussed.

To increase heat extraction for district heating, the suitability of flue gas cooling is being investigated.

The workshop «Flue Gas Cleaning 2018» in Hamburg was prepared and hosted.

TG «Fire Protection»

Sebastian Zimmerling

The activities of the Technical Group «Fire Protection» centre around 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 2018. 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 has sent the draft of the document in German and English to a selected group of experts 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 protecting wind power plants and individual components against fire hazards. Publication is scheduled for mid-2018.

In addition to the general committee activities, the experiences with the mechanical stability and service life of flame-retardant belts in conveyor systems for coal feeding were presented and discussed. The material properties of flame-retardant belts differ fundamentally from those of normal belts (e.g. in terms of flexing properties), and therefore a detailed design for the particular application is necessary. Flame-retardant belts have been used without problems for 30-40 years, especially underground, but recent reports have shown that belts imported from China often do not seem to meet the mechanical and fire protection specifications.

Furthermore, reports were presented on the annual «Climate Camp», which took place again this year together with the «End of Site» campaign days. The tactics were agreed in advance with the local authorities, the district government and the local fire brigades. Due to the comprehensive preparation and experience from previous years, this year's deployment was disciplined and without any major incidents.

Another important topic was the fire protection measures for power plant units in standby mode for backup purposes. For the affected lignite sites, standby mode means that the plant will be shut down for a period of 4 years but must be able to be restarted within 10 days. During this time, all fire protection systems must also be kept ready for operation. No additional fire protection requirements are expected to be imposed by the supervisory authority.

TC «Safety & Health at Work»

Guido Schwabe

The definition and interpretation of Key Performance Indicators (KPI's) is a key issue in the area of Health & Safety (Table 1). A key indicator for accidents is required that is clearly defined and internationally comparable. The Technical Committee «Safety & Health at work» has therefore opted for the Lost Time Injury Frequency (LTIF). This is the number of accidents with a lost time of 1 day or more per 1 million working hours. The advantage of these most frequently used definitions is their uniqueness. Neither the presentation to a doctor nor different levels of unconsciousness or measures going beyond first aid are defined more precisely. On the other hand, the absence due to an accident on the day after an accident (and longer) is clear. The reference to working time makes more sense than the reference to the number of employees, since working hours differ internationally by up to 20 percent.

The accident rates of contracting companies are higher than those of own employees. To counteract this trend, «safety walks», awards, safety discussions and instructions are held, among other things.

Other topics include internal structures, the role of management and the relationship between occupational health and safety and human resources, stress management and work/life balance.

Accidents and the methods of investigation used play an important role in the committee's work.

TG «Occupational Health and Safety»

Guido Schwabe

Accidents are the main topic of the Technical Group «Occupational Health and Safety».

The amendment to the Ordinance on Industrial Safety and Health (Betriebs-sicherheitsverordnung) has given rise to extended tasks for occupational safety, particularly in the field of risk assessment.

The handling of working materials is very important. Currently, possible evaporation from insulating material is on the agenda. Questions on asbestos are addressed in the national «Asbestos Dialogue».

The power plant operators have established a series of regulations as a base for partner companies, but these differ in their implementation and are subject to constant adaptation. With Security Safety Management (SeSaM), VGB PowerTech e.V. provides a procedure for assessing companies with regard to their occupational safety management. Certified companies are included in a list. The list is available to VGB member companies online free of charge.

Occupational health and safety management systems (AMS) are an issue at meetings. In doing so, the high standard of the energy suppliers is secured and increased.

TG «Industrial and Environmental Medicine/Health Management»

Lena Jentjens

One permanent item on the agenda for the six-monthly meetings of the Technical Group «Industrial and Environmental Medicine/Health Management» 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. Compared with the two previous seasons, the 2017/2018 influenza wave was even more severe. The practice index is used as a parameter to monitor the regional influenza activity (shown here for all of Germany).

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 in future. Preventive vac-

ination, for which a satisfactory solution still has not been found, provides a special reason for discussions in this context.

Work 4.0, which spans the entire process of change in the working world in the digital age, is becoming increasingly important as a topic. Generally, the same trend can be seen everywhere; companies increasingly tend to use open offices without assigned workstations. The working group agrees that this trend is not unproblematic from an industrial medicine viewpoint. The psychological and hygienic consequences are particularly worrying. However, since the trend cannot be stopped, one must try to help shape the new working conditions as optimally as possible and at least endeavour to address the occupational healthcare concerns. One case in which a lounge area was designed with work stools without taking occupational healthcare aspects into account shows that this is important. As a result of this omission, four work-related accidents occurred.

In the wake of this digitisation, some companies have begun to offer digital health checks: a small mobile service unit makes an on-the-spot health check, the results of which are available via app on the mobile phone of the employee about 20 minutes later.

Another topic in this area is the digitisation of patient files. This encompasses both old files, which are to be digitally reformatted, and the management of current patient files. Suitable industrial medicine software should make it possible to dispense with any kind of paper files.

TG «Medical Scientists at Nuclear Power Plants»

Lena Jentjens

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

The 2018 meeting focussed on special radiological aspects and burdens during the dismantling of nuclear power plants. Apart from the organisational challenges posed by such a dismantling project, the psychological burden on the employees must not be underestimated. Depending on the location of the power plant, the general conditions such as workload, personnel development and future prospects place in part extremely large burdens on the employees. This is also reflected in increased illness rates. |

Technical Services

Technical Services/ Engineering Consultancy

Christian Ullrich and Dr. 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.
- Oil management including laboratory oil analyses.

The services are used by VGB members worldwide to achieve sustainable, safe, trouble-free and economical operation of their plants. For the respective tasks, tailor-made and individual solutions are developed which are characterised by competence and cost-effectiveness. Our mission is to provide our members services oriented to the requirements of practical work. Direct integration into the design and the manufacturing, installation and commissioning process enables undesirable influences to be detected, eliminated or limited in their effects at an early stage. The cooperation of the different departments of the VGB Office and the VGB network of experts has a decisive influence on the work of Technical Services. The results of the work of Technical Services are continuously reflected in the VGB standards and guidelines and so provide important impulses for the establishment of new «best practice» approaches.



Materials Laboratory

The VGB Materials Laboratory investigated and resolved around 230 cases of damage. It makes use of state-of-the-art laboratory equipment for this purpose.

In many cases, by determining the cause of damage the laboratory staff managed to develop solutions to reduce damage occurrence in future. This objective is also achieved through the close exchange of information with the departments Water Chemistry and Construction and Installation Supervision and the experts in the Power Plant Technologies department, and intensive use was once again 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 expended lifetime, a large number of special tests also were 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 on-line monitoring and description of the operating behaviour of various power plant components are worthy of mention. These systems for online monitoring of plants are installed by VGB in Germany and even outside Europe.

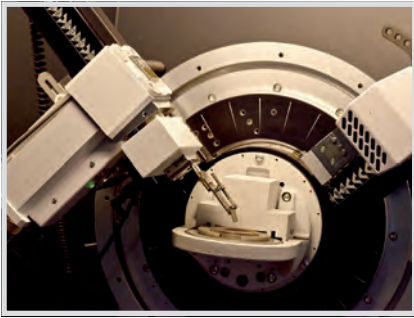
During the period under review, special attention was given to damage caused by unexpected crack formation in the austenitic material HR3C occurring in several new-build power plants after a short operating time. In addition to numerous damage investigations on weld seams containing cracks, a project was established and carried out together with several operators and the base material manufacturer to determine the conditions which lead to the initiation of damage.

Water Chemistry

The Water Chemistry department supported operators of fossil, refuse derived fuel and biomass-fired power plants of all output ranges. The department has added to the extensive experience it had already gained regarding the interplay of the working medium and the materials used in the latest generation of large fossil-fuelled steam generators. Thanks to the close cooperation between the Materials Laboratory and the Water Chemistry department it was possible to put the scientific findings on the behaviour of new materials into practice under operating conditions, with successful results.

In the period under review, numerous examinations were performed on the premises of members in Germany and abroad. In many cases, it was possible to avert damage for the customers and ensure safe and economical operation of the plants. 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. The technique gives the VGB experts the opportunity to respond systematically to any deviations from normal operating patterns.





Construction and Installation Supervision

The Construction and Installation Supervision team assists the members to ensure quality both in the fabrication of new components and in the context of modernisation work. The field of activity covers all components of power plants. Despite the decline of new-build activities in the power plant sector, it was possible to keep the team busy and so preserve the existing know-how in the VGB Group.

Future activities of the oil laboratory

In the period under review, the VGB Board of Directors decided to install an Oil Management team at VGB. The equipment of the oil laboratory of Uniper Technologies GmbH in Gelsenkirchen was purchased for this purpose and several highly experienced people hired. In Heiko Fingerholz (formerly Uniper Technologies) we managed to recruit an internationally esteemed expert who will address the topic of oil management for the VGB Group. Business activities were taken up by the team on 1 January 2018.

Engineering Consultancy

Dr. Oliver Then

Consulting activities within the scope of Technical Services are an important component of our know-how management and, in addition to economic effects, provide valuable input for the work of the committees and the work on standards. Last year we were able to provide our member companies and external customers support in dealing with technical issues and for the solution of extremely complex problems. In addition to our own experts, we were also able to use experts from member companies as partners for the projects. The portfolio of our services covers all areas of energy and power plant technology:

- Engineering consultancy in the planning, construction and operation of power plants.
- Damage analyses
- Supervision of construction and field erection, including quality management and expediting.
- Materials testing.
- Water chemistry analyses

Engineering Consultancy and Damage Analyses

The combined expertise of the VGB Secretariat and our network of experts as well as their vendor independence are important reasons for the interest of member companies and third parties in the participation of VGB in consulting and analysis activities. We also make well-targeted use of consultancy as a means to gain new members. The following examples are intended to illustrate the variety of tasks undertaken in the period under review:

- Handling of projects and workshops within the scope of energy partnerships of the Federal Ministry of Economic Affairs and Energy in India and China
- Creation of teaching materials for online and classroom training for the flexibilisation of power plants and electricity generation systems
- Advice and support for planning and carrying out major inspections of steam turbines
- Assistance in compiling tender documents with regard to operation and project documentation
- Damage analysis and condition assessment on boilers, steam turbines, gas turbines and condensers
- Function as expert assessor and arbitrator in various legal and arbitration proceedings



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.

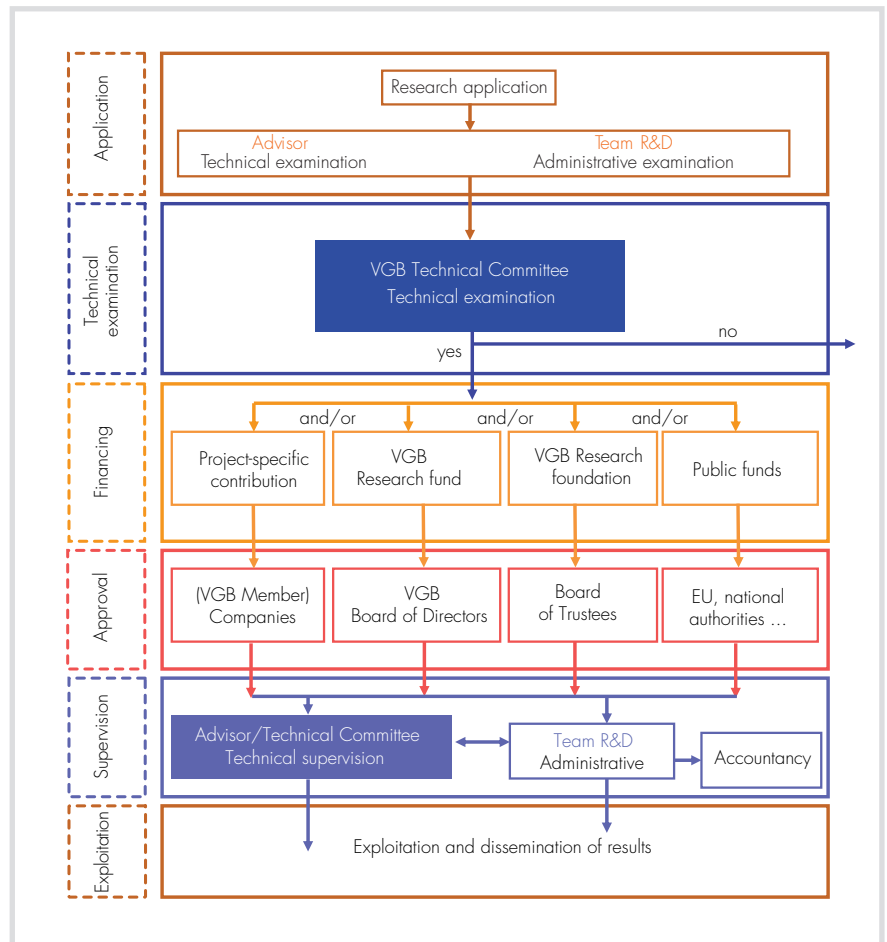


Fig. 1: Organisation of R&D coordination.

Project Funding in 2017

Table 1 shows the status of project funding as of June 2018. 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 2017 VGB took part in a total of 29 projects with a total volume of 16.8 million euros (last year: 28 projects with a

volume of 11.8 million euros). Of these, 10 projects with a volume of 5.2 million euros were started in 2017 (last year: 9 new projects and 1.2 million euros). The share of operator funds spent on these new projects amounts to 27%, raised through 24% project contributions of individual companies and 3% 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 16%. Considerably more than half of the total project volume was raised through public funding.

Tab. 1: Projects funded by VGB since 2014, completed projects are highlighted in grey (as of 06/2018).

No.	Abbreviated title	Duration	Project results
	Projects no. 1 to 377	1971-2013	see VGB Annual report 1986/87, p. 51/52f
378	Burner-induced vibration values of boilers	2014	Final report
379	Flue gas flow rate determination to EN ISO 16911	2014-2015	Final report
380	Ammonia Masking in SNCR Plants	2014-2016	Final report
381	Sulphate Resistance - Long-term Storage*	2014-2016	Final report in progress
382	Design Optimisation of Grate Firings for Biomass - European Transfer of Results****	2014-2018	
383	Condition Monitoring of Wind Turbines, Part I – Best Practice Study****	2014	Final report
384	Balancing energy provided by wind and PV plants****	2014-2016	Final report
385	Biomass Storage Monitoring, Part I****	2014-2016	Final report
386	Efficiency of air filters at high humidity****	2014-2017	Final report
387	Inspection intervals of welded offshore wind structure (FeLoSeFI)****	2014-2018	Final report
388	Investment requirements in European electricity-generation infrastructure towards 2050	2014-2015	Final report
389	New Materials for Steam Turbines V (Continuation 314)**	2014-2020	
390	Microbiological emissions from cooling towers	2015-2018	
391	DENA Ancillary services platform****	2015-2018	Final report
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	2015-2018	
395	Mercury emission and control in the USA	2015-2016	Final report
396	INADAR (Hydro power plant dam restoration)****	2015-2019	
397	New 12% chromium steels**	2016-2018	
398	Long term prospects of CHP	2016	Final report
399	Impact of operation conditions on lifetime of boiler circulation pumps (Continuation 393)**	2016-2017	Final report in progress
400	Benchmark E-PRTR emission reporting	2016-2017	Final report
401	Ice Detection Systems for Wind Turbines, Part II: Field test****	2016-2018	
402	ASR - Variation of Prestorage Time II (Continuation 349)*	2016-2018	Final report in progress
403	Pozzolanic reactivity of fly ash - New test procedure*	2016-2017	Final report in progress
404	Belit-Calciumsulfoaluminate-Cement from lignite and hard coal fly ash*	2016-2017	Final report in progress
405	Mercury detector in flue gas cleaning systems	2016-2019	
406	Self-ignition of biomass II: Analysis and modelling of initial self-heating (Continuation 359)****	2017-2019	
407	Power plant flexibility by thermal energy storage****	2017-2019	
408	European control reserve markets****	2017-2018	Final report
409	Emission compliance evaluation	2017-2018	
410	Impact of the European Network Codes on the operation of power plants	2017-2019	
411	GORE test facility in the Schkopau power station	2017-2020	
412	Subsynchronous Torsional Interaction (SSTI), Preliminary study	2017-2018	Final report
413	Bottlenecks of the German Energiewende	2017-2018	
414	Alkali Reaction – long-term storage (Continuation 245, 300, 344, 374)*	2017-2021	
415	Application of fly ash concrete in sleepers*	2017-2018	
416	Hardfaced sealing surfaces of fittings**	2018-2019	
417	Calculation methods II (Continuation 263)**	2018-2020	
418	Biomass feeding****	2018-2020	
419	KORINNA Online corrosion probe	2018-2021	
420	Environmental compatibility of fly ash concrete*	2018-2020	

* 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)

Nuclear Power Engineering

The General Committee «Nuclear Power Plants» funds 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 2017, 36 projects with a total funding volume of 1.9 million euros (last year: 42 projects with 2.3 million euros) were awarded.

Collaboration with Universities and Promotion of Vocational Training

VGB's close collaboration with university institutes is implemented 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 eleven 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 21 August to 1 September 2017. 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 2017, 14 Students from nine German, Austrian 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.



Fig. 2: Participants from the summer school POWER PLANTS 2017.

VGB Innovation Award

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

- Dr. Tobias Vogel (32) for the development of new hybridisation concepts for solar-thermal power plants with a high solar contribution.

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 Generation in Competition 2017» in Essen, 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. Hans Bunting (right) presents the VGB Innovation Award 2017 to Dr. Tobias Vogel (left) at the VGB Congress 2017, Essen, Germany.

KRAFTWERKSSCHULE E.V.

Kraftwerksschule e.V. (KWS)

Ernst Michael Züfle

General

KRAFTWERKSSCHULE E.V. (KWS, PowerTech Training Centre), based in Essen-Kupferdreh, has been the central training facility for all technical fields of power and heat generation and thermal waste treatment for over 60 years. Plant operators all over the world trust KWS to provide training and continued professional development to their specialists, and they benefit from expert advice on problems of organization and human resources development. In 2017 more than 2,600 participants took advantage of the offer of 304 courses and training programmes. As a reliable partner, KWS thus contributes to a safe, environmentally friendly and affordable supply of energy.

Training at KWS

Conventional Power Plant Technology

KWS is the leading initial and advanced 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. A current focus of development is courses designed specifically for the operating personnel of thermal waste treatment plants.

Renewables

Initial and advanced training in many fields of renewables can be provided at KWS. This applies, for example, to biomass and onshore/offshore wind power plants as well as to hydroelectric power plants. In March 2018 the pilot course «Empower Refugees» was launched, in which refugees are trained specifically for the power industry. For example, retraining to become a state-approved «Industrial Electrician Wind Power» with a Chamber of Industry and Commerce (IHK) certificate is intended to give the participants the opportunity to obtain a permanent job.



Participants of the «Empower Refugees» course.

Organisational Development

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

The Nuclear Engineering/Radiation Protection competence team offers a broad range of officially recognised courses for

training of the responsible nuclear power plant personnel and preservation of 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 post-shutdown operation and dismantling of nuclear power plants also are taken into account. 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. Instruction can be given in a variety of languages. 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

In a KWS-owned apartment building, course participants find modern accommodations in the immediate vicinity of the school that create ideal conditions for successful learning.

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

VGB: Events and Publications

VGB Events

Angela Langen

In the period under review, July 2017 to June 2018, VGB hosted 23 events attended by a total of 2,388 persons, of which 771 participated in seminars and workshops and 1,617 in conferences and the congress.

Events were accompanied by trade exhibitions, at which 186 companies presented their products and services.

VGB Congress «Generation in Competition» in Essen

The 2017 VGB Congress took place from 12 to 14 September 2017 in Essen. Under the slogan «Generation in Competition», the congress brought together more than 320 participants and 28 exhibitors from 20 countries.

In their presentations and in the discussions, prestigious speakers explored the latest ways to meet the technical and commercial challenges, delivering technical contributions aimed at strengthening the market position of each individual source of energy and, on the other hand, addressing the transformation in the energy sector itself, which is opening up new horizons and market opportunities.

VGB Conference «Chemistry in Power Plants 2017» in Koblenz

From 24 to 27 October 2017 the traditional VGB chemistry conference plus technical exhibition took place in Koblenz. The chief topics included experiences and new insights into the water-steam cycle, legionella in the cooling water cycle, new insights into the behaviour of N-S components in FGD waste water, and experience with new filter materials for dust removal.

38 exhibitors presented their products and services, and 277 conference attendees exchanged experience.

VGB Conference «Maintenance in Power Plants 2018» in Bonn

This year's VGB Conference «Maintenance in Power Plants» took place on 28 February and 1 March in Bonn. More than 220 participants took the opportunity to visit the technical exhibition with its 38 exhibitors and listen to the presentations. Detailed reports about strategies and practical examples on how to achieve good maintenance with few resources were the leitmotif running through this conference.

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 «Steam Generators, Industrial and Cogeneration Plants 2018» in Rostock

Focal topics on 21 and 22 March 2018 at this biennial VGB conference were storage technologies, flexibility, conservation and the «future of power plants in 2025». The aim and task was to discuss current operating experiences with new technologies and practical applications. The Workshop CHP 2018 took place parallel to the conference in Section B on 22 March. In addition to a top-notch lecture programme there was an intensive exchange of experience between the 160 or so participants and 27 exhibitors, operators and manufacturers.

VGB «KELI Conference 2018» in Potsdam

The Conference for Electrical, I&C and IT Engineering in Power Plants, KELI for short, took place this year from 15 to 17 May 2018 in Potsdam and attracted 253 participants and 21 exhibitors. The VGB presentations, focussing on the benefits and risks of networked plant data (digitization, Industry 4.0), IT security for power generation, system integration of renewable power generation (modified operation of conventional power plants, system stability, market models) and requirements on the staff, were again complemented by matching presentations from the manufacturers (exhibitors). The topic of education and training and next-generation engineers was dealt with in a student forum in lectures and discussion rounds.



VGB Conference «Chemistry in Power Plants 2017», Koblenz, Germany.



VGB Conference «Maintenance in Power Plants 2018», Bonn, Germany.



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



VGB Conference «Steam Turbines and Operation of Steam Turbines 2018», Leipzig, Germany.



VGB Conference «Electrical, I&C and IT Engineering in Power Plants, KELI 2018», Potsdam, Germany.



VGB Congress «Generation in Competition» in Essen, Germany.

Date	Place	Kind of event	Title
1 and 2 September 2017	Emden	Workshop	8 th Emden Workshop on Offshore Wind – Occupational Health
5 to 7 September 2017	Essen	Seminar	Chemistry in the Water-Steam Cycle (German)
13 and 14 September 2017	Essen	Congress with exhibition	VGB Congress – Generation in Competition
20 and 21 September 2017	Mannheim	Workshop	Conservation
24 to 26 October 2017	Koblenz	Conference with exhibition	Chemistry in Power Plants
7 and 8 November 2017	Copenhagen, Denmark	Workshop	Oil Monitoring for Wind Power Plants
9 November 2017	Düsseldorf	Expert Forum	Die Umsetzung der 42. BImSchV in der Praxis – Legionellenüberwachung (German national law only)
15 and 16 November 2017	Mannheim	Workshop	Oil in Power Plants
28 to 30 November 2017	Höhr-Grenzhausen	Training	Training for Immission Control and Incident Commissioners (German national law only)
30 Jan and 1 Feb 2018	Essen	Workshop	Water Treatment
20 February 2018	Herne	Workshop	Storage
22 February 2018	Berlin	Expert Forum	Die Umsetzung der 42. BImSchV in der Praxis (German national law only)
28 Feb and 1 March 2018	Bonn	Conference with exhibition	Maintenance of Power Plants
21 and 22 March 2018	Rostock	Conference with exhibition	Steam Generators, Industrial and Cogeneration Plants
17 April 2018	Lübbenau	Workshop	Operational Management in Practice
7 and 8 May 2018	Munich	Conference	Maintenance of Wind Power Plants
15 to 17 May 2018	Potsdam	Conference with exhibition	KELI
16 and 17 May 2018	Hamburg	Workshop	Flue Gas Cleaning
6 June 2018	Copenhagen, Denmark	Workshop	Biomass Ash
6 and 7 June 2018	Berlin	Workshop	Water in Power Plants
6 and 7 June 2018	Koblenz	Conference with exhibition	Steam Turbines and Operation of Steam Turbines
19. June 2018	Essen	Workshop	Closedown and Deconstruction of Fossil-fired Power Plants (German)
27 and 28 June 2018	Kassel	Conference	Fuel Technology and Combustion

Tab. 1: VGB events July 2017 to June 2018.

VGB Conference «Steam Turbines and Operation of Steam Turbines 2018» in Koblenz

Every two years, operators, manufacturers, insurance companies, authorities and experts from the field of R&D discuss current issues relating to steam turbines and their operation. As in previous years, the cooperating companies presented their products and services in an accompanying trade exhibition. Both in discussions at the booths and during the background programme, around 270 participants and 34 exhibitors had the opportunity for a brisk exchange of ideas and the establish-

ment and intensification of business contacts on 7 and 8 June 2018.

We would 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.

Energy fairs 2017 and 2018

VGB took part as an exhibitor in

- Husum Wind in Husum, 12 to 15 September 2017,
- Kraftwerkstechnisches Kolloquium, Dresden, 17 and 18 October 2017,
- INNPS in Istanbul, 6 and 7 March 2018, and
- Electrify Europe 2018, 19 to 21 June 2018 in Vienna,

and used these opportunities to make new contacts and attract new members.

VGB Publications

Christopher Weißelmann

VGB POWERTECH Journal

From 1 July 2017 to 30 June 2018 a total of 131 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 March of the following year. In the meantime, the issues since 1990 were digitised and are available on DVD covering some 25,000 pages.

VGB-Standards

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

- VGB-B 105-007, KKS Pocketbook, 128 pages/128 Seiten
- VGB-S-002-01-2015-10-EN, Basic Terms of the Electric Utility Industry, 180 pages
- VGB-S-002-01-2015-10-FR, Termes fondamentaux du secteur de l'électricité, 180 pages
- VGB-S-002-02-2014-06-FR, Hydroélectricité – Définitions et indicateurs, 119 pages
- VGB-S-013-00-2017-04-EN, Construction and installation supervision in the manufacture and assembly of water-tube boilers and associated systems in thermal power plants (2nd edition), 155 pages
- VGB-S-021-01-2018-04-DE, VGB/BAW Standard: Korrosionsschutz von Offshore-Bauwerken zur Nutzung der Windenergie, Teil 1: Allgemeines, 3. Ausgabe 2018, 19 Seiten
- VGB-S-021-01-2018-04-EN, VGB/BAW Standard: Corrosion Protection for Offshore Wind Structures, Part 1: General, 3rd edition, 19 pages
- VGB-S-021-02-2018-04-DE, VGB/BAW Standard: Korrosionsschutz von Offshore-Bauwerken zur Nutzung der Windenergie, Teil 2: Anforderungen an Korrosionsschutzsysteme, 3. Ausgabe 2018, 43 Seiten
- VGB-S-021-02-2018-04-EN, VGB/BAW Standard: Corrosion Protection for Offshore Wind Structures, Part 2: Requirements for Corrosion Protection Systems, 3rd edition, 44 pages
- VGB-S-021-03-2018-04-DE, VGB/BAW Standard: Korrosionsschutz von Offshore-Bauwerken zur Nutzung der Windenergie, Teil 3: Applikation von Beschichtungssystemen, 3. Ausgabe 2018, 34 Seiten
- VGB-S-021-03-2018-04-EN, VGB/BAW Standard: Corrosion Protection for Offshore Wind Structures and Wind Park Components, Part 3: Application of Coating Systems, 34 pages
- VGB-S-033-00-2017-07-DE, Zusammenwirken von Konformitätsbewertung und Arbeitsschutz in Wasserkraftanlagen, 2. Ausgabe, 112 Seiten
- VGB-S-036-00-2017-04-DE, Konservierung von Dampf- und Gasturbosätzen, 38 Seiten
- VGB-S-036-00-2017-04-EN, Preservation of Steam and Gas Turbo-Generator Sets, 38 pages
- VGB-S-040-00-2017-03-EN, Prequalification of Partner Companies for High-Quality Maintenance, 152 pages
- VGB-S-043-00-2016-06-EN, Concept of (recurrent) training for performance of non-routine activities in German NPPs, 13 pages
- VGB-S-048-00-2017-05-DE, Fachkunde und Kenntnisse verantwortlicher Personen in Anlagen nach § 6 AtG, 11 Seiten
- VGB-S-104-O, Online-Leitfaden zur Umsetzung der Betriebssicherheitsverordnung in Kraftwerken – 2007 (Update 2018).
- VGB-S-123-00-2017-06-DE, Leitfaden zum Thema »Pre-Job Briefing« und »Post-Job Debriefing«, 13 Seiten
- VGB-S-130-00-2017-07-DE, Abnahmemessung und Betriebsüberwachung an wassergekühlten Oberflächenkondensatoren, 78 Seiten
- VGB-S-130-00-2017-07-EN, Acceptance test measurements and operational monitoring of water-cooled surface condensers, 78 pages
- VGB-S-131-00-2017-07-DE, Abnahmemessungen und Betriebsüberwachung an luftgekühlten Kondensatoren unter Vakuum, 71 Seiten
- VGB-S-131-00-2017-07-EN, Acceptance Test Measurements and Operation Monitoring of Air-Cooled Condensers under Vacuum, 71 pages
- VGB-S-164-11-2016-08-DE, Empfehlungen für den maschinentechnischen Generatorschutz, 65 Seiten
- VGB-S-164-11-2016-08-EN, Recommendations for thermal/mechanical generator protection, 65 pages
- VGB-S-164-12-2016-10-EN, Avoidance of generator damage resulting from condensation on live parts, 14 pages
- VGB-S-170-20-2017-02-DE, Auslegungsstandards für die Leittechnik – Sammelband –, 154 Seiten)
- VGB-S-503-00-2017-06-DE, VGB-Standard für die internen Rohrleitungen des Turbosatzes, 68 Seiten
- VGB-S-503-00-2017-06-EN, VGB-Standard for the Internal Pipework of Turbine Systems, 68 pages
- VGB-S-811-01-2018-01-DE, KKS Kraftwerk-Kennzeichensystem (Richtlinie und Schlüsselteil). 8. überarb. Aufl., 836 Seiten
- VGB-S-811-01-2018-01-EN, KKS Identification System for Power Stations. KKS Standard and Key Part, 8th Edition, 836 pages
- TW 103 Ve (Edition 2017) VGB/EURELECTRIC – Availability of Power Plants 2007 – 2016
- TW 103 V (Edition 2017) VGB/EURELECTRIC – Verfügbarkeit von Kraftwerken 2007 – 2016
- TW 103 Ae (Edition 2017) VGB/EURELECTRIC – Analysis of Unavailability of Thermal Power Plants 2007 to 2016
- TW 103 A (Edition 2017) VGB/EURELECTRIC – Analyse der Nichtverfügbarkeit von Wärmekraftwerken 2007 bis 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 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)
ECOBA European Coal Combustion Products Association
EEC Excellence Enhancement Center for Indian Power Sector
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 Manufactures
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 Deutschland und 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)
VTI ALL-RUSSIA THERMAL ENGINEERING INSTITUTE
Wirtschaftsverband Kernbrennstoff-Kreislauf und Kerntechnik e.V. (WKK)
World Association of Nuclear Operators (WANO)
World Energy Council (WEC)

Power Plant Statistics

Stefan Probst and Jean-François Lehoucq

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 649 power plants and 174 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-002-01 «Basic Terms of the Electric Utility Industry» as also in the VGB-Standards VGB-S-002-02-2014-06-EN «Hydropower – Definitions and Key indicators», VGB-S-002-03-2016-08-EN «Technical and Commercial Key Indicators for Power Plants» and VGB-S-002-05-2015-10-EN «Wind Turbines (WT) – Definitions and Indicators».

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

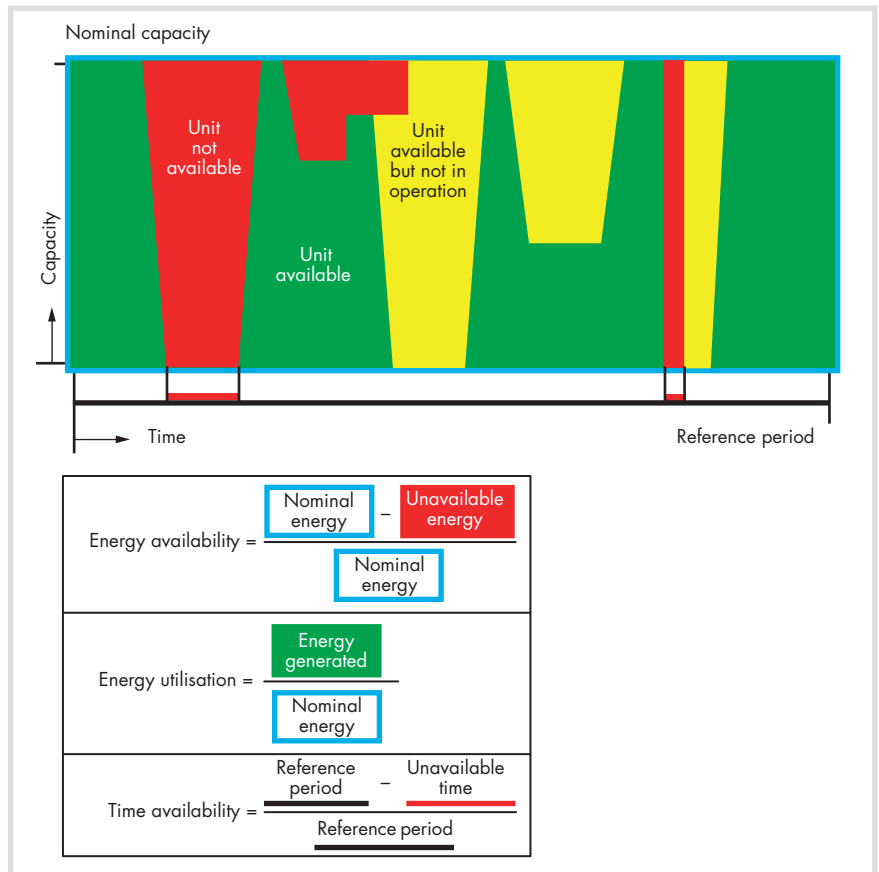


Fig. 2: Operating diagram and performance indicators.

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.

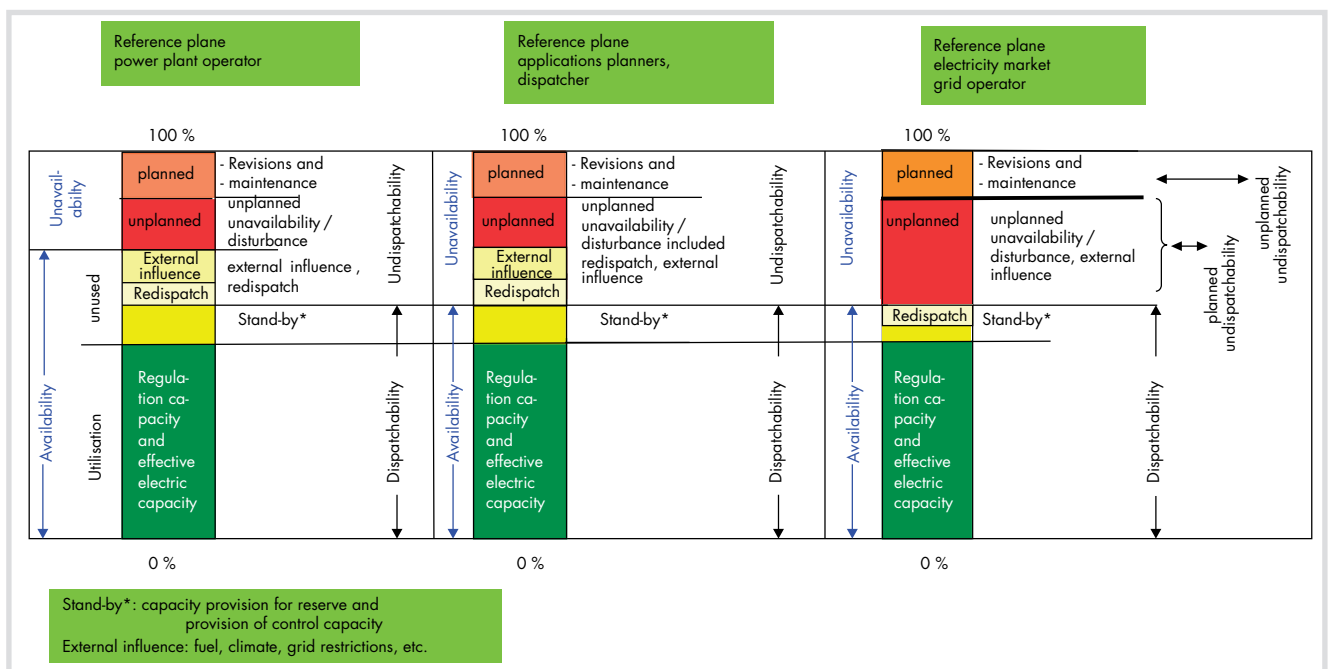


Fig. 1: Analysis of unavailability, availability, dispatchability (reference plane net). Different views of the power industry.

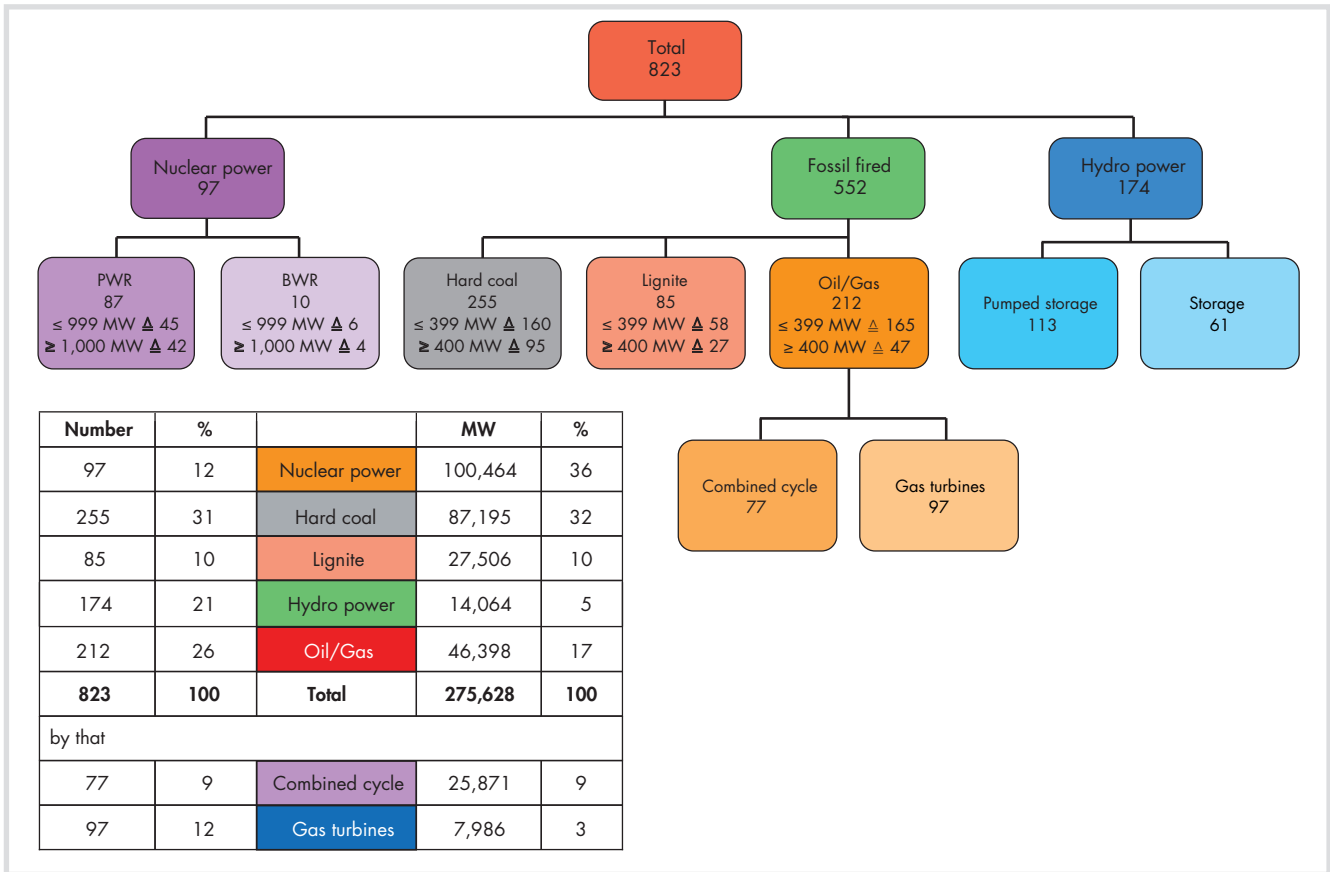


Fig. 3: VGB member units evaluated in 2017.

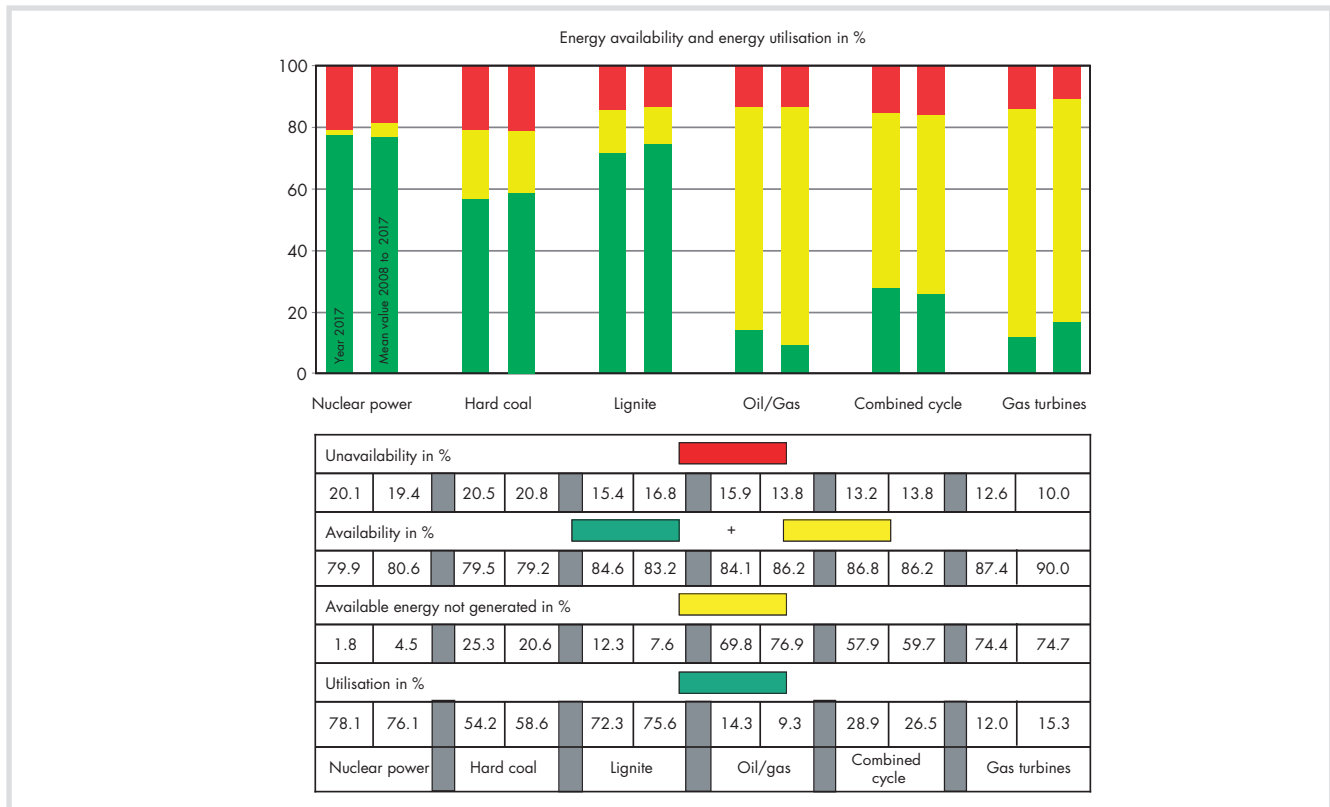


Fig. 4: Energy availability and energy utilisation. Data for 2017 and mean values for 2008 to 2017.

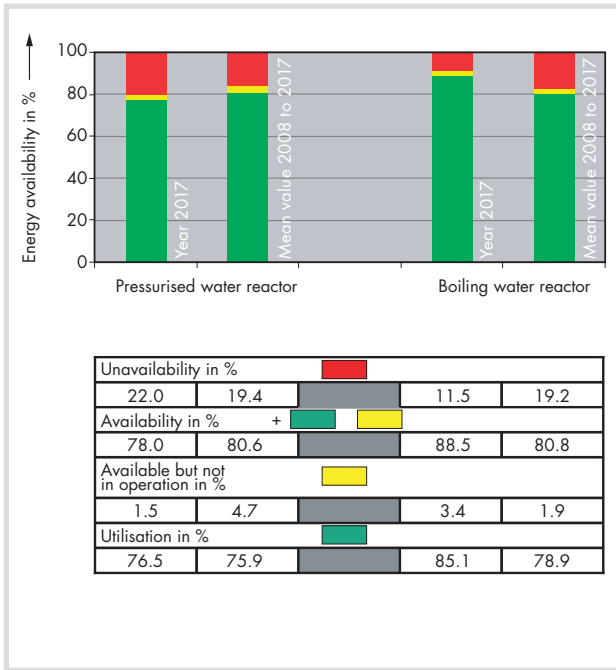


Fig. 6: Nuclear power plants: data for availability year 2017 and mean values 2008 to 2017.

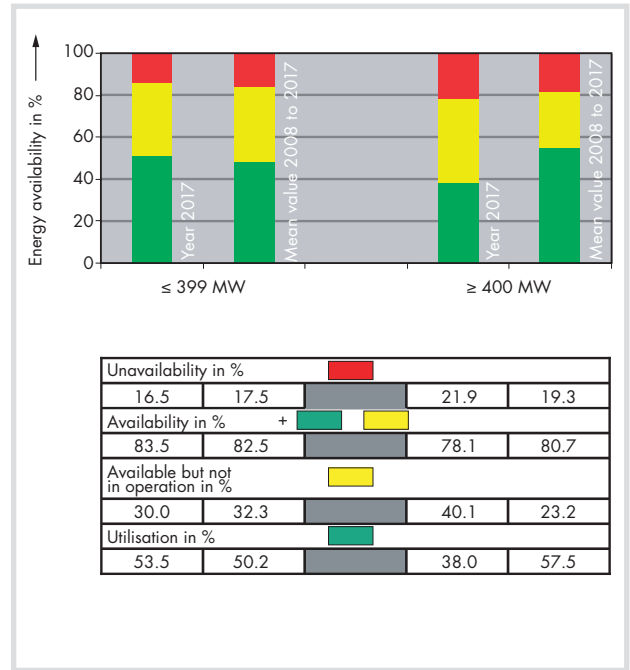


Fig. 7: Hard coal-fired power plants: data for availability year 2017 and mean values 2008 to 2017.

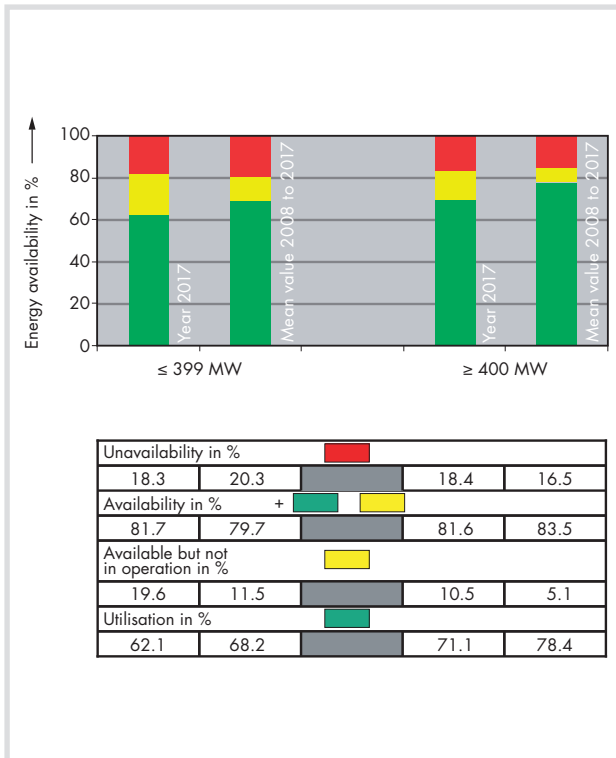


Fig. 8: Lignite-fired power plants: data for availability year 2017 and mean values 2008 to 2017.

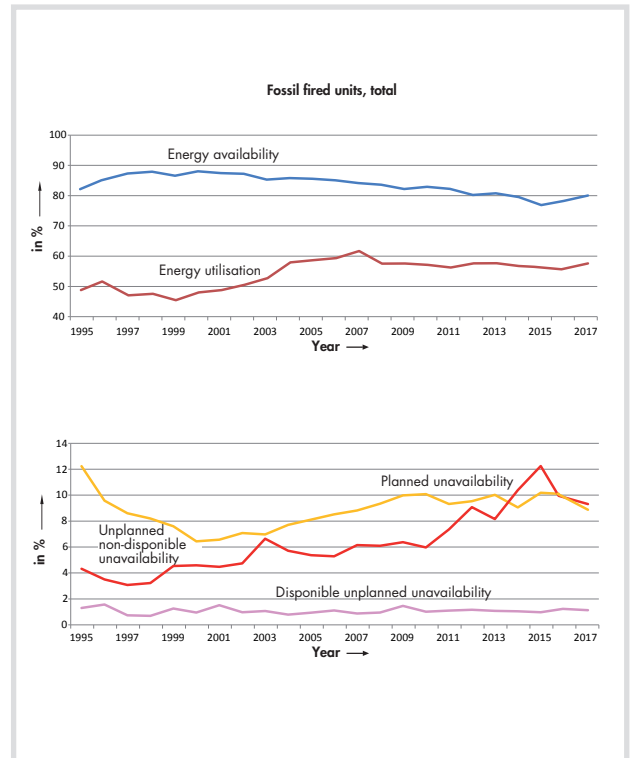


Fig. 9: Fossil-fired power plants: data for availability and unavailability 1995 to 2017.

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 302,000 MW of the VGB PowerTech members is represented in the following power plants (as of 30 June 2018):

227,500 MW fossil-fired power plants
34,500 MW nuclear power plants
40,000 MW hydro power plants and other renewables

The member contributions are taken in accordance with the contribution regulation for thermal power plants and non-thermal power plants according on the maximum net rated electricity capacity.

In the reporting period 2017/2018, 12 companies joined the VGB with a total capacity of 3,600 MW. 27 companies with a total capacity of 57,000 t/h withdrew from VGB.

The installed maximum net rated electricity capacity of the members at that point reduced by 131,000 MW or 43.4 % to a total of 302.000 MW as a result of the net

rated electricity capacity of the new members and after the drop in the net rated electricity capacity of the withdrawn companies.

The headquarters of 325 members are located in Germany, the country in which VGB PowerTech was set up in 1920. The headquarters of 112 members (26 %) are located in further 32 countries in Europe and other parts of the world.

1	Argentina
29	Austria
3	Belgium
1	Canada
1	China
2	Croatia
3	Czech Republic
7	Denmark
8	Finland
1	France
325	Germany
1	Greece
1	Ireland
2	Italy
3	Japan
1	Latvia
1	Luxembourg
1	Malaysia
1	Mongolia
1	Morocco
16	Netherlands
4	Poland
1	Portugal
1	Romania
2	Russia
1	Saudi Arabia
2	Slovenia
1	South Africa
2	Spain
4	Sweden
7	Switzerland
2	Turkey
1	USA
437	Companies from 33 countries

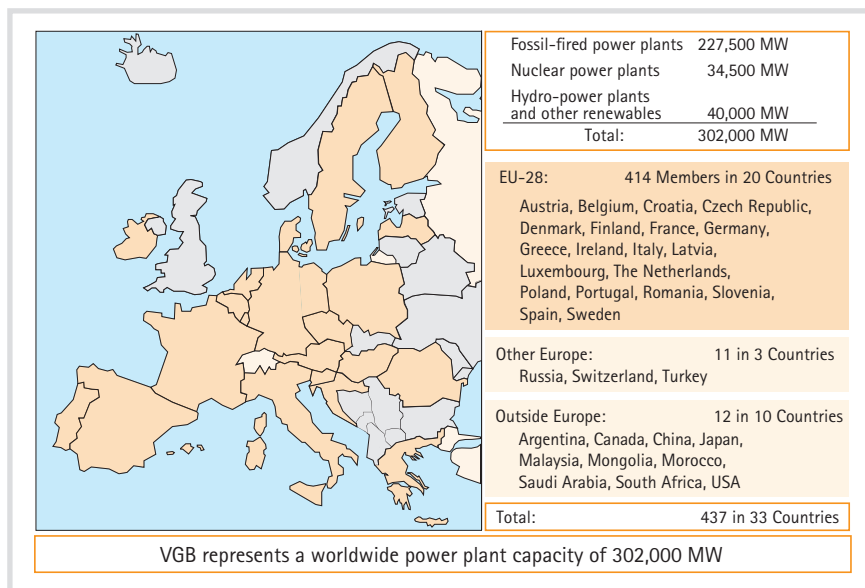


Fig. 1: VGB memberships according to European countries. Outside of Europe, another 12 companies in 10 countries are VGB members

Size of members with power plants according to installed maximum net rated electricity capacity:

Size	Share		Share of total steam capacity	
	2016/2017 in %	2017/2018 in %	2016/2017 in %	2017/2018 in %
up to 60 MW	35.0	34.8	1.3	1.2
61 to 150 MW	21.3	21.5	1.3	1.4
151 to 300 MW	7.8	7.7	1.1	1.1
more than 300 MW	35.9	36.0	96.	96.3
Total	100.0	100.0	100.0	100.0

On June 30, 2018 VGB had the following membership:

	Companies		Net rated electrical capacity	
	Number	in %	in MW	in %
Public supply companies (utilities)	152	64.1	280,500	92.9
Industrial supply companies	84	35.9	21,500	7.1
Total (supply companies)	236	100.0	302,000	100.0
Affiliated members	33			
Sponsoring members	168			
Total	437 members			

The installed capacity of the 84 industrial member companies is divided over the following branches of industry:

Industry	2016/2017 in %	2017/2018 in %
Mining	10.6	10.5
Chemical industry	26.7	27.2
Iron and steel industry	17.8	16.9
Textile industry	2.2	2.1
Paper and cellulose industry	17.6	17.5
Potassium, aluminium, glass and cement industry	0.5	0.6
Oil refineries, petrol industry	10.2	10.8
Apparatus industry, electrical and automotive industry, shipyard	10.4	10.1
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	3.0
Total	100.0	100.0

List of ordinary, affiliated and sponsoring VGB Members

(Status: June 30, 2018)

Ordinary members (power plant operators)

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

Berliner Stadtreinigungsbetriebe, Berlin, Germany

BioMa Energie AG, Wals, 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

DNV GL Netherlands B.V., Arnhem/The Netherlands

Donausäge Rumplmayr GmbH, Enns, Austria

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
 eins energie in sachsen GmbH & Co. KG, Chemnitz, 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
 enercity AG, Hanover, Germany
 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, Kirchlengern, Germany
 Energieversorgung Oberhausen AG (EVO),
 Oberhausen, Germany
 Energieversorgung Offenbach AG,
 Offenbach am Main, Germany
 Enertec Hameln GmbH, Hameln, Germany
 ENGIE Deutschland GmbH, Berlin, Germany
 ENTEGA AG, Darmstadt, Germany
 envia THERM GmbH, Bitterfeld-Wolfen, Germany
 EPZ, Vlissingen, Netherlands
 ERZ Entsorgung + Recycling Zürich, Zürich, Switzerland
 ESB Electricity Supply Board, Dublin, Ireland
 ESKOM Johannesburg, South Africa
 Essent, Eindhoven, Netherlands
 Essity Operations Mannheim GmbH, Mannheim, Germany
 EVN AG, Maria Enzersdorf am Gebirge, Austria
 Evonik Industries AG, Marl, Germany
 EWN Entsorgungswerk für Nuklearanlagen GmbH,
 Lubmin, Germany
 Fjernvarme Fyn A/S, Odense, Denmark
 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
 GETEC BBE GmbH, Magdeburg, Germany
 GfA – Gemeinsames Kommunalunternehmen für Abfallwirtschaft,
 Olching, Germany
 GHP Glunz Holzwerkstoffproduktions GmbH,
 Horn-Bad Meinberg, Germany
 GKS Gemeinschaftskraftwerk Schweinfurt GmbH,
 Schweinfurt, Germany
 Grace GmbH, 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
 Heizkraftwerks-gesellschaft 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
 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 ENGIE Group), Linkebeek, Belgium
 Lahti Energia Oy, Lahti, Finland
 Lausitz Energie Kraftwerke AG, Cottbus, Germany
 Lechwerke AG, Augsburg, Germany
 Lenzing AG, Lenzing, Austria
 Mainova AG, Frankfurt am Main, Germany
 Mark-E Aktiengesellschaft, Hagen, Germany
 Martinswerk GmbH, Bergheim, Germany
 MAYR-MELNHOF KARTON GmbH, Frohnleiten, Austria
 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

Nettingsdorfer Papierfabrik AG & Co KG, Haid bei Ansfelden, Austria

Nucleoelectrica Argentina SA, Buenos Aires, Argentina

NUON Energy Power, Heat & Services, Amsterdam, Netherlands

Nuon Power Buggenum, Buggenum, Netherlands

OMV Refining & Marketing GmbH, Vienna, Austria

Ontario Power Generation, Niagara on the Lake, Canada

Ørsted A/S, Fredericia, Denmark

OXEA GmbH, Oberhausen, Germany

Palm Power GmbH & Co. KG, Wörth, 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

Pfleiderer Baruth GmbH, Baruth/Mark, Germany

PreussenElektra GmbH, Hanover, Germany

Public Power Corporation S. A., Athens, Greece

PZEM, Middelburg, Netherlands

R.D.M. Arnsberg GmbH, Arnsberg, Germany

REMONDIS Production GmbH, Lünen, Germany

RheinEnergie AG, Cologne, Germany

Rhodia Acetow GmbH, Freiburg, 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

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 Zülpich Papier GmbH, Zülpich, 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 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

SWM Services GmbH, Munich, Germany

SWN Stadtwerke Neumünster GmbH, Neumünster, Germany

Tampereen Sähkölaitos, Tampere, Finland

TEAtherm GmbH, Dinkelsbühl, Germany

Technische Hochschule Lund, Lund, Sweden

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