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Preface

Dear ladies and gentlemen,

This Annual Report presents the results of VGB PowerTech’s work in the 2015|2016 reporting year. As a technical association for electricity and heat generation, VGB PowerTech provides a forum for the issues and interests of the industry as a whole, and a platform for research and development. VGB supports its members on the operational front and in strategic matters, and is a point of contact providing international links for a global exchange of information and ideas. The activities for the member companies are oriented towards the achievement of high operational reliability, optimum plant availability, sustainability and excellence in environmental protection, optimum health and safety at work and cost-effective plant operation.

The topics and key issues of the activities of VGB PowerTech e.V. and its associated institutions are detailed in this report.

Electricity generation in a state of flux

The changes in the electricity markets in Europe and worldwide and new weighting of the generation technologies are having far-reaching effects on the structures of power generation. The challenges are also growing as a consequence of a significantly broader energy mix with generation from renewables and conventional fuels and the associated interrelationships, some of which are new and complex. The topics include network stability and security of supply just as much as the issue of electricity storage for periods of low generation with an oversupply of renewables feeding into the grid.

Against that background, the topic of technology relative to the energy mix is definitely increasing in importance, and is equally affecting the work of VGB. The topic of cost-effectiveness is becoming more and more important. We are, then, constantly facing massive challenges which are set to continue – both for the industry and for VGB. One indicator alone, that of installed power generation capacity, makes this clear. Whereas previously one megawatt of power plant capacity was sufficient to secure supply, three or four megawatts will be necessary in the future generation and storage mix of renewables and conventional plants. Moving into the third generation of its generation portfolio, Germany is a pioneer in this respect.

VGB’s work focuses on this transformation, its technical challenges in the market environment and the entire, broad spectrum of generation from small, distributed systems to large-scale power plants, from hydro and wind power to nuclear and fossil fired facilities.

VGB members in 34 countries across the globe

The stable membership structure is certainly a good indicator of the regard in which VGB’s expertise and work continue to be held by its members. At 478 members, the number remains constant at a high level, and having members based in 34 countries across the globe emphasises the international importance of VGB. With 452 members, the EU is the most strongly represented region. 13 further members come from other European countries, and 13 member businesses are based in 10 countries outside Europe.

The association therefore represents a power generation capacity totalling 466,000 MW, with notable growth of around 4,000 MW or 5 % in renewables in the period under review.

Future VGB

With the «Future VGB» project, the association is facing up to the change in the industry in order to provide systematic support to its members in future with suitable structures and an optimum portfolio of services.

Together with the PowerTech Training Centre (KWTS) and the Simulator Centre (KSG/GIS), the Deilbachtal Energy Campus in Essen is the first port of call for all the topics surrounding power generation. Training, further education, technical training, simulator training, the exchange of reports on technical experience and services comprising engineering consultancy, construction and installation supervision, materials laboratory and water chemistry services are now provided there on the basis of a joint infrastructure and further synergies resulting from close cooperation.

Experience with the modified and adapted committee structure of VGB PowerTech has been thoroughly favourable. It meets the challenges and supports efficient and effective action, addressing issues actively and promptly, as is shown by the technology and transparency initiative «Hg», *. In the course of «Future VGB», the VGB Head Office has been restructured and the former «Competence Centres» brought inside a departmental structure. The integration of the previous fields of activity provides on the one hand for a more streamlined organisation and on the other hand for further synergies between topics and an additionally optimised exchange of experience between the individual committees and beyond. The competence areas remain as a thematic guideline in external relations, and are designated «Nuclear Power Plants», «Power Plant Technologies», «Renewables and Distributed Generation», and «Environmental Engineering, Chemistry, Safety and Health».

In the year under review, we have constructively continued the exchange of experience in the committees, and also dealt with issues which are important to our members. This took place both on the national level and within the European framework, in some cases jointly with partner associations such as Eurelectric and BDEW. On the international scene, for example, cooperation with the Excellence Enhancement Centre for the Indian Power Sector (EEC), the Japanese Thermal and Nuclear Power Engineering Society and the Turkish-German Energy Forum (TGEF) was successfully continued. The members of all the partner organisations benefit from these professional contacts.

VGB PowerTech regards itself as a top service provider for technical cooperation in electricity and heat generation – in Europe and beyond – with a focus on cost-effectiveness, efficiency, safety, environmental friendliness and health and safety at work in the construction, operation and dismantling of plants.

The challenges facing electricity and heat generation today are enormous, as are therefore the tasks for technology and the contribution made by VGB PowerTech to overcoming them.

We hope you will enjoy reading the VGB Annual Report 2015|2016!

Dr Bernhard Fischer
Chairman of the VGB Board of Directors

Erland Christensen
VGB Executive Managing Director

*Hg**: Hg, chemical symbol for mercury, cap = capture
VGB PowerTech e.V. is the European technical association for power and heat generation with international relationships. VGB’s 478 members from 34 countries represent a power plant capacity of 466,000 MW thus in 2015/2016 VGB achieved again a good result in terms of «members», «countries», and «power plant capacity». (Figure 1)

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
- Technical Services.

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
- Re-organisation of VGB Department organisation.

Fossil-fired power plants   246,000 MW  
Nuclear power plants   120,000 MW  
Hydro-power plants  and other renewables   100,000 MW  
Total:   466,000 MW

EU-28: 452 Members in 20 Countries
Austria, Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Luxembourg, The Netherlands, Poland, Portugal, Romania, Slovenia, Spain, Sweden

Other Europe: 13 in 4 Countries
Norway, Russia, Switzerland, Turkey

Outside Europe: 13 in 10 Countries
Argentina, Australia, Brazil, China, Israel, Japan, Mongolia, Saudi Arabia, South Africa, USA

Total: 478 in 34 Countries

VGB represents a worldwide power plant capacity of 466,000 MW

Fig. 1: VGB memberships according to European countries. Outside of Europe, another 11 companies in 9 countries are VGB members.
During the year under review, the committees, groups and forums of VGB convened at over 180 meetings. All VGB members are informed about the results of these meetings through the bimonthly «VGB Newsletter» by e-mail, through the VGB Home Page, and via internet (closed user groups). Other interested parties can also obtain the VGB Newsletter free of charge by e-mail. Interested parties can register at www.vgb.org | Publications.

Apart from overseeing the activities of the committees, the VGB Secretariat also performs other tasks. In addition to working on the rules and regulations in form of VGB-Standards, VGB is also responsible for organisational support and coordination of joint research of power plant operators in the VGB-Forschungsstiftung (Research Foundation). The joint research supplements the company-specific research objectives. Furthermore, the VGB Offices organise seminars, symposia, conferences, and the annual Congress «Power Plants». 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 focuses on:

- continued internationalisation of VGB,
- renewables and the related technologies as well as synergies,
- technical issues related to future conventional generation,
- bundling of technical expertise and services for members companies in the fields of:
  - power plant concepts
  - fuels and furnaces
  - steam generators
  - steam and gas turbines
  - electrical engineering, I&C, and IT
  - materials and civil engineering
  - operational, maintenance, and environmental management

including VGB’s technical services in the fields of:

- engineers’ consulting
- damage analysis and material test laboratory
- monitoring of construction and assembly/quality monitoring
- external chemical investigations
- Creation of technical Standards (no-official standards), in detail:

- since August 2011 VGB Guidelines and VGB Instruction Sheets have been published as VGB-Standards
- data bases and technical information in all fields of generation
- coordination of projects and R&D measures
- European networking with associations like EURELECTRIC, EURturbines, Foratom, Euracoal and others.
- training and further vocational training of power plant personnel (at KWS and KSG/GfS)
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 3). He also has a close association with the KRAFTWERKSSCHULE E.V., the Kraftwerks-Simulator-Gesellschaft (KSG) and the Gesellschaft für Simulatorschulung (GfS), which are responsible for training concerning conventional, renewable and nuclear technology. Furthermore, he coordinates the distribution of tasks amongst other sector associations.

KRAFTWERKSSCHULE and KSG|GfS

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

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

The personnel at nuclear power plants are trained in The Simulator-Centre KSG|GfS in Essen-Kupferdreh/Germany. Simulator training for reactor operators began on Klinikstraße in Essen in the VGB Offices as early as 1977. In 1987, the KSG (Kraftwerks-Simulator-Gesellschaft mbH) and GfS (Gesellschaft für Simulatorschulung mbH) companies were founded by 11 German and two international energy supply companies. KSG provides the simulators in the new Simulator Centre and the appropriate infrastructure which GfS uses to carry out its training (Figure 5).

VGB PowerTech Service GmbH

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

VGB FORSCHUNGSSSTIFTUNG

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.
Competence Area
Nuclear Power Plants

Nuclear Power Plants
Ludger Mohrbach

In connection with the reorganisation of the VGB Secretariat, the former «Competence Centre 1» has been renamed «Department N (Nuclear)». The change has no effect on the structure of this body (Figure 1):

- GC Nuclear Power Plants
- TC Engineered Safety
- WP Safety Assessments
- WP Component Integrity
- WP Reactor Core
- WP Impacts on Civil Structures
- WP Nuclear Power Plant Operation
- WP Mechanical and Process Engineering
- WP Electrical and I&C Engineering
- WP Practical Radiation Protection
- WP NPP Management Systems
- WP Event Analyses
- WP Decommissioning and Disposal
- WP Interim Storage
- WP Safeguards

Nuclear power plant operation

Nuclear power plants of VGB members worked largely trouble-free in 2015 (with exceptions in Belgium and Switzerland, see below). In many central European countries, nuclear power plants were providing more and more grid services due to their excellent control features. All German plants recorded energy availability factors between 88.5 and 93.8 % in 2015.

At mid-year 2015, E.ON Kernkraft discontinued operation of its Großenhain nuclear power plant, in spite of the fact that the German federal government’s plan for phasing out nuclear power would have enabled operation through to the end of the year. The reason was the German nuclear fuel tax (expires at the end of 2016), which skims off about two thirds of the previous revenues from nuclear power plant operation and is imposed on new fuel assemblies. As there was no further fuel for the unit available on site, fresh fuel assemblies could have been utilized only to about one third, and since permits cannot be obtained for the transport of partially spent fuel assemblies in Germany ( unlike in virtually all other countries), continued operation of the reactor was no longer possible after the minimum reactivity level was reached.

After this shutdown there remained eight nuclear units still in operation in Germany. With 998 PJ they accounted for 14.1 % of national electricity generation and 7.5 % (last year: 8.1 %) of the national primary energy consumption.

Despite a reduction by half since 2011 (Fukushima), the contribution of nuclear energy to CO₂ avoidance is still more than twice as large as that of wind (2.3 %) and sun (1.0 %) together (Source: BMWi [German Federal Ministry for Economic Affairs and Energy], AG Energiebilanzen).
Final waste repository in Germany: «Back to Zero»

In 2015 the government-appointed commission to find a final repository site continued its discussions on the criteria for a new site selection process for an underground repository for heat-generating waste with some additional delay. Publication of a final report is now scheduled for mid-2016. Gorleben will remain in the selection process.

Conversion work at the former iron ore mine «Schacht Konrad», licensed as final repository for non-heat-generating radioactive waste, encountered further delays. Commissioning is now expected to take place in 2022/2023 at the earliest. Until then, materials accumulating especially during the dismantling of decommissioned plants and suitable for storage at «Konrad» will have to be placed in interim storage at the sites, entailing considerable expense.

Nuclear power plants of international VGB members

After a hiatus of several years, in 2015 a VGB member company again reported the commissioning of a nuclear power plant. The heavy-water reactor Atucha-2 (installed capacity 745 MWel) in Argentina completed commissioning after a 35-year construction period. Commercial operation then was taken up in May 2016.

In Belgium, following extensive assessment of the condition of the reactor pressure vessels over a period of three years – drawing on the available expertise worldwide and the results of additional irradiation test on specimens – the regulatory authority FANC granted approval for the restart of the nuclear power plant units Doel-3 and Tihange-2 (in December 2015). Hydrogen flakes – in the mm to cm range – had been detected in both reactor pressure vessels in areas outside of weld seams. The investigations confirmed that all flakes are «paperthin», lie parallel to the surface (and therefore are not exposed to any mechanical stresses), originate from the forging process carried out in the 1970s (Manufacturer: Rotterdamse Droogdok Maatschappij; not existing any more), and do not exhibit any crack growth. Operator ENSIE (formerly GdF Suez/Electrabel) was able to provide evidence that the vessels continue to possess full adequate strength to withstand the loads produced also by accidents. Parallel to this the Belgian government, as recently announced, extended the operating periods for Doel-1 and Doel-2 by ten years.

All other potentially affected nuclear power plants carried out reviews for applicability of these findings; indications were found only at Beznau-1 (Switzerland) based also on the first-time use of improved ultrasonic testing equipment. The reactor pressure vessel in question comes from a different manufacturer (AREVA, Chalon); the indications are much smaller in scope and number and evidence a different phenomenology. The restart of Beznau-1 is scheduled for 2016.

In Sweden, in June 2016 a five-party coalition including the Social Democrats and Greens decided to repeal the Swedish nuclear energy tax of 0.7 €cents/kWh, pointing to the climate-friendliness of nuclear power. In addition, the further operation of the (recently) ten Swedish nuclear power plant units and their sitebound replacement by new-build plants until 2040 has been approved.

Worldwide extension of nuclear power

Since the Fukushima event in 2011, no other country as yet has followed the German example of the premature, complete and permanent shutdown of nuclear power plants.

Instead, in Europe, in the period covered by this report, the United Kingdom, for example, has announced additional projects, besides Hinkley Point C (2 x 1,700 MW of the EPR type, decision on investment by EdF Energy taken in June 2016, but immediately challenged again by the new British government), with 3 x 1,250 MW (Westinghouse AP-1000) in Moorside (Sellafield) and 2 x 1,350 MW (General Electric/Hitachi ABWR) in Wylfa Newydd; other new-build projects are under way in Finland (Hanhikivi-1), Belarus (Ostrovets 1-2), Russia (Kaliningrad 1-2, among others), Bulgaria (Kozloduy-7) and Turkey (Akkyuo 1-4) (all Atomstroyexport WWER-1200). Further projects were announced by Turkey (Sinop 1-4, Akmea-1000), Poland, Czech Republic, Hungary and the Ukraine, while the Slovak Republic and Romania continue to pursue the (delayed) completion of two units each in Mochovce and Cernavoda.

During the coming years, China will continue to commission new nuclear power plant units at the rate of one nearly every six to eight weeks. In Japan, applications for 23 recommissioning projects have been filed to date (five of which have been approved); apart from the six Fukushima-Daiichi units, six further units have been permanently closed. For twenty units the decision is still pending, while another two are under construction. Parallel to this, as sole OECD country Japan is pursuing an ambitious construction programme for some 50 hard-coal-fired power plants to enable the substitution of expensive liquefied gas.

Chiefly influenced by the erosion of prices on the Central European electricity exchanges, prompted by developments in Germany, and by local nuclear energy taxes, only operators in Sweden (Oskarshamn-1 and Oskarshamn-2, Ringhals-1 and Ringhals-2), in Switzerland (Mühleberg) and in France (Fessenheim-1 and Fessenheim-2) have announced the premature shutdown of nuclear power plants by 2020, whereas the Spanish government is pressuring the operator of the oldest Spanish reactor, Santa Maria de Garona (466 MWel BWR), to extend the unit’s lifetime.
First permit worldwide for a repository for spent fuel

On 12 November 2015 the Finnish government issued the construction licence for a subterranean final repository – a worldwide premiere – for 6,500 tons of spent fuel at the Olkiluoto site. This removes the last obstacle to construction, which is scheduled to be completed by 2020 (Figure 2).

Project Management

Thomas Linnemann

The subcommittees of the General Committee «Nuclear Power Plants» can initiate operation-related projects that are financed in each case directly by the German nuclear power plant operators according to the cost-sharing principle, across all plants involved. In 2015, excluding the newly established WANO membership, 39 projects (last year: 33) with a total funding volume of 3,484,277 € (last year: 2,666,272 euros) were awarded, including

- 18 by the TC «Engineered Safety» with 1.7 M€ (last year: 12 with 0.7 M€), and
- 20 by the TC «Nuclear Power Plant Operations» with 1.7 M€ (last year: 21 with 1.7 M€).

Mid-term budgeting

All VGB committees dealing with nuclear technology communicate their expectations for the medium-term development of their expenditures for operation-related VGB joint projects once each year to the VGB Secretariat, which draws up a mid-term budget on this basis.

The «General Committee» had requested the VGB Secretariat to suspend the regular budget for the five-year period 2016 to 2020 and instead budget a six-year period (2016 to 2021) on a one-off basis so that the overall expenditures for joint projects can be estimated only on a cross-project basis (statistically averaged), and from a competition law point of view only for the individual operator. For the year 2014, budget deferrals to the following year totalling around 3.1 M€ were reported, and budget deferrals for the year 2015 were on a comparable level (around 3.2 M€). These budget deferrals always concern contractual liabilities from joint projects applied for, reviewed, approved and assigned in conformity with VGB rules.

In the past two years, each year about 60 % of the expected total costs were received by the VGB Secretariat in the form of invoices (2014: 12.0 M€ expected and 7.3 M€ received as invoices; 2015: 10.9 M€ and 6.6 M€).

For information purposes, in April 2016 the General Committee received the new VGB mid-term budget (2016 to 2021), agreed bottom-up with all committees dealing with nuclear technology. According to this updated budget, total costs of just about 11.9 M€ are expected for 2016. Obligations arising from all assigned, ongoing projects account for 8.3 M€ of the total (Figure 4).

In the further course of the period concerned, a distinct, progressive decline in the overall expenditures for joint projects can be observed: for 2021, based on current budgeting, the VGB committees expect a reduction to 3.4 M€.

Generally speaking, the VGB mid-term budget is intended as an orientation aid for the individual budgets of the operators. The next VGB mid-term budget (2018 to 2022) will be compiled in the spring of 2017.

Technical Committee

Engineered Safety

Ludger Mohrbach

In three meetings and one telephone conference in all, the Technical Committee (TC), set up in 2013, continued its consultations in 2015. Apart from receiving continued reports from the assigned working panels (including Working Group «IT Security») and carrying out the assigned Project Management function (including mid-term budgeting), the TC dealt with the approval of project applications.

Topics and projects of the technical committee included

- Review of the membership costs in other organisations (e.g. ISOE Radiation Protection),
- Commercial handling of research projects (payment delays),
- Generic robustness analyses for PWR-1300 plants,
- KTA 2207 review (protection of nuclear power plants against flooding),
- Fatigue evaluation of reactor pressure vessel internals for boiling water reactors,
- Evaluation of the influence of the new fatigue curves (air) and the new thresholds (fluids) contained in the current KTA standard 3201.2 on the PWR secondary system,
- Seismological statement on the location issue for the planned seismic free-field instrumentation in connection with the redraft of KTA 2201.5,
- Water gaps in PWR reactor cores,
- Overall strategy on long-term cladding tube embrittlement in storage casks,
- Transfer of neutron flux noise measurement data (for research purposes),
- QUENCH tests with cladding tubes from Westinghouse and Areva,
- Evaluation of the influence of fuel assembly deformation on the mechanical safety assessments of fuel assembly structures under normal operation,
- Supply of data and determining of influence on output data in relation to the topic of statistical Loss-Of-Coolant-Accident (LOCA) analysis,
- Information about the continuation of the OECD project PKL III (without operator involvement),
- Statement on the guidelines for the secure transport of nuclear fuels,
- Line of action in regard to the scope of disclosure of plant data in reply to inquiries under the German Environmental Information Act,
- Crack initiation on generator wedges,
- Project «Cost Study High Active Waste Repository»,
- AREVA evaluation agreement for event reports,
- Sale of data rights of «Central Event Database» ZEDB,
- Determining of the synergy potential of the joint monitoring of new laws,
- Operator contributions to CNS (Convention on Nuclear Safety),
- Transfer of «QP» database (lubricants, chemicals and other fluids) from AREVA to VGB,
- Establishment of a Working Group «Ageing Management» (Working Panel «Component Integrity»),
- Selected topics of the Reactor Safety Commission (RSK).

**Working Panel «Safety Assessment»**

**Thomas Linneweber**

As in the previous years, the focus of the panel’s deliberations was the coordination of the technical conclusions to be drawn from the Fukushima event, based on the demands of the Reactor Safety Commission (RSK: Reaktorsicherheitskommision), and the implementation of these conclusions. This includes the measures summarized under the heading «plant robustness» (for instance for lightning protection), specifically also the question of spent fuel pool cooling systems and the effectiveness of selective containment pressure relief in the course of core melt accidents.

In its capacity as interface between RSK and the VGB Secretariat, the panel coordinated inquiries on issues discussed in RSK and the four RSK committees and organized nine operator presentations and four written feedback reports in the period under review (last year: 9 + 0) (Table 1).
Working Panel «Plant Security»

Georg Schäfer

The WP «Plant Security» held intensive discussions about the new regulatory requirements for the protection of nuclear installations and for transports of radioactive materials. A further focus of discussion was the new IT security guideline.

Working Panel Component Integrity

Jens Ganswind

The primary task of the working panel 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 posed in particular by

- regulatory requirements of the federal supervisory authorities (BMUB Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety), including GRS (German Expert Organisation for Plant and Reactor Safety) Information Notices,
- statements of the Reactor Safety Commission,
- requirements of authorities/experts,
- requirements arising from the revision of KTA standards,
- notifiable events in VGB plants and events in external plants.

Assessment of damage cases

The procedure in the case of mechanical damages basically consists of identifying the damage cause and damage mechanism, determining corrective and repair measures and assessing the transferability to other BWR and PWR plants of the operators represented in the panel, as well as assessing whether new findings will materialise that help to control plants. An exemplary damage case dealt with in this manner is presented below:

Slot wedges of generator rotors

Based on a damage event involving a slot wedge in the interior of a 60 Hz generator in a U.S. nuclear power plant, the VGB operators launched a test programme to assess the transferability to (European) rotors of 50 Hz generators of the same type. The programme focussed on damage analysis, NDT (non-destructive testing), indication assessment and integrity assessment.

<table>
<thead>
<tr>
<th>RSK/Committee</th>
<th>Subject of discussion</th>
<th>Date</th>
<th>VGB WP</th>
</tr>
</thead>
<tbody>
<tr>
<td>RB</td>
<td>Betriebsverfahren zum DWR-Neutronenflussrauschen (Operating experience with PWR neutron flux noise) (written feedback report without presentation)</td>
<td>11.02.2016</td>
<td>R</td>
</tr>
<tr>
<td>RSK</td>
<td>Robustheitsanalysen: Robustheit der Nebenkuhlwasserleitungen bei Erdbeben (Seismic robustness of auxiliary cooling water pipes) (written feedback report without presentation)</td>
<td>14.12.2015</td>
<td>NWV</td>
</tr>
<tr>
<td>EE</td>
<td>Rückwirkungen von Stabilitätsproblemen im deutschen Stromnetz auf elektrische und leittechnische Einrichtungen von Kernkraftwerken (Influence of German power grid stability problems on to electrical and I&amp;C components in nuclear power plants)</td>
<td>25.06.2015</td>
<td>EL</td>
</tr>
<tr>
<td>EE</td>
<td>Ein- oder zweiphasiger Ausfall des Haupt-, Reserve- oder Notstromnetzanschlusses: Umsetzungsstand bei Einrichtungen zur Detektion und Einleitung von Maßnahmen (One- or two-phase failure of the main-, reserve-, or emergency power connections: Status of installations for detection and countermeasures)</td>
<td>11.08.2015</td>
<td>EL</td>
</tr>
<tr>
<td>EE</td>
<td>Blitzes mit Parametern oberhalb der genormten Blitzstromparameter, Robustheit des Blitzschutzes sowie Betriebsverfahren mit Blitzeinschlüssen (Lightnings with above-standard parameters, robustness of protection as well as operating experience with lightning strikes)</td>
<td>13.11.2014</td>
<td>EL</td>
</tr>
<tr>
<td>RSK</td>
<td>Robustheitsanalysen: Prüfung generischer VGB-Konzepte für SWR auf Gültigkeit, eventuell Modifizierung und Bestätigung (Robustness analyses: Check of generic VGB concepts for SWRs on applicability, eventually modification and confirmation) (written feedback report without presentation)</td>
<td>12.10.2015</td>
<td>NWV</td>
</tr>
<tr>
<td>RSK</td>
<td>Robustheitsanalysen: Prüfung generischer VGB-Konzepte für DWR auf Gültigkeit, eventuell Modifizierung und Bestätigung (Robustness analyses: Check of generic VGB concepts for PWRs on applicability, eventually modification and confirmation) (written feedback report without presentation)</td>
<td>10.11.2015</td>
<td>NWV</td>
</tr>
<tr>
<td>DK</td>
<td>Befund am Wärmeschutzeinrichtung in einem Stutzen des nuklearen Nachwärmetauschsystems im Kernkraftwerk Isar-2: Bericht zur Situation in den deutschen Kernkraftwerken (Fault indication on a thermosleeve of the residual heat removal system in KKI-2: Status report from the German nuclear power plants)</td>
<td>24.09.2015</td>
<td>KOM</td>
</tr>
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<td>DK</td>
<td>Schaden an einer Entwässerungsleitung im Frischdampfsystem der Anlage Brokdorf: Bericht zur Übertragbarkeit (Damage on a drain pipe at the live steam system of KBR: Report on applicability on to other plants)</td>
<td>11.09.2015</td>
<td>KOM</td>
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<td>RSK</td>
<td>Robustheitsanalysen: Bewertung extremer Wetterbedingungen und Übertragbarkeit seismischer DWR-Robustheitsanalysen auf den SWR (Robustness analyses: Evaluation of extreme weather conditions and applicability on to other plants of seismic PWR-robustness analyses for BWRs) (hearing without presentation)</td>
<td>14.08.2015</td>
<td>NWV</td>
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<tr>
<td>EE</td>
<td>Whiskerbildung an leittechnischen Baugruppen in deutschen Kernkraftwerken (Whisker formation on I&amp;C components in German nuclear power plants)</td>
<td>19.03.2015</td>
<td>EL</td>
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<tr>
<td>AST</td>
<td>Robustheit der Erdbebenauslegung, Seismic-Margin-Assessment-Methdik (Robustness of seismic design, Seismic-Margin-Assessment methodology)</td>
<td>14.10.2014</td>
<td>EAB, NWV</td>
</tr>
</tbody>
</table>

Tab. 1: Operator lectures given before the RSK and its committees «Plant and Systems Engineering» (AST), «Electric Installations» (EE) and «Reactor Operation» (RB). The lectures were organised by the VGB Working Panel «Safety Assessment».
The results of the project should make improved assessment of NDT indications in regard to component integrity possible and should so improve the decisions basis on continued operation or repair. Further subjects on this panel’s agenda in the year under review were, among others:

- Hydrogen flocks in the reactor pressure vessels of the Belgian nuclear power plants Doel-3 and Tihange-2,
- Fault indications on a drain line of a main steam system,
- Crack indications on a thermosleeve in the nuclear residual heat removal system, and
- Fracture of an internal water duct of a BWR fuel assembly.

In each case the panel assessed the transferability and, where necessary, drew up joint concepts for determining corrective action.

Working Panel «Reactor Core»
Guido Vallana

Current projects continue to deal with safety case issues of neutronic and thermohydraulic core design as well as the layout and operating behaviour of fuel assemblies and fuel rods for the required safety assessments.

For every core configuration (now after every refuelling), along with the hot rod analysis that determines the reactor core distribution the rules require evidence that in a hypothetical loss-of-coolant-accident 90 % of the fuel rods will remain intact («damage extent analysis»).

This evidence is to be provided for PWRs (BWRs have stabilising fuel assembly channels), also setting margins for the maximum operational deformation of fuel assemblies. This requires extensive modification of the mathematical methods used for safety assessments, controlled by means of a suitable research & development programme of the working panel. Statistical LOCA analysis is being improved for this purpose (jointly with AREVA).

The embrittlement characteristics of the employed fuel cladding tubes play an important role in this problem. They are being investigated, for example, in the context of QUENCH-LOCA tests conducted by KIT (Karlsruhe Institut für Technologie). The results will be discussed in the Working Group «Safety Assessments for Core Reloading» and in the panel.

Working Panel «Impacts on Civil Structures»
Jens Ganswind

The focus of the working panel lay mainly on relevant civil engineering issues in the fields of seismic design, flooding, extreme weather, explosions, fire protection and ageing management.

In order to highlight the major changes resulting from the revision of KTA standard 2101, «Fire Protection in Nuclear Power Plants», the panel organised a workshop for the users from the plants on 7 October 2015. The participants were all interested users from the nuclear power plants.

ECJ ruling on general technical approvals – Recommendation

For technical approvals, in its ruling of 16 October 2014 the European Court of Justice declared inadmissible the granting of «individual approval» or a «national technical approval» based on higher German requirements as opposed to an existing European approval. The working panel thoroughly discussed the consequences of this ruling for power generation systems and, in consultation with Deutsches Institut für Bautechnik (DIBt), drew up a recommendation for action in two variants.

Technical Committee «Nuclear Power Plant Operation»
Ludger Mohrbach

The Technical Committee «Nuclear Power Plant Operation» is a forum for discussion for all nuclear power plant managers of VGB member companies. Apart from German plants, Swiss, Dutch, French, Belgian, Finnish, Spanish, Brazilian, Argentinian and Polish operators are represented. The committee works bilingually in German and English. The plant reports in the committee’s minutes are regularly written in English.

The committee met four times during the reporting period. In addition to steering its associated working panels and groups, the committee focussed discussion on the most important issues:

- VGB system to assess safety culture,
- human performance tools,
- WANO reporting,
- project management and project budgeting,
- participation of Swissnuclear in the AREVA exploitation agreement.

Examples for the exchange of experience are described in the reports of the individual working panels.

Working Panel «Mechanical and Process Engineering»
Heinrich Grimmelt

During the 2015/2016 reporting period this new panel met four times for two-day meetings. The first day of each meeting is devoted to post-operation issues. This part of the meetings is also attended by representatives from the plants that are still in operation, so that they can start making preparations for the transition to the post-operation phase in good time.

Typical topics at the meetings are operating status history, licensing procedures, reduction of inspection inspections and maintenance activities, energy management and other cost-saving options.

The second day of a meeting is devoted to operational plants. The participants explain their plant reports, which address notifiable events, technical events below the notification threshold, and current activities relating to inspections and power operation.

The panel additionally discussed in greater detail certain topics fixed by the TC «Nuclear Power Plant Operation». They included:

- Leak in a drain line of a main-steam valve station (Brokdorf),
- Actuation of the reactor protection signal during a steam generator pressure test (Philippsburg-2), and
- Recommendations of the Reactor Safety Commission on the spent fuel pool cooling system for both power operation and inspections.

New VGB-Standard on avoidance of foreign material ingress into opened systems

The associated Working Group «Maintenance» completed the revision of the VGB standard «Avoidance of foreign material ingress into opened systems/ components of nuclear power plants» during the period under review. The new version contains – among other things – a chapter on «Electrical and I&C engineering», it can also meaningfully be used in other power plant types, and can be obtained through the VGB online shop (Figure 5).
Working Panel «Electrical and I&C Engineering in Nuclear Power Plants»

Jörg Kaiser

The Working Panel «Electrical and I&C Engineering in Nuclear Power Plants» continued to deal with the pertinent electrical engineering and instrumentation and control (I&C) topics of different internal and external committees and panels, deriving joint measures as required and evaluating events of generic importance. This also included the exchange of experience with conventional power plants, especially in regard to large electrical components like generators and transformers, but on matters of IT-security as well.

In particular, the panel ensured coordinated action to maintain the functionality of all electrical and I&C equipment, utilising the potential this affords for economic optimisation. The individual projects are managed mainly by the associated working groups «Component Qualification» and «Loss-of-Coolant-Accident (LOCA) Qualification».

Impacts of single-phase grid connection failures

Initiated by the German nuclear power plant operators, the VGB project group «Grid Issues» dealt with the analysis, impacts and possible measures for detecting single-phase failures and the related asymmetries in the auxiliary service supply systems of nuclear power plants.

In the reporting period the group managed successfully to finalize the joint VGB activities started for this purpose. These activities involved, among other things, investigations and simulations conducted at transformer manufacturer ABB, Fraunhofer Institute for Wind Energy and Energy Systems Technology IWES Kassel, and high-voltage grid operator Amprion.

The RSK committee «Electrical Installations» took note of and approved the results presented by the panel on 17 March 2016. The derived measures are now being implemented in the plants.

Possible repercussions of instabilities in the German power grid

On its 223rd meeting on 21 November 2012, the RSK committee «Electrical Installations» made a detailed analysis on the subjects of grid stability and the impacts of stability problems on nuclear power plants, subsequently summarising the results in an RSK statement entitled «Grid Stability». As most important new factor for grid stability it identified the increasing feed-in of renewable power. Thus, more and more power is being integrated by means of static inverters; however, this power is no longer available as ready reserve due to the finite switching times. Rotating masses (turbine-generators) remain indispensable.

Increasing use is being made of static components also for voltage management, and it is planned to lay new high-voltage transmission lines underground over large distances.

Following extensive preparation and coordination with the transmission system operators, drawing among other things on current statistics, on 12 April 2016 the working group issued a statement entitled «Impact of stability problems in the German power grid on electrical and I&C installations of nuclear power plants and securing the required electrical power supply for these plants from the grid».

Owing to a multitude of measures, up until now the grid and plant operators have succeeded in maintaining grid stability at its previous and present high level. However, the regional imbalances between infed and consumption increasingly necessitate redispatch measures (selective local run-up and turn-down of power plants) to relieve the loads on high-voltage transmission lines, at the price of additional costs and risks.

Working Panel «Practical Radiation Protection»

Lena Jentjens

At the Working Panel «Practical Radiation Protection» meetings, which take place twice a year, the emphasis is on the active exchange of experiences from plant operation and dismantling activities. In-depth reports were given, inter alia, on the re-actor coolant system decontaminations carried out so far and the supplementary radiological training of external personnel for non-destructive testing.

In addition, the panel commented on, among other things, the draft of the new German Radiation Protection Act. As for the many other activities, the reader is referred to last year’s report.

New mass study on the effect of low doses

In addition, the panel discussed the results of the long-time INWORKS study on the health effects of low-dose ionising radiation in nuclear installations in France, UK and USA. The cohort comprised 308,000 employees in nuclear installations, of whom meanwhile around 66,000 are deceased, including 1,638 due to leukaemia. The additional risk due to occupational exposure to radiation (average additional dose 1.1 mSv/a) can be described with straight lines (scaled according to dosage groups). The gradients accord with the linear dose-response relationship derived from studies of Japanese atomic bomb victims (with high doses). That is to say, the results in particular for the groups with higher doses (over 100 mSv additional lifetime dose [Organ dose for red bone marrow]) lie in the anticipated range. On the other hand, the number of such cases is small.

However, below 100 mSv this study, too, is unable to detect any reliable dependency, and consequently none also for positive effects («hormesis»). All in all, the authors describe the additional leukaemia risk (and thus the risk that can be assessed for all nuclear power plant employees) as «minute».

Radiation protection during non-destructive testing

Especially in Third World countries, but also, for example, in Germany, radiation protection-relevant incidents repeatedly occur during non-destructive tests with radioactive sources. The working panel has elaborated a VGB standard on this subject that was adopted in March 2015.
Committee «Decommissioning and Disposal»

During the reporting period the Technical Committee «Decommissioning and Disposal» held two meetings, exchanging experience and discussing different recommendations of the ESK (Disposal Commission; Entsorgungskommission) and their impacts and implementation.

On behalf of the committee, working groups elaborated a «Periodic safety check guideline for interim storage sites with negligible heat development» and a «Guide to the performance of periodic safety checks and technical ageing management for interim storage sites for heat-generating waste».

These are now being successfully applied and enable the power plants to follow standardised procedures.

Other tasks and topics dealt with by the committee were:
- inputs to the topics «supply and disposal» for the general committee and the TC «Nuclear Power» (FA «Kernenergie»),
- observation of the further development of «partitioning and transmutation» and
- observation of the work of the EU technology platform on final storage.

Annual calculation of the average nuclear fuel cycle costs was discontinued by decision of the general committee.

Working Panel «Management Systems»
Georg Schäfer
A focus of the «Management Systems» panel’s work was the adaptation of the management systems of nuclear power plants to the requirements of post-operation along with the evolution of the safety culture (including VGB-SBS (Safety culture assessment system) assessments).

Cross-plant system- and product-related quality assurance continued to be the most important task. This includes the assessment of contractors according to KTA standard 1401, training in special nuclear knowledge for contractors (and operators), and nuclear procurement in the field of mechanical engineering. Last year’s report contains a detailed description.

Working Panel «Event Analyses»
Guido Vallana

The Working Panel «Event Analyses» discussed all relevant event reports from nuclear power plants throughout the world (obtained through WANO and others) and assessed their transferability. The most interesting reports from a technical viewpoint were subjected to an in-depth analysis by AREVA in the framework of the VGB event report evaluation agreement. This analysis enabled the VGB nuclear power plants to learn and benefit, tailored to their requirements.

In addition, the panel worked out a statement on the practical application of national and international event assessment criteria (e.g. INES).

The reader is referred to last year’s report for information about holistic event analyses, specific issues for nuclear safety commissioners (Kerntechnische Sicherheitsbeauftragte), safety culture assessments and their performance as well as human factor-related topics.

Technical Committee «Decommissioning and Disposal»
Katrin van Bevern

During the reporting period the Technical Committee «Decommissioning and Disposal» held two meetings, exchanging experience and discussing different recommendations of the ESK (Disposal Commission; Entsorgungskommission) and their impacts and implementation.

In addition, the panel develops and supports methods used to simplify the monitoring of nuclear materials. For example, with the technology of the new Digital Cerenkov Viewing Device (DCVD), time flexibility and economy can be achieved without public participation. The first decommissioning licences are expected to be issued before the end of 2016.

The panel conferred on various guidelines and rules from, inter alia, the field of industrial safety and health (e.g. IAEA Safety Requirement DS452 «Decommissioning of Nuclear Installations» and DS 478 «Safety of Nuclear Fuel Cycle Facilities»), and on the «Guidelines for the decommissioning of nuclear plants» from the Nuclear Waste Management Commission (ESK). A further guide probably will be published in 2016 by BMUB, the Federal Ministry for the Environment.

The operators expect the Federal Ministry for the Environment to publish a further «Guideline for decommissioning and dismantling of plants or components (safe confinement)» according to Section 7 of the Atomic Energy Act before the end of 2016.

Working Panel «Interim Storage»
André Seidel

The Working Panel «Interim Storage» dealt with generic issues relating to the loading, transport and storage of spent fuel in casks and the interim storage of spent fuel. In addition, the panel ensured the exchange of experience required by the interim storage guideline of the Nuclear Waste Management Commission and by the plant licensees.

Among other things, the guideline requires periodic safety checks for interim storage facilities. To this end a working group of the panel prepared a guide that also covers technical ageing management for irradiated fuel assemblies and heat-generating radioactive waste.

Working Panel «Safeguards»
Katrin van Bevern

As part of the exchange of experience on current inspection practices, the Working Panel «Safeguards» keeps track especially of events in connection with the ongoing monitoring activities of EURATOM and IAEA and, where permissible and meaningful, plays an active role in the pertinent committees.

In addition, the panel develops and supports methods used to simplify the monitoring of nuclear materials. For example, with the technology of the new Digital Cerenkov Viewing Device (DCVD), time flexibility and economy can be achieved by facilitating or eliminating the time-consuming coordination between EURATOM and operators during the sealing of dry storage casks by the operators themselves, especially where lengthier loading processes are involved that depend on obtaining a specified residual moisture content.
Competence Area
Power Plant Technologies

Power Plant Technologies
Oliver Then

In the course of restructuring at the VGB Head Office, the organisational units comprising the previous competence centres were dissolved and replaced by a departmental structure incorporating the fields of work of the former competence centres. For the purposes of external communications, however, the previous topics are kept in place in the form of competence areas.

Cooperation with and contributions to BDEW and EURELECTRIC remained intensive in the year under review, as a large number of directives, laws and regulations were revised or newly created on both the European and the national levels, one example being the German Electricity Market Act. On the European level, joint work on the various Network Codes has continued. The Network Code RG is still in the legislative process, which is not expected to end before the first quarter of 2017. We have continued providing support in further processes, such as BREF-LCP, BREF for waste incineration and BREF for industrial cooling systems. Details of all these topics and the corresponding documents can be found on the VGB website.

In August 2015, VGB received the appointment from the Federal Ministry of Economic Affairs and Energy to coordinate Working Group 3, Conventional Plants, Modernisation of Power Stations and Lignite Extraction within the Turkish-German Energy Forum. The German members conducted a Working Group meeting in March 2016, and the Working Group presented its work at ICCI 2016 (International Energy & Environment Fair and Conference) in Istanbul. Together with interested companies, VGB presented solutions and discussion partners on relevant issues at its trade fair booth, and organised the session on «Turkish-German energy cooperation: challenges and opportunities» on the opening day of the ICCI Conference (Figure 1 and 2).

In the context of the Indo-German Energy Forum (IGEF), at a meeting of Working Group 1, Conventional Plants, in New Delhi in May 2015, which was attended by high-ranking representatives of the ministries of both countries, new project ideas were developed on the subjects of flexibilisation and emission reduction, and funding commitments were obtained from the German side. The activities to be coordinated by VGB include the compilation of studies and the performance of workshops and study trips.

The increased interlinking of activities in the committees and more intensive interdisciplinary cooperation between the competence areas of Renewables and Power Plant Technologies were continued. The most recent example is the organisation of an oil workshop for wind turbines, similar to the ones which have been successfully conducted for steam and gas turbines for many years.

Technical Committee «Conventional Plants»
Werner Hartwig

With the massive expansion of energy generation from renewable sources, the energy transition in Germany is having a dramatic effect on the conventional plants. The new, major challenges facing existing power plants include not only a smaller number of full load operating hours, but also frequent startups and shutdowns, and steep load ramps. These are associated with increased lifetime consumption of components. As the revenues obtainable on the market are at the same time dropping rapidly, the budgets for operation and maintenance are becoming squeezed more and more tightly. The continued existence of many power plants is therefore under threat.

Different situations obtain among the power plants which supply district heating or process heat in addition to electricity, depending on the specific local conditions. It is to be expected that the new combined heat and power legislation will only affect combined cycle and unittype CHP plants in future.
Further relevant changes for power plants in Germany will result from the new Electricity Market Act, which is due to come into force in 2016.

Operators of the new build plants with boiler materials T24 and HR3C have, after intensive discussions and thanks to the VGB ad-hoc working group, developed plans to address the outstanding material issues and remediation of damage. Most of the operators have modified their plants accordingly in the meantime.

Technical Group «Steam Generators»
Werner Hartwig

General
The plant operators have implemented plant optimisation measures, co-combustion of fuels of all kinds, and resource savings. The companies are continuing to explore all options permitting continued operation of their plants. Nevertheless, the utilisation of plant capacity has not improved, and in some cases exceptional conditions have been reached. Electricity prices have dropped further, with the result that none of the earnings which are urgently required remain. As a result, some power plants are being closed. Only a few individual power plants are still reaching a notable number of operating hours or have been employed for certain periods by the Federal Network Agency. Whether operating hours in that context will pay remains to be seen.

In an exchange of experience, all the current issues in the existing and new build projects were discussed. Quality problems occupied a large proportion of the further discussions, both for the new build projects and for replacement and upgrading measures. A major part of the problems cannot be generalised, as they mostly concern details which have considerable effects on the operation of the power plants. Special attention was paid in the discussions to pickling and heat treatment of the new materials (Super 304 H and HR3C). In that connection, individual problems in the various areas of application of the boiler systems, some of which were serious, were dealt with.

The subject of the circulating pumps in once-through boilers and the reworking of the connection flanges is still receiving attention from the manufacturers and some of the operators. The Working Group on boiler circulating pumps has in the meantime published the results of its research. These results and the latest findings in process engineering have been collated and applied by the manufacturers. The flanges currently being supplied reflect the latest findings. More detailed knowledge will only be available following installation and operating experience, which has to date been primarily gained at the Staudinger power plant.

Standards
A number of standards are currently being drafted or revised:

- Revision of Standard R 116 «Preservation of Power Plant Systems». The standard is complete and at the production stage. For the first time, there is now a comprehensive work which deals not only with the boiler, but also with the fuel and flue gas systems.

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

Technical Group «Fuel Technology/Firing Systems»
Christian Stolzenberger

The «Fuel Technology and Firing Systems 2016» conference took place in Kassel on 15/16 June 2016. There were twelve presentations on the subjects of fuel quality, flexible combustion systems, measures
to reduce slagging and corrosion, operating experience and the latest combustion technologies (plasma burners). Around 60 people attended the event, which traditionally takes place every two years.

The revision of VGB Standard VGB-S-210, «Characterisation of Power Plant Coal» is complete and has been published. It is the second edition of this important standard, following the first after an interval of twelve years (Figure 3).

VGB Information Sheet VGB-M 206, «Coal Bunkers» withdraws the recommendation for pneumatic pressure surge equipment to be used to remove arcs in silos, as falling coal could, for instance, damage the hopper.

A project group was formed on the topic of «Preservation of fuel, air and flue gas channels», in order to add to VGB Standard VGB-S-116, «Preservation of Power Plant Systems». The standard is to be published in the summer of 2016, and a workshop on preservation is to take place in Hanover in the autumn with the involvement of this Technical Group (Figure 4).

The Chairman of the Technical Group will also take part in the revision of manufacturing standards DIN EN 12952-8, «Requirements for firing systems for liquid and gaseous fuels for the boiler» and DIN EN 12952-9, «Requirements for firing systems for pulverised solid fuels for the boiler».

The Technical Group has agreed on measures in the case of an emergency stop of mill systems. Inertisation is to be performed immediately, hot parts removed from the fuel as soon as possible, and the success of oxygen displacement is to be checked. If stopped for a long period, the mill is to be cleared.

In slag tap boilers, the proportion of volatile matter in hard coal is being increased from the previous 26 to 27% to 36%, in order to use the volatile coal which is increasingly available on the market and provide an alternative to German hard coal, mining of which is to end in 2018.

The focal topic of flame monitors has been brought to a conclusion with the following result: The overwhelming majority of power plants are equipped with flame monitors. New plants are equipped with 4 flame monitors per level. In the course of flexibilisation of the plants, e.g. with single mill operation, existing plants are being retrofitted.

Cleaning of the flame monitors is a recurrent issue. Cleaning is performed either at regular intervals or as required. The involvement of the inspectorate TÜV and the manufacturer in furnace monitoring ensures that the improvement of flame monitoring will be optimally implemented.

A continuation of Project Group 3V (Slagging) was not considered necessary, as slagging is not currently a problem and the issue has been mastered. There is no obstacle to any exchange of experience on specific cleaning methods, e.g. explosive cleaning, whenever members consider it necessary.

Technical Group «Fluidised Bed Firing Systems»

Christian Stolzenberger

The Technical Group Fluidised Bed Firing Systems has decided to conduct a conference together with the colleagues from Thermal Waste Utilisation at the turbine house of the Moabit power plant in Berlin on 15/16 November 2016. The programme fundamentally covers two groups of topics: on the one hand, technologies and strategies for emission reduction, taking account of the expected new emission limits, and on the other hand operational issues such as the industrial health and safety regulations, plant and operating mode optimisation, flexibilisation and maintenance.

There is regular reporting on inspections, damage and repairs to refractory material in fluidised bed systems. It has become apparent, however, that the scope of inspections increases with the increasing age of a system.

Some plants have now reached an age at which the I&C systems will have to be replaced in the coming years. The main reasons are either the lack of software updates or discontinuation of spare parts for the I&C systems. In the latter case, difficulty in implementation of the macros is expected in some plants.

Since 1 June 2015, coal has not only been classified as a dangerous material, but also as a hazardous substance under the terms of the European CLP Regulation (H252 – Self-heating in large quantities; may catch fire). The indication that a material is a hazardous substance is a positive result in UN test N.4. German hard coal and raw lignite are not hazardous substances. The technical measures implemented to date for identification and avoidance of hot spots and fires in coal stores, conveyor systems, silos, bunkers, mills and pulverised coal lines have been developed over decades in 5 VGB-Standards, and describe the present state of the art. With the support of specialist personnel such as medical officers or health and safety at work specialists, the employer is to compile hazard assessments and works instructions, observing the Safety Data Sheet for coal and the PSA, TRBS and TRGS regulations.

In the coming years, plants which have to date used domestic hard coal will have to switch to imported coal, as subsidies for hard coal mining in Germany will cease in 2018 and therefore mining will be uncompetitive and will stop.

Together with ceramic coatings and HVCC and HVOF coatings as protection from wear, tests are being conducted with alternatives such as Ni-based materials, FeCrAl and spray coatings. The results are still outstanding.

Preservation of plant components is becoming more and more of an issue for fluidised bed firing systems, as inspection periods and downtimes are already increasing. A special focus is being placed on the effects and avoidance of sulphurous acids created by sulphur and moisture in the masonry.

Technical Group «Thermal Waste Utilisation»

Andreas Wecker

The process leading to the BREF Waste Incineration is currently in the phase of data collection and evaluation. At present, delivery of carbon fibre composites is causing problems at various plants. They are liberated during incineration and deposited in the electrostatic precipitator and scrubber. Most plants will not accept this material now, as the fibres
can escape when the residues are dried and cause health and safety problems. The Federal Office of the Environment is expected to conduct a research project to clarify which materials are involved and how they can best be disposed of.

The Working Panel is supporting the research project «Ammonia Masking», in which the possible reemission of ammonia from ammonium salts is to be studied. Extensive measurements are being taken at 6 selected plants of different configurations for that purpose. The first measurements have already been evaluated, with the balance deviating slightly from the actual measured values. It was found that the measured NH₃ content is strongly influenced by the sampling system (type of filter, dust, temperature and dwell time).

VGB Instruction Sheet VGB-M 205, «Measures for the Avoidance of Wear on Heating Surfaces in Waste-Fired Boilers» is currently being revised and restructured.

The Technical Group is preparing a joint conference together with the TG on Fluidised Bed Firing Systems.

Technical Group «Industrial and Cogeneration Stations»

Werner Hartwig

The TG Industrial and Cogeneration Stations is the largest at VGB in terms of membership. Nevertheless, only around 20 to 25 members normally attend the meetings. In many cases, this is dependent on the previously announced selection of topics and the various events in the industrial plants. As a result of the large number of plant types and the variety of technical topics, the members of the working panel are largely occupied with the exchange of experience.

As a result of the favourable economic position and the fact that most of the members have optimised and are operating back-up plants, new plants are necessary for growth.

At present, the petrochemical, paper and automobile industries and municipal utilities are in the process of constructing new plants. One focal area is the fact that contaminants and residues are also to be incinerated in the plants which are to be built. In the petrochemical industry, old plants are being modernised in order to preserve the existing approvals. VGB for its part is consulting with the companies, and in some cases with the relevant engineering firms, in various disciplines. The calls for amendments to the cogeneration and renewables legislation are becoming louder.

Standards

- Compilation of a new standard on grate firing systems. VGB has completed a first draft, which has been discussed at Head Office. It has been decided in the Technical Committee Steam Generators that a corresponding standard should be produced for biomass plants only. We are at present looking for participants to work on the standard, especially from the sponsoring members.

- Compilation of a new standard on finned tubes. A first VGB draft has been produced and has been reviewed by a sponsoring member. We are looking for members interested in this standard to work on its further progress. Universities and one operator have indicated that they are prepared to collaborate.

NOVALIS II research project

Following the presentation of the NOVALIS I final report (Measurement of vibrations on boilers by an optical-acoustic measuring system), a further one-day workshop was conducted at Salzgitter Flachstahl AG in January 2015. The purpose of the workshop was a critical examination of the measuring methods and the results obtained. Both members and flow experts from the member companies were invited.

As what had been achieved is not sufficient for future problems of the members, and a standard on knowledge-based preliminary work was requested, a further research project would make sense. DBI has compiled a proposal, which was evaluated by the three TGs Industrial and Cogeneration Stations (project leader), Steam Generators, and Fuel Technology/Firing Systems. It was then submitted to the TC Conventional Plants for approval. As the steelworks are at present unable to provide any funds, there will initially be no support from VGB. Should the situation change for the better, the sponsorship is to be recommenced.

Technical Group «Flue Gas Cleaning Systems»

Andreas Wecker

The Technical Group «Flue Gas Cleaning Systems» deals with the technical aspects of flue gas cleaning systems, fundamentally comprising denitrification, particle removal and desulphurisation systems.

The working panel is at present mainly dealing with potential mercury reduction methods, exploiting the co-benefit effect by optimising existing flue gas treatment systems, and is examining innovations in this field. A system trial has also been conducted with the purpose of increasing the chloride concentration in the scrubber. In that context, a reduction of mercury emissions in the treated gas was achieved.

In the new systems, an increased incidence of foam formation in the scrubber was observed, but its cause has not yet been clarified. An increased about of anti-foaming agents has been used to combat this. The Technical Group is compiling a list detailing experience with the various anti-foaming agents.

Technical Committee «Mechanical & Civil Engineering»

Peter Richter

The TC «Mechanical & Civil Engineering» with its five Technical Groups deals with the issues of the day during a regular exchange of experience. Due to the variety of the requirements this involves, the TC works together with other TCs. These are mainly the TC «Materials and Quality Assurance», the TC «Electrical Engineering, I&C, and IT», and the TG «Steam Generators».

One important topic within the TC is reporting on defects of quality. Contracts are breached again and again in that tests and inspections agreed in the Inspection and Test Plan (ITP) are consciously announced with too little notice, with the result that attendance at the test is not possible or castings (rotors) have already been pre-machined and no further US testing can take place.
Installation of pressurised and unpressurised coal-fired plants to biomass and the existing plants and ranged around conver- 

cibilisation were conducted on the basis of review, discussions on the topic of flexi-

tional power plants. In the period under deal with innovative generation con -

The TG «Power Plant Concepts» continues to -

In addition, information is provided on past and future conferences and work-

The various Technical Groups have pro-

- VGB-S-504-DE published. 
  Testing of large forgings and castings for steam and gas turbine generators 
- VGB-S-115-DE published. 
  Recommendations for the inspection of steam turbines 
- VGB-S-145-DE published. 
  Guide to procurement of steam turbine systems 

In planning: 
- Formation of a PG for compilation of a standard on the subject of «Maintenance of Gearboxes» 

Technical Group «Power Plant Concepts» 
Oliver Then 

The TG «Power Plant Concepts» continues to deal with innovative generation con-

ised thermal storage facilities in coal-fired and combined cycle plants, among other issues. One interesting aspect is the reduc-

tion of the condensation power share of heat-led cogeneration plants. A further op-

portunity for the more efficient provision of heat is the concept of flue gas condensa-

ion which is being successfully implement-

ed in some CHP plants in Sweden. 

The flexibilisation measures on steam tur-

bines for combined cycle plants include shortening start-up times by starting with 

the medium pressure section of the steam turbine, and reducing lifetime consumption 

on hot starting by keeping the machine on hot standby. Future developments will 

focus on the efficiency and final moisture at low partial loads, extending the operation 

of turning gear and further improving the steam parameters to increase efficiency. 

One interesting question in that connec-


With regard to innovative generation con-

tcepts, two different projects on combined oxygen and hydrogen combustion and the corresponding research facilities at the Technical University of Berlin were for ex-

ample presented and compared. Together with regenerative hydrogen production, interesting power to gas concepts result. 

As a consequence of the increasing feed-in of electricity from renewable and volatile generation and the resulting market situ-

ation, which is characterised by dramatical-

ly lower electricity prices on the exchange and lower utilization of capacity at the conventional power plants, the number of new build projects being implemented is also significantly reduced. While indi-

vidual new combined cycle plants are be-

ing constructed in Germany and western Europe, mostly in connection with cogen-

eration and/or industrial production, there are only significant new coal-fired projects in Poland and the Czech Republic. 

The «Partner Steam Power Plant» project was presented in detail in the previous year’s report, and was brought to an of-

ficial conclusion in spring 2016 with the publication of the final report and a final workshop in Berlin attended by Manfred Remmel, Minister of the Environment and Climate Protection of North Rhine-Westphal-

ia. The successor project, «FLEXI-TES» fol-


Current topics are discussed 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 and oil pumps, etc., to be lent out from operator to operator in order to avoid long downtimes while waiting for deliveries. 

The problems occurring on USC steam tur-

bines were an important topic within the TG. A joint meeting between operators and the manufacturer was organised in that connection. The aim of the talks was to establish a common level of information between the operators of the USC steam turbines concerned and the manufacturer on the various technical problems occurring at the different locations, and the methods of solving them. These included, for example, a complete identification of the issues, clarification of misunderstandings, establishing consensus on root cause analysis (RCA) and the existing or potential approaches to solutions, and stipula-


tion of the next steps to be taken by the participants. Detail engineering with re-

gard to the RCA and the approaches to solutions was expressly excluded from the planning, as was discussion of aspects specific to individual projects. The various project managers and persons responsible for engineering matters were responsible for those in bilateral conversations. A con-


Further activities: 
- Revision of the VDMA/VGB Infor-

- Applicability of the Pressure Equipment Directive in relation to steam turbines and their main components. 
- Standard currently being revised: 
  - VGB-R 503, «Guideline for the Internal Pipework of Turbo-Generator Sets»
Technical Group «Gas Turbines»
Peter Richter and Manfred Freimark

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

The six-monthly exchange of experience is based on structured status reports on all of the gas turbines operated by the members of the VGB TG Gas Turbines, which can be downloaded in advance of the meetings as advance information.

As a result of changing market requirements, manufacturers have, in close cooperation with operators, achieved significant results in the extension of the usable capacity range of existing combined cycle and cogeneration plants by measures such as staggered burner shut-down and reduction of compressor mass flow while maintaining NOx and CO-ELV levels. In combined cycle and cogeneration plants with gas turbines of the 200 and 300 MW capacity class, minimum output of the gas turbine at around 25 % and of the 2+1 plant system of approx. 15 % have been achieved.

As a consequence of increased start-ups and increased power gradients of CCGT systems (combined cycle and cogeneration) with significantly reduced operating hours, increased premature damage to components – especially in the hot gas path of the gas turbine – has been noted and found to be attributable to growing non-steady components of thermomechanical stress. The new findings, increasingly gained in relatively volatile operating modes, has caused a number of OEMs to implement upgrading strategies on heavy duty gas turbines by inserting inexpensive parts subject to wear in expensive components such as annular combustion chambers. Necessary improvements in the service life of components in the hot gas path with the problem of detachment of thermal barrier coatings have been achieved by operators rapidly and cost-effectively with innovative refurbishment strategies from non-OEMs.

Three-stage air filtering with filter stages of the HEPA class, implemented in many cases in the course of LTE measures, have effected a significant reduction in contamination of the compressor and the cooling activities in the hot gas path, which have resulted in some cases in dispensing with the compressor online scrubber.

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

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

Discussion of the final report on the BVT (BAT) conclusions with regard to emissions in industrial scale furnaces, which belongs to the EU-IED BREF project, with the responsible department of BDEW. Presentation of rational arguments from the VGB TG Gas Turbines for BDEW and LAI, which are to be taken into account in the impending revision of the 13th Ordinance to the German Pollution Control Act with more stringent NOx and CO-ELV regulations for OCGTs and CCGTs in existing and new plants.

VGB-Standards

- VGB-S-121 «Supervision, Limiting and Protection Devices on Gas Turbine Systems»
- Addition of the topic «gas turbines» to VGB-S-036; «Preservation of Steam Turbine-Generator Sets»

Fig. 6: Steam turbines: corrosion at a steam turbine after downtime of about half a year. Left: overview, right: in detail.

Fig. 7: Damages at gas turbines: FOD-damage at an industrial gas turbine of 25-MW-class.

Fig. 8: Damages at gas turbines: Overheating indications at the blade of a 75-MW-class heavy duty gas turbine

Fig. 9: Damages at gas turbines: Tribological damage at the combustion chamber mounting.
Technical Group «Cooling Systems»

Wolfgang Czolkoss

The function of the TG «Cooling Systems» in Power Plants is to pursue opportunities for increasing efficiency and optimizing operation of cooling systems, taking account of the changes to operation brought about by approval procedures and background conditions, and the types of cooling tower to be used in the future. In that context, the investigation and assessment of microbiological risks in the operation of cooling towers in power plants plays an important role.

The Project Group «Microbiology in Cooling Systems», comprising members from TG Cooling Systems in Power Plants and TG Chemical Process Engineering, has dealt intensively with the problem of legionella. VDI standard 2047 Part 2, «Ensuring the hygienic operation of evaporation cooling systems» deals with cooling systems with a thermal capacity of up to 200 MW. Natural draught cooling towers with a thermal capacity over 200 MW were excluded on the basis of objections by VGB, as the structure of the large power plant cooling systems and the risk of infection they pose differ significantly from those of the small cooling systems in building and air conditioning units. The large cooling towers with thermal capacities > 200 MW will now be dealt with in standard VDI/VGB 2047 Part 3, which is being compiled jointly with VGB. Publication of the draft is expected in autumn 2016.

Together with BDEW, detailed comments were produced on the ministerial draft of the 42nd Ordinance to the German Pollution Control Act on «Evaporation Cooling Systems», published in January 2016. In prior discussions on the state (Jülich) and federal levels, it had already been ensured that the draft provided for action levels for legionella concentration in the cooling water which were higher by a factor of 5 for natural draught cooling towers > 200 MW. The final Ordinance is expected to come into force at the end of 2016.

In summer 2016, further measurements in cooling tower plumes are to be taken and laboratory examinations performed in the course of a VGB research project. These are intended to facilitate study of the actual legionella emissions from power plant cooling towers and development of strategies to improve the hygienically safe operation of evaporation cooling systems where possible without the use of biocides.

One essential point in the six-monthly meetings of the TG is the exchange of experience among the participants, in which reporting included methods of cleaning cooling tower internals and pipework, the use of biocides, and damage in cooling towers.

Technical Group «Civil Concepts/Specific Civil Solutions»

Technical Group «Civil Structural Maintenance/Condition Monitoring»

Thomas Eck

In the field of civil engineering at VGB with its two Technical Groups (TGs) «Civil Concepts/Specific Civil Solutions» and «Civil Structural Maintenance/Condition Monitoring» and at present seven Project Groups, the exchange of experience on current topics has been pursued in the period under review and work continued primarily on the drafting and editing of VGB-Standards.

The focus of the work is increasingly shifting from new construction, retrofitting and modernisation of power plants and systems for power plants to the areas of dismantling, maintenance and lifetime management, especially in the light of changes in remaining service life and generally increasing economic pressure. The subjects not only concern thermal power plants, but also and increasingly generation facilities based on renewable energy sources.

In the course of the exchange of experience between the participants at the meetings, discussions have been conducted, for example, on the subject of the security reserve in the area of lignite-fired power plants and the resulting requirements for structural maintenance. Further key topics in this area with which the groups are to deal more intensively in future include preservation, closure, dismantling or partial dismantling and, for example, the maintenance of public safety at power plant facilities, including the duty in that respect which persists after closure.

As a further topic in the exchange of information, discussions were conducted on digitisation in the area of design and construction, and in particular the operation of building structures, in the context of Building Information Modelling (BIM). Fundamental changes in this field are expected in the coming years.

The present seven Project Groups in the civil engineering section of VGB are working on the revision of existing VGB-Standards and VGB Information Sheets, and on the compilation of new VGB-Standards which will then be in line with revised laws and new European standardisation and are designed for European and international application. VGB-Standards VGB-S 609, «Application, design and quality assurance criteria for the use of fibre-reinforced plastics in power plant construction», VGB-S 602, «Indication and application of actions on buildings in power plants», and VGB-S 641 and VGB-S 642 on industrial stacks in power plants, from principles of design through overall construction to lifetime management, will be published in mid/end 2016.

In addition, there are also VGB Standards in preparation on the topics of «Construction techniques for cooling towers», «Lifetime management for footings, foundations and towers of onshore wind turbines» and a thoroughly new VGB Standard on the subject of «Lifetime management of structures in power plants». Two articles on the subject of «BIM» and the new generation of VGB standards in the construction field are to be published in the August 2016 issue of VGB PowerTech magazine.
Technical Committee «Electrical Engineering and I&C»

Jörg Kaiser

The TC «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 are processed and work on standards for the field of electrical engineering and I&C is performed. There is a regular exchange of experience on the above topics and issues.

KEU 2016 (Conference on Electrical Engineering, I&C and IT)

Every two years, VGB PowerTech organizes a Technical Conference on Electrical Engineering, I&C and IT. Operators and planners of all types of generation plants, such as conventional, nuclear and hydro power plants, and renewables-based, distributed and industrial generation facilities are addressed. Current questions and solutions are presented in lectures and discussed with international experts from operators, manufacturers, insurers, authorities and universities.

KEU 2016 took place in Cologne from 10/11 to 12. May 2016. Around 300 participants used the platform to discuss the technical challenges caused by the current European energy policy. The main topics were as follows:The integration of power generation from renewables in the grid (system stability, system services, dispatching, market models and grid reconstruction)
- The changed requirements and functions of electrical engineering, I&C and IT systems for all types of generation

A good tradition has already been established in the form of student support at KEU, which once again took place with a special programme of lectures and discussions. In that connection, travel and accommodation for the students are subsidised.

Research projects

Two research projects with supporting documentation were completed in the period under review.

The research project «Wear investigation model for primary and secondary control in thermal power plants in the ENTSO-E grid» was performed in cooperation with the University of Rostock, analysing the influence of feed-in from wind and photovoltaic generation on additional component ageing in the water-steam circuit when control power is supplied.

The research project on «Generator wear from reactive power supply» was performed jointly with the Ruhr Hochschule West and the Sensoplan company. Its aim was to supply reliable qualitative findings on how generators, their auxiliary systems and the further components of the generator bus are subject to greater wear when additional reactive power is supplied, in comparison with normal loads.

As a result of both projects it was demonstrated that changes in service conditions lead to increased wear. Assessments relative to individual plants can be deduced from the generic findings.

VGB is participating in the «System Services 2030» project organised by the German Energy Agency (Dena) (Figure 11). The aim of the study is to analyse the technical, political and economic background conditions and limits of a rising proportion of energy from renewable sources to the supply of system services for the period from 2030 onwards. The development of demand for system services products and the future role of conventional power plants are under consideration. This includes primary, secondary and tertiary control power, 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. The study is to be completed in 2017.

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

The question arises of the effects of new technologies in the transmission system on the power plant components, for instance with the increasing use of frequency converters. There is a need for firm answers to the question of whether the feed-in stations from the HVDC links of offshore wind farms or the planned head-end stations of the HVDC transmission networks have an impact on the turbine generator sets at power plants in the vicinity. The topic was addressed in a multi-party approach at a conference entitled «Power electronics in the transmission system» with transmission system operators, operators of power plants, universities and manufacturers. The hazards presented by sub-synchronous resonance are real and, in the view of VGB, require communication with the TSOs on the power plant – grid interface, monitoring of the grid activities and coordination of the interests of the VGB members. VGB has offered to coordinate the necessary work together with the transmission system operators.

Technical Group «Electrical Equipment»

Jörg Kaiser

Work has been performed in the Technical Group «Electrical Equipment» on various VGB Standards in electrical engineering. With the application of those standards, the electrical systems in power plants are optimally designed and rated, procured, installed with quality assurance and maintained. The topic of quality in the manufacture and maintenance of electrical components continues to be of central importance.

Generators

The PG Generators manages a damage database and conducts technical discussions with the manufacturers in order to evaluate current events and identify optimum solutions for further improvements in the operation and long-term stability of the generators. The database was systematically evaluated most recently in a presentation at KEU 2016 (Figure 12). It was shown that even relatively new gen-
and quality requirements for manufacturing and testing are available. A VGB recommendation for maintenance measures is in preparation.

The Working Group Electrical Engineering of the Association for Industrial Construction (AGI) is to revise the AGI Data Sheet «Fire Protection on Transformer Systems» (J21-1 of June 1997). The PG Transformers has nominated representatives to assist in the revision, coordinate interim results with the PG Transformers and safeguard the interests of the operating companies.

### Technical Group «Control and Instrumentation»

Jörg Kaiser

### VGB-Standards

The new VGB Standard VGB-S-171-43, «Measurement Technology» has been published. Starting with the former VGB Guideline VGB-R 123 C1.9, proven and recommended measuring systems which reflect the experience and recommendations from operational practice have been described. All the relevant measured variables in conventional and renewables-based plant for power and heat generation were considered.

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 the PG. The objective is to bring the work in line with the current technical and economic challenges without neglecting the requirements for cost-effective operation and maintenance including troubleshooting.

The revision of the subject matter is planned to be complete in autumn 2016.

### IT Security for the I&C System

The IT Security Act (IT-SiG) in Germany and the associated Ordinance for definition of critical infrastructures have already been passed, and the Security Catalogue for Energy Conversion Plants is to follow by autumn 2016. In the form of the standard VGB-S-175 on IT security, VGB created a basis on which I&C systems were already specified in terms of IT security and operated accordingly in the past. Regular reports on its application are presented at the meetings.

The Technical Group on I&C Systems 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.

### Technical Group «Acceptance and Control Tests»

Wolfgang Czolkoss

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

A Project Group has issued the new standard VGB-S-012, «Process Quality in Power Engineering».

The «Pulverised Coal Measurement» has compiled a specification for a non-proprietary measuring process with online capability based on experience with measurement in practice and the changed application conditions. This specification is to be set out in a new VGB Standard.

Standards VGB-S-130 and VGB-S-131 on acceptance and control tests on water and air cooled turbine condensers are in the final stage of drafting. For water cooled turbine condensers, the calculation model of a single tube condenser has been developed and validated. For ease of use, input and output of the data now take place via a standard spreadsheet.

Flow measurement is of special importance for the efficient operation of power plants. Laser-optical measuring methods and their practical applications have been discussed with PTB in Berlin. The results to date have been published on the VGB homepage, discussions are to continue, and test measurements are to be organised if possible.

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. Analog and field bus systems are increasingly being replaced or supplemented by wireless systems with WirelessHART technology. The further developments and experience of the users are being monitored.
A number of members of the Technical Group and its PGs are actively involved in standardisation committees for acceptance measurements (VDI 2048, ISO 1888, IEC 60953, VDI 3921) and thus ensure a good exchange of information during the processing of these standards.

**Technical Group „Interface Power Plant – Grid“**

Jörg Kaiser

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

- **PG Network Codes**
- **PG German Regulation**

The Project Groups ensure that there is a coordinated procedure among the operators of generation facilities.

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

**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 the 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 standards by the generation companies on the draft Network Codes 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 2 years. It is apparent that an intensive European exchange of experience will also be necessary in the TG Interface Power Plant – Grid during and after the legislative process and the implementation in national law. At the Agency for Coopera tion of Energy Regulators (ACER), a Stakeholder Committee has been established to provide support and coordination in the implementation of the RfG, and VGB as an independent stakeholder has 2 seats on that committee.

Further Network Codes are in the resolution phase and require continuous monitoring and involvement by the responsible PG Network Codes.

**German Regulation**

The TG «Interface Power Plant – Grid» is, through its PG German Regulation, also responsible for coordinated reactions to German requirements resulting from laws and regulations, for instance the consultation and stipulation proceedings of the Federal Network Agency, 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 Green Paper, on the draft of the Electricity Market Act and on the Capacity Reserve Ordinance. This is done in cooperation with BDEW, and there is also active input into statements issued by BDEW.

**Technical Group „Maintenance Management“**

Heinrich Grimmelt

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

**Prequalification of service firms**

The in-house personnel at power plants can only perform the core functions such as operation and maintenance of the plant. Their capacity is oriented towards normal operation with regular maintenance work. However, as soon as inspections and overhauls, repairs or projects turn that normally operating plant into a construction site, the deployment of contractors is unavoidable. This also applies to special work which is only occasionally required and for which the necessary know-how is therefore not available in-house.

As with the procurement of components, just so is special attention to be paid to quality in the procurement of services. The times when contractors were appointed without competition and satisfactory quality was delivered have been replaced by pressure on costs and price-driven contract awards.
In the period under review, the members of the Technical Group met for their 51st meeting in Prague. There, the discussions covered topics such as the implementation of the new IED emissions standards in the Czech Republic, the maintenance of plants which are now only run for a few operating hours, and teething troubles with new plants. A planned second meeting in Brussels was replaced by a video conference as a result of the terrorist attack. In that conference, new challenges for combined heat and power generation were discussed. These included falling electricity prices, a decline in sales of thermal energy with simultaneously rising prices, and new emissions standards.

In addition, reports were delivered on the shift plans presented also focused on the requirements to an exceptional degree. The operational, commercial and staff-related requirements of continuous professional education.

The Working Group Operational Practice completed its work on the topic of maintaining knowledge in spring 2016 and prepared a VGB standard on this subject. The group then took up the topic of “Operational Management in Production”. Operational management in production has to ensure smooth operation and a permanently good technical condition of the plant components under the given economic conditions. Monitoring of the plant by process management systems and the operators, and regular servicing and maintenance, are important modules of the power plant process. In order to respond to the economic constraints on conventional power plants in today’s energy market, new forms of structuring are required for the work of the operators and in particular for shift personnel. Account also has to be taken of human factors and appropriate qualifications in the monitoring and control of dynamic processes in a demanding and stressful situation.

For the Technical Group, this individual topic represents an important building block for the higher level subject complex of “Optimisation and Savings Potentials in Operational Management”. The Technical Group and its predecessor, the Working Panel on “Training of Plant Personnel” have also dealt intensively with this topic in previous years and in the period under review. A compilation of the results of that work is available to interested committee members and can be helpful to plant engineers and production managers in particular by providing an overview of approaches to optimisation and savings potentials which have already been made in operational management. The Technical Group will continue the work on this topic.

**Technical Group “Plant Management Systems and Technical IT”**

Jörg Kaiser

The Technical Group Plant Management Systems and Technical IT is pursuing activities to support the integration of human beings, data and information systems,
with the purpose of using information technology as a management tool. The activities are performed with the aim of implementing the added value processing of data into supporting information for all areas from production to management.

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

Further challenges in the period under review included arrangements for KELI 2016 (Conference on Electrical Engineering, I&C and IT) with a separate section on IT security and further contributions.

**IT Security**

The topic of IT security affects all areas of the power plant and its offices, above all when data networks are used. A graduated strategy is implemented, corresponding to the degree of protection required, and is described in VGB Standard VGB-S-175, «IT Security for Generating Plants». This standard is permanently on the agenda and is reviewed to determine whether updates are required.

As the threats to the critical infrastructures, to which the electricity and heat generation facilities also belong, are demonstrably real and increasing, legislation is currently in progress on the European and national levels on IT security.

The Project Group VGB Coordination of the IT Security Act established by the Technical Group actively accompanied the process of drafting the German IT Security Act, the directly associated Ordinance on the Definition of Critical Infrastructures and the IT Security Catalogue. For that purpose, statements were compiled in cooperation with BDEW and talks were held. Within VGB, the required activities are also coordinated with the committees on wind turbines and distributed generation systems to generation of electricity and heat, throughout the lifetime of the systems.

The IT Security Act came into force in July 2015 and the Ordinance was published in early June 2016 (Figure 14).

**Technical Group «Performance Indicators»**

Stefan Prost

The main areas of activity by the Technical Group «Performance Indicators» in the period under review were as follows:

- Revision and publication of guidelines for the definition of parameters in German, English and French
- Establishment of inter-plant statistics for renewables-based power plants
- Further development of the power plant information system KISSY

**VGB-Standards**

The VGB-Standard «Basic Terms of Electricity Generation» (VGB-S-002-01) was revised, and the version of October 2015 is available at the VGB homepage together with all the other standards in the VGB-S-002 series free of charge. Draft translations into English and French have been produced and will also be available in the coming months. The VGB Standard «Wind Power – Definitions and Parameters» (VGB-S-002-05) was compiled together with the members of the Technical Group for wind power, and published in June 2016.

**Power Plant Information System «KISSY»**

KISSY was brought up to the latest state of the art last year. The implementation of the research and development project «Reliability Indicators with KISSY» has been pursued in a pilot with the project groups. The aim is to examine power plant components, for example, for reliability and probability of failure. Further master data have also been incorporated, facilitating the evaluation of additional groups of power plants such as cogeneration plants or single or multiple shaft combined cycle systems, without any additional annual data collection.

**Scientific and technical reports**

The contents of the scientific and technical reports on «Availability» and «Analysis of Non-Availability» of thermal power plants have been revised. In addition, the layout was adjusted to provide for increased information content and improved understanding. New categories related to rated capacity, service life expended, and operating time. New availability diagrams incorporating quartile values such as have long been in use internationally have been incorporated. National power plant groups have been replaced by international ones, but can be recompiled for specific countries online. Information on the situation of the European power generation industry has been integrated in order to make it easier for readers to analyse and interpret the results (Figure 15).

The inter-plant statistics for the period from 2006 to 2015 were compiled in cooperation with 35 national and 23 international VGB members with currently 833 power plant units and a total gross installed capacity of approx. 272 GW.
Wind statistics

The joint Project Group KISSY/Wind Energy consists of international members of the VGB Technical Groups «Performance Indicators» and «Wind Energy». With the compilation of the VGB Standard «Wind Power – Definitions and Parameters» (VGB-S-002-05) the foundation is laid with initially general definitions and indicators for statistical recording and evaluation of operating data relevant to availability. The further development of the standard is also intended to lead to harmonisation of the previously company-specific definition of parameters in the industry.

In KISSY, preparation can now be made at VGB for an inter-plant data collection. Rules for collection, the scope of the data, evaluations and use of the database thus obtained are to be defined. The benefit from this work is on the one hand a measurable exchange of experience between the members, and on the other hand in -

Further focal points of the second meeting of the TG Industrial Safety were as follows:
- Discussion of the draft of TRBS 1111, «Hazard Assessment»
- Classification of boiler circulation pumps to TRBS standards

Details of the ABS meeting were reported at the third meeting of the TG Industrial Safety, followed by reports on the following further committee meetings:
- BDI/BDA Working Group on Industrial Safety
- ABS UA1 and working groups
- ABS UA3 and working groups
- VGB PG Mirroring ABS, VGB-S-104
- Further topics of the meeting were as follows:
  - Status of the reaction to the letter from the German Guild of Scaffolders on the qualification of persons authorised to inspect scaffolding
  - Questions of implementation of the Federal Industrial Safety and Health Ordinance, including decoupled pressure systems, plant demarcation and testing

Technical Group «Reference Designation and Plant Documentation»

Andreas Böser

The professional cooperation between VGB PowerTech e.V. and eCl@sse e.V. is already well advanced. It has been ensured that the results of the joint work will appear in the new eCl@sse Release 10.0. The release will be published in November 2016.

With input from the TG, DIN SPEC 91303 has been published, defining the structure of a CV file. The DIN SPEC is to become part of a DIN standard with a broader range of application, and the application for standardisation has already been accepted. The TG will also be actively involved in this follow-up project, dealing with the technical documentation of plants covered by VGB-S-831 (Figure 16). Actively shaping this development in the interests of the operators is therefore considered extremely important by the TG.
**RDS-PP**

The addition to and updating of the application guideline VGB-S-823-32 is being actively pursued by the Maintenance Team (MT). The team is composed of experts from the wind energy field and the field of identification marking. The results of their work will be published on completion in the form of revision sheets available for free downloading at the VGB website.

The RDS-PP code section (VGB-B 101) has been revised. Publication of the new issue is planned for later in 2016.

**Revision of the KKS Guideline**

Revision of the KKS code section (VGB-B 105) has been completed. The notes on application (VGB-B 106) have been updated and included in the code section. The publication of the new issue is planned for later in 2016.

**Documentation and Technical Plant Data**

The documentation standard VGB-S-831-00 (formerly VGB-B 171) was published in German and English in 2015. The contents have been expanded to meet the requirements of wind turbine operators. In order to make this addition clear, the title of the standard has been changed to Provision of Technical Documentation (Technical Plant Data, Documents) for Energy Supply Units.

The revision of VGB-B 103 (now VGB-S-832-00) (Designation codes for document kind classification code [DCC key]) is now complete. Publication of the new bilingual issue is planned for 2016.

For the first time, the TG Reference Designation and Plant Documentation is planning a conference, «Future-proof designation and documentation of energy supply units», to take place in Essen on 9 November 2015. Seven presentations focusing on documentation are to be delivered.

**Technical Committee «Materials and Quality Assurance»**

Olaf Baumann

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

- Flexibilisation and lifetime concepts
- Developments in materials
- Quality assurance measures in the course of procurement, manufacture and installation of steam boilers, pressure vessels and piping systems
- Evaluation of damage to pressurised components
- Regulations on the procurement and operation of pressure equipment
- Requirements for fabricated supporting structures of offshore wind turbines and corresponding transformer stations

The following research projects were in the focus:

- Boiler circulating pumps I and II
- Follow-up project 12% chromium steels flexPTW
- GKM HWT III
- Kopernikus

Reports were delivered on the meetings of the TG Supervision of Construction and Assembly / Quality Assurance and the TG Pipes and Valves.

The activities of Working Group T24/HR3C were discussed and the latest test results on material HR3C were presented.

In the Working Group Calculation Methods, the topic of flexibilisation was in the foreground. The project is to be started in 2016.

In the Working Group on Boiler Circulation Systems and its three ad-hoc groups on:

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

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

The PG Corrosion Protection on Wind Turbines is dealing with Standard VGB-S-021, «Corrosion Protection of Offshore Wind Turbine Components». Parts 1 to 3 of the VGB/BAW standard have been published on the VGB website.

In the «Renewables» section, discussions have been conducted on:

- the FeLoSeFI (Fatigue Life Load Sequences effects and Failure-probability driven Inspection) research project, and

Fig. 16: VGB-Standard «Provision of Technical Documentation (Technical Plant Data, Documents) for Energy Supply Units» VGB-S-831-00-2015-05-EN.

- standardisation of welded joints on wind turbines.

A report was delivered on damage to hard-facing on turbine valves.

A survey on the future of the AD 2000 set of standards was evaluated. The further updating of the standards was recommended, confirming our active participation in the AD working group.

The next VGB workshop, «Materials and Quality Assurance» is planned for May 2017.

**Technical Group «Supervision of Construction and Assembly/Quality Assurance»**

Christian Stolzenberger

VGB-Standard VGB-S-013, «Construction and installation supervision in the manufacture and assembly of water-tube boilers and associated systems in power plants» was published at the end of 2014 without the consent of FDBR. Talks are currently taking place between members of FDBR and VGB to obtain the consent of FDBR to the standard. The talks started in spring 2016 and both parties describe their course as favourable, so the approval by FDBR is likely. The modified standard will then prospectively be published at the end of 2016.
The latter involves considerable organisational effort and time. A likely candidate is the Phased Array UT method, which however has to be qualified for each testing institute to the VGB-ENIQ directive. Digital x-ray radiography is a further alternative. VGB is preparing a paper leading to inclusion of both methods in DIN EN 12952.

A report was delivered on the current status of the damage investigations and identification of causes on the components in material HR3C.

With regard to the handling of ISO 9606 (international welder testing), the Technical Group recommends ensuring that the welders successfully pass the manual dexterity test can submit a valid welding certificate. A prolongation of the certificate should preclude internal prolongation of the international welder’s test (ISO 9606) by the company.

**Technical Group «Pipes and Valves»**

**Christian Stolzenberger**

The Project Group on revision of VGB-Standard VGB-S-107, «Valves» met several times so as to achieve publication at the end of 2016. For reasons of topicality, intensive work is currently being performed on the section on hard-facing. In shut-off and control valves of turbines and HP bypass stations, cracks had been noted in the seat facings of Stellite 21 on base material P91, which had predominantly been applied without buffering. Some of the cracks ran through the hard-facing and then continued in parallel to the fusion line. The cause of the damage is unclear. Suspected causes include the changed operating regimes or the application of the hard-facing without buffering. The Technical Group is preparing a research project, in which valve and facing material manufacturers are to take part. The results will not however be available in time for publication of the standard, but will be added in a supplement. It is pointed out here that the matter has led to a research project by EPRI in America.

The integration of lifetime monitoring programs in modern I&C systems does not appear to be proceeding as smoothly as desired. In the past, more and more deviations between the calculated lifetime and microstructure examinations on critical components have been noted. It is suspected that only the influence of creep behaviour has been taken into account to date. The new load regime, however, causes fatigue which has most probably not been sufficiently considered. The I&C system manufacturers are called upon to make improvements in this respect.

Corrosion damage has been found on the outside of a straight tube in a boiler drainage line to a flash tank. In the subsequent inspection, a longitudinal crack was found on the inside. Furthermore, there were visible corrosion cavities on the inside at locations where lugs had been welded on from outside. The line has a service life of 200,000 operating hours and is to be repaired.

On replacement of a feedwater control valve, a square tube with clear signs of wear was found downstream from the non-return valve. Neither the origin of the square tube nor the length of time it had been installed there could be determined. The square tube was removed and the system restarted.

The heater line of a boiler circulating pump broke at five places downstream from a throttle, and measurements revealed a major reduction in wall thickness. The cause was erosion corrosion, as the throttle had been washed out in low-oxygen operation around 10 years ago as a result of difficulties with water chemistry and increased corrosion occurred. The Technical Group recommends testing at changes of geometry in pipework. Digital x-ray testing has proven to be a suitable inspection method, as the insulation does not have to be removed for testing of geometrical transitions. In addition, wall thickness measurement can easily be performed.

Parts 1-3 of VGB-Standard «Offshore corrosion protection» (Figure 17) were completed and published within only one and a half years, as a result of know-how contributed by members which had been gained in the coating of, for example, flue gas desulphurisation systems. The standard can be downloaded free of charge from the VGB website. Publication of the English translation of Parts 1-3 is planned for July 2016, and it will also be available free of charge. The compilation of further parts is in progress. Further information can be found in the section on wind energy.

The members are also involved in the creation of the new VGB Standard VGB-S-040, «Prequalification of contractors», in a process led by the Technical Group on Maintenance. The know-how gained from experience in building new power plants and retrofit projects will support the project.

Shorter inspection periods are forcing the operators to experiment with alternative non-destructive testing methods to RT, as the latter involves considerable organisational effort and time. A likely candidate is the Phased Array UT method, which however has to be qualified for each testing institute to the VGB-ENIQ directive. Digital x-ray radiography is a further alternative. VGB is preparing a paper leading to inclusion of both methods in DIN EN 12952.
Renewables and Distributed Generation

A mainstay for the future

Mario Bachhies

VGB concerns itself in 24 committees and groups, including temporary project groups dealing with specific issues, with technical and environmental topics in the field of renewables and distributed generation. Capitalising on the intensive exchange of experience, it offers its members an ideal international platform with the goal of achieving further improvements in operation, efficiency, safety, environmental friendliness and economy. Along with aspects of the optimisation of plants already in operation, the detailed investigations and in-depth analyses focus on the formulation of technical requirements for the erection of new plants. The whole range of topics encompasses hydropower, wind energy, biomass, biogas, distributed generation and storage technologies. In addition, the activities increasingly are interlinked in cross-cutting committees between the areas renewables and power plant technologies.

In close consultation with the operators, in the renewables and distributed generation sector eight VGB-Standards, partly in German, English and French, have been created that are revised at regular intervals to bring them up to date; another five new VGB-Standards are in the drafting stage. The list of all VGB-Standards is available on the website at https://www.vgb.org/regelwerk.html.

The share of operator funds spent on the projects in progress amounts to an average of 9.1 %, raised through 5.4 % joint research contributions of ordinary VGB members (VGB research levy) and 3.8 % project contributions of individual companies (ordinary VGB members). “Other funds”, including manufacturer contributions, amount to 56.4 %. A substantial portion of the project funding volume is raised through public funding (34.4 %).

During the period under review, the activities and cooperation in particular with EU-RELECTRIC – Union of the Electricity Industry and BDEW (Bundesverband der Energie- und Wasserwirtschaft/German Association of Energy and Water Industries) remained very intense, because at the European level, as well as in Germany, a large number of initiatives, guidelines, laws and ordinances had to be revised or introduced for the first time.

### Research Projects

<table>
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<th>VGB Ordinary Member [€]</th>
<th>Public Funds [€]</th>
<th>Other Funds [€]</th>
<th>Total Volume [€]</th>
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<tr>
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<td>1,345</td>
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<td>376</td>
<td>264</td>
<td>2,411</td>
<td>3,953</td>
</tr>
</tbody>
</table>

**Tab. 1: Current research projects in the field of renewables and distributed generation.**
Fig. 1: Share in renewables according to member state (in % of the gross final energy consumption, Source Eurostat, data: 2014).

Renewables in the EU

Mario Bachhiesl and Ulrich Langnickel

The member states of the European Union (EU) have set high goals for the expansion of renewables. The plan for renewables is to have a 20 % share of gross final energy consumption and 10 % in the transport sector in the year 2020. For each EU member state an individual target value 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 2014 the share of renewables in the gross final energy consumption of the EU was 16.0 % and thus almost double the figure of 2004 (8.5 %), the first year for which data is available. One third of the 28 EU member states have already reached levels that satisfy their national targets for 2020 (Figure 1): Bulgaria (18 %), the Czech Republic (13.4 %), Estonia (26.5 %), Croatia (27.9 %), Italy (17.1 %), Lithuania (23.9 %), Romania (24.9 %), Finland (38.7 %) and Sweden (52.6 %). Furthermore, Denmark and Austria each need less than one percentage point to reach their individual targets for 2020. In contrast, the lowest shares of renewables were reported in Luxembourg (4.5 %), Malta (4.7 %), the Netherlands (5.5 %) and the United Kingdom (7.0 %).

In the field of power generation, at the end of 2014 more than 28 % of the electricity in the EU was being produced with renewables, with around 39 % of that coming from the use of fluctuating sources – wind and solar energy (Figure 2). Wind power generation was more than tripled in the period from 2005 to 2014. After hydropower, which accounts for more than 41 % of the total renewable power generation, wind power now makes the second largest contribution. Power generation from biomass also is growing, attaining a share of nearly 19 % in 2014.

Hydropower

Mario Bachhiesl and Wolfgang Czolkoss

Hydropower has been used since the late nineteenth century as first renewable source of energy for electricity generation. Worldwide, 16.6 % of the total power generated was produced in hydropower plants in 2014. Hydropower 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 hydropower to serve as universal system service provider for all necessary network services takes on growing importance. Pumped storage power plants and impoundment hydropower 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.

In the hydropower 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 more than 100 members from over 34 member companies from 11 countries actively address a variety of technical and environmental topics relating to hydropower and engage in an intensive exchange of experience.

Fig. 2: Shares of renewables in the electricity sector in the EU-28 (Source Eurostat, data: 2014).
Strategic Forum «Hydro»

Wolfgang Czolkoss

The Strategic Forum (SF) «Hydro» comprises top management members of European hydropower operators, offering them a platform for discussing management issues of the European market and coordinating them with EURELECTRIC in Brussels and other international and national organisations. In addition, the SF coordinates the topics of the Technical Committee (TC) «Hydro Power».

Topics at the last SF «Hydro» meetings included the representation of hydropower by VGB in other organisations, in particular stronger representation of hydropower by VGB at the European level. VGB, as interface to EURELECTRIC, is the technical platform for European operators of hydropower plants, which speaks with one voice through the SF «Hydro», with its associated technical committee and technical groups, in European and national organisations. On political issues such as market design or the German Renewable Energy Act, VGB supports other associations such as the BDEW (Bundesverband der Energie- und Wasserwirtschaft/German Association of Energy and Water Industries) or the AGAW (Arbeitsgemeinschaft Alpine Wasserkraft/Working Group of Alpine Hydro Power).

The brochure «Hydropower – Part of the Renewable Family» (Figure 3), issued by VGB and its members, outlines the historical development of hydropower use up to the present state of the art. In addition, the brochure explains the special economic and ecological significance for present and future European power supply, which to an increasing degree is based on renewable sources of energy. The brochure can be downloaded free of charge from the VGB website.

Technical Committee «Hydro Power Plants»

Wolfgang Czolkoss

In the Technical Committee «Hydro Power Plants», technical experience is exchanged, projects are coordinated, and liaison and cooperation with other organisations in the field of hydropower take place (BDEW, DWA [Deutsche Ver einigung für Wasserwirtschaft, Abwasser und Abfall/German Association for Water, Wastewater and Waste], AGAW …). In the period covered by this report, two meetings took place at which, among other things, the modernisation of the Weinzälli power station (Austria), major inspections at the power plants Säckingen and Pfreimd (both Germany), Vianden (Luxembourg) and Rosegg (Austria), as well as various cases of damages were presented and discussed as part of the exchange of experience. Other topics dealt with the provision of system services, the VGB report on levelised costs of electricity (LCOE) 2015, and in this context the financial assessment of pumped storage power plants. Here the direct comparison with other storage technologies is of special importance on account of the dynamic developments in this field in order to appreciate these plants’ important contribution to grid stabilisation in the context of the rising share of fluctuating feed-in from wind and solar energy.

The current market situation for hydropower is characterised by the decline of obtainable electricity prices, at times to as low as 20 €/MWh on the EEX, and a lack of promotion. As a result, the existence of many current plants is threatened. The expansion of hydropower, desirable from an ecological viewpoint, is not economically feasible under such conditions. The additional services provided, for flood control or shipping, for example, thus also are in jeopardy and would have to be provided by other means if the decommissioning of hydropower plants threatens. In general, hydropower is valued by the political community as an important contribution to renewable power generation. However, where promotion and licensing issues are involved, inadequate support is provided. For example, the coming Natur 2000 directive leads to even lengthier licensing procedures. The Technical Group (TG) «Ecological Aspects of Hydro Power» deals with the ecological side of hydropower plants and the resultant licensing problems.

The tense financial situation of many hydropower plants also has the result that expenditures for servicing and maintenance must be reduced. Maintenance intervals are extended and the expected service life of components increasingly is utilised to the limit. The two new 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 modernisation and replacement. As...
sistance in this area is offered by the VGB-Standard VGB-S-033 «Interaction of Conformity Assessment and Industrial Safety in Hydro Power Plants>, for which the reactivated Project Group (PG) «Conformity Assessment» has already begun preparing a complementary workshop.

Based on the standard VGB-S-175 «IT Security for Generating Plants» the PG «IT Security in Hydro Power Plants» is working out the safety risks and consequences for the equipment and operation of hydropower plants. Apart from exchanging experience, the participants monitor the current status of laws and regulations and clarify the consequences. Hydropower plants up to 500 MW generally are not considered to be «critical infrastructure», but owing to their importance for shipping and flood control can belong to this category. The goal of the project group is to draw up a «VGB minimum catalogue» for service and maintenance agreements for hydropower plant IT.

The DWA publishes worksheets and instruction sheets which often serve as basis for licensing procedures in the area of hydropower. The cooperation with DWA has been strengthened, with several members of VGB hydropower committees now contributing to new DWA working groups. This ensures appropriate consideration of operator interests in the DWA sets of rules.

Technical Group «Ecological Aspects of Hydro Power»
Wolfgang Czolkoss

In the TG «Ecological Aspects of Hydro Power», established jointly with the AGAW, an independent, quotable synthesis paper has been elaborated on the Fish Protection Forum that was held in 2011 to 2014 by the German environmental protection agency – UBA; it will be published through the VGB website. Its presents the position of the major hydropower plant operators more clearly and is intended as an additional argumentation aid for the discussion of the relevant issues.

Furthermore, the group is continuing its work on a general overview of all ecological issues having a bearing on hydropower. These issues concern not only fish passes, but also topics like fish monitoring, hydropæaking (surge and low water), or habitat improvements. For instance, VGB is participating in a demonstration project for dam restoration with ecological enhancement of riverbank areas (INADAR – Innovative and ecological approach for dam restoration). Information about this is available on the VGB website in the chapter on research. The topic matrix and its compilation in a single document by VGB will be completed by the end of 2016. This overview also will encompass the state of the art (to the extent defined), research projects and literature references to the issues concerned.

An important part of the work of this TG is the exchange of experience among all participants on all ecological and licensing issues as well as on the results of the related studies and projects.

Technical Group «Operation and Maintenance of Hydro Power Plants»
Wolfgang Czolkoss

The Technical Group «Operation and Maintenance of Hydro Power Plants» initially was set up with members from the technical committee. The group develops maintenance strategies and deals in depth with selected maintenance issues. To this end it also compares the maintenance strategies of other industries. In view of the constraints that lead to extended maintenance intervals and greater use of the calculated life (were already discussed in the technical committee) and considering the requirements of IT security, the following tasks were prioritised:

- Development of adapted maintenance strategies for machine units and weirs/shut-off valves with the aim of working out minimum standards
- Elaboration of a guide to remotely controlled operation/IT security
- Clarification and description of the responsibility of operators of hydropower plants

The remote control operation guide to be developed will deal with technical issues, not topics relevant to licensing. An exchange of views with the VGB Project Group «IT Security in Hydro Power Plants» is necessary for handling this topic. If there is a risk of flooding, provision must be made for protection measures in the local systems.

One subject on which experience was exchanged was the influence of primary control on wear. There were reports of increased wear and shorter service lives of single components of Kaplan turbines. In the discussion on maintenance outsourcing, participants pointed to experience in Sweden, where outsourcing has been scaled back again owing to negative experience.

Technical Group «Components of Hydro Power Plants»
Wolfgang Czolkoss

The Technical Group «Components of Hydro Power Plants» analyses the current general conditions prevailing at operators and manufacturers, the resultant market requirements, and the influence of component quality which they give rise to in all project phases, from design through production and erection to commissioning and first start-up. To compile specifications and standards for the subsequent maintenance of hydropower plants, close cooperation with the Technical Group «Operation and Maintenance» is necessary. Not only material fatigue, but also the required maintenance effort and expense are considered.

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

Wind Energy
Ulrich Langnickel

The use of wind power has to be further extended in order to meet the requirements of the European Union within the scope of its Energy and Climate Change Package. However, extensions should be purposefully selected at very favourable «wind sites» taking into account power plant specific criteria. At the end of 2015, about 25,980 wind turbines with an output of 44,946 MW were in operation in Germany. At that time the installed capacity in Europe amounted to 147,772 MW (Table 2) and 432,883 MW worldwide.

VGB members operate wind turbines with a total capacity of more than 38,000 MW. Approximately 80 % of the installed capacity of offshore wind farms is owned by VGB member companies. In the VGB committees and groups, 95 members from 17 countries actively deal with a vast range of topics related to wind power and carry on an intensive exchange of experience.

Strategic Forum «Wind»
Ulrich Langnickel

In mid-2015 the Strategy Forum «Wind» was set up, in which the leading operators of wind power plants, e.g. E.ON, EnBW, RWE, Statkraft and Vattenfall, pool their interests under the roof of VGB PowerTech. Apart from exchanging information and experience, the participating companies seek mainly to advance standardisation (best practice) and to express common operator interests in the different user groups.
The reduction of installation and operating costs as well as the enhancement of operational safety and reliability urgently require coordinated and joint analysis of operating experience. The findings and knowledge obtained will provide the basis for determining construction and operating standards (VGB-Standards). In the SF «Wind», the strategic requirements for the utilisation of wind power, from the viewpoint of the operators, are discussed at management level and appropriate measures are initiated. In addition, the activities of the TC «Wind Energy» and the different user groups are coordinated. These bodies deal mainly with operating experience and requirements and initiate as well as support relevant research projects.

The use of the VGB-Standard «Reference Designation System for Power Plants – RDS-PP® for Wind Power Plants», a necessity from the viewpoint of the operators, was a subject of intensive discussion between SF Wind and the wind turbine manufacturer Siemens Wind Power GmbH. The designation systematics of RDS-PP® is applied as a uniform feature over the entire lifecycle of these plants. The RDS-PP® definitions, based on international designation standards, make it possible to share unambiguous digital data between all parties in the sector and thus bring major advantages, including even cost reduction, since all stakeholders speak a common language. The VGB member companies were very pleased that at the request of the operators Siemens is using the VGB-Standard for its wind turbines.

**Technical Committee «Wind Energy»**

Ulrich Langnickel

The goal of all companies active in the wind energy business is, or must be, joint to cut the costs of maintenance and repair of wind power plants. To achieve this, corresponding activities were pursued, coordinated by SF «Wind» and TC «Wind Energy».

To optimise the maintenance strategies, standardisation is an absolute necessity in the wind energy field. Various VGB-Standards contain requirements and necessary measures for the installation and operation of onshore and offshore wind farms, similar to the recommendations for conventional power plants:

- For the first time, special information requirements lists were developed with which the information needs for a wind power plant can be precisely and clearly ascertained and contractually stipulated. These lists have been integrated in the new VGB-Standard VGB-S831-00-2015-05 (formerly VGB-R 171) «Provision of Technical Documentation (Technical Plant Data, Documents) for Energy Supply Units». The 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.

- The VGB-Standard «Guideline for Life Cycle Management of Foundation and Tower of Onshore Wind Turbines» mainly deals with the repair and rehabilitation of these wind power plant components, which are made of steel, reinforced concrete and other materials as well as combinations of these. It is a guideline for prevention of damages, for servicing, repair and strengthening of foundation and tower of wind turbines. This document also deals with building materials like mortar or coatings which are part of the basic package or are used for repair. However, electrical or electrically conducting components are not considered. Publication of this VGB-Standard is scheduled for the end of 2016 or early 2017.

- In collaboration with the Federal Waterways Engineering and Research Institute (BAW), currently a VGB/BAW standard entitled «Corrosion Protection for Offshore Wind Turbines and Wind Farm Components» is being drawn up in consultation with specialist associations. Recommendations are provided for assessing corrosion protection technologies in order to avoid, as far as possible, cost-intensive offshore repairs during the planned useful life. The standard will have the following five parts and cover all corrosion protection options: general information, demands on coating systems, application of coating systems, repair of coating systems, and cathodic corrosion protection. The first three parts already were published in March 2016; the remaining chapters will follow successively beginning in autumn 2016.

- Members of the TC «Wind Energy», in collaboration with fire protection experts (TG «Fire Protection»), are compiling minimum requirements for fire protection in wind turbines. Early fire detection and identification of fire risks are particularly important. Building on this, the measures necessary to enable extinguishing locally occurring fires are described. The action required to protect human life also is explained. The relevant VGB-Standard will be published in 2017.

<table>
<thead>
<tr>
<th>Country</th>
<th>Installed capacity end 2013 [MW]</th>
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<th>Installed capacity end 2015 [MW]</th>
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Tab. 2: Installed wind energy capacity in Europe in 2013, 2014 and 2015 (EWEA 2016).
To harmonise the definitions and indicators, members of the TG «Performance Indicators» have compiled such terms for the wind energy sector for the first time and reconciled them with the members of the TC «Wind Energy». They are published in the VGB-Standard VGB-S-002-05 «Wind Turbines – Definitions and Indicators». A medium-term goal is to create a uniform definition of availability. In this case the technical availability of the wind power plants of different manufacturers could be compared with each other.

To enable attaining high availability rates for the gearboxes in wind turbines, great demands are made of the quality and cleanliness of the lubricants that are used. Building on the existing documents on «Oil system cleaning and in-service monitoring of turbine oils in steam and gas turbines», the specific requirements of wind turbines also will be incorporated into a VGB-Standard. Publication is scheduled for early 2018.

Icing significantly influences the development and operation of wind farms. It causes production losses and is a safety risk for passers-by and service personnel (Figure 5). For safe operation of a wind power plant, icing on rotor blades must be detected as early as possible. The plant then can be stopped or a de-icing system activated. Moreover, an instrument is needed that can signal that the rotor is ice-free again and normal operation can be resumed. The reliability of these systems – nine nacelle-based and four rotor-based systems in all – was analysed in a VGB research project and compared with the operating experience of VGB member companies. The results of this project were published in February 2016. The results also show that for rotor-based systems no manufacturer-independent studies are available as of yet. Therefore, the TC «Wind Energy» is endeavouring to realise a comparison of the four systems on the market in a follow-up project.

According to the requirements of the German Maritime and Hydrographic Agency (BSH), foundations of wind turbines that are approved by BSH have to be checked every four years and the foundations of transformer platforms every year. To enable calculation of the real fatigue of the materials used, including the welded joints, in a project coordinated by TNO (Netherlands Organisation for applied research) the relevant loads are being analysed. The general aim of the project is to enable verification of the conservative calculation methods used to date. The results of the research project, in which VGB PowerTech is participating, thus could have an influence on possible adjustments of the intervals for in-service inspections.

With the support of the TC «Wind Energy» the annual technical conference «Maintenance of Wind Power Plants» was held on 2/3 March 2016 in Hamburg parallel to the corresponding VGB conference for conventional power plants and a joint technical exhibition. More than 90 participants from ten countries addressed issues relating to the operation, servicing and maintenance of wind power plants (Figure 6) onshore and offshore. The focal topics of this event were rotor blade maintenance and ice detection, but also the experience gained with condition monitoring systems. The lectures and intensive discussions at the technical conference emphasised that optimisation of the maintenance and repair strategies remains a necessity. In future, the continued operation of wind power plants after the subsidisation phase (for example, after 20 years in Germany) will play an important role. The next technical conference will be held in the spring of 2017.
For the first time a workshop on «Oil Monitoring in Wind Power Plants» took place on 23/24 June 2015 in Rostock/Germany. Since wind power plants are structures that are subject to highly dynamic stresses and a high number of stress cycles, great demands are placed on the lubrication of the gearbox bearings. The objective pursued with the two-day workshop thus was to present suitable practical solutions to these challenges and put the scope for optimisation up for discussion. The correct performance of oil changes and oil analyses played an important part in the discussion. The measures required for this purpose will be incorporated into a VGB-Standard.

User Groups «Siemens» and «Vestas»
Ulrich Langnickel

The User Groups «Siemens» and «Vestas» organise an intensive exchange of information and experience on specific technical issues – from foundation to rotor blade – relating to the wind turbines from certain manufacturers. For this purpose, in consultation with the member companies a database containing the key technical parameters of the wind power plants was created. The goal of the VGB member companies is to optimise the maintenance and repair measures for the respective plants and to discuss suitable measures with the manufacturers. Currently, based on a decision taken by the SF «Winds, the user groups are concentrating for the time being on the multi-MW wind turbines of manufacturers Siemens and Vestas. However, an Enercon user group also will be set up in the near term.

Technical Group «HSE for Offshore Wind Parks»
KarlHeinz Puch

The evaluation and communication of accidents are the main topics of the Technical Group «HSE for Offshore Wind Parks». This includes information about protection and safety concepts. VGB contributed with its expertise both to German Statutory Accident Insurance (DGUV) rules like DGUV 203-007 «Wind Power Installations» and to the guidelines on «Diving in the German Exclusive Economic Zone».

Intensive fundamental work was carried out on a number of medical issues. Examples are the Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften e.V. (AWMF) guideline on medical fitness for offshore workers and the DGUV first aid information.

Examples of other topics are dealing with drinking water quality, hazardous substances and microorganisms.

Development of the «Rescue Chain Offshore Wind» is supported. This includes questions about the use of helicopters and ships for rescue work, the medical personnel and telemedicine.

The «Emden Workshop on Occupational Health and Safety» has become a regular event and took place on 9/10 September 2016 for the seventh time (Figure 7).

Technical Committee «Use of Renewables and Distributed Generation»
Ulrich Langnickel

The Technical Committee «Use of Renewables and Distributed Generation» coordinates the activities of the three Technical Groups «Biomass», «Biogas» and «Distributed Generation» and assesses the technical developments and application options of all forms of utilisation of renewables – with the exception of wind energy and hydropower – and of decentralised power generation. This includes, for example, the use of solar and geothermal energy. In addition, the committee supports various national and international research projects and publishes position papers on the efficient use of renewable sources of energy.

In view of the vigorous expansion of renewables and decentralised generation, the integration of these systems and the development and demonstration of storage technologies – e.g. batteries, power-to-gas and power-to-heat – will play a major role in future. Accordingly, at present the committee is looking very closely at the related issues on behalf of the VGB member companies. Hence, along with the technical development the international regulatory framework, in particular, must be analysed. In addition, questions about IT security for virtual power plants and other topics must be discussed.

Semi-annually, the essential changes in the support schemes for the use of renewables, including combined heat and power generation, will be summed up for the VGB member companies.

Technical Group «Distributed Generation»
Doreen Kückelmann and Ulrich Langnickel

The Technical Group «Distributed Generation» assesses the technical and economic development of small combined heat and power plants (CHP) that are mostly based on conventional piston engines. The group’s work focuses on the system integration of fuel cell technology and of micro gas turbines and Stirling engines. These technologies enable combined heat and power generation also for units with a very small output, for application e.g. in house heating systems, district heating systems and in the industrial sector.

Since power generation from fluctuating sources of renewables will continue to grow, the expansion of storage capacity is an urgent necessity. The storage systems can be divided into central storage power plants, small local storages, short-term or long-term storages. Moreover, storage of electric energy as well as thermal energy is possible. For provision of grid services the storage systems must feature fast reaction times. Furthermore, the selection of
the proper site plays a major role. For the use of the different storage technologies, realisation of market-conforming developments is crucial. The TG «Distributed Generation» has analysed the battery technology options and the use of Power-to-Gas (PtG, Figure 8) and Power-to-Heat (PtH) systems for these applications.

The German federal government is striving to increase the share of renewables in electricity generation in Germany to 55 to 60 % in the year 2035. The fluctuating generation of power from wind and solar energy will play a key role in this effort. However, since wind energy mainly is utilised in the North of Germany and the load centres mainly are in the South, appropriate steps must be taken to ensure a reliable and sustainable future power system. The results of various studies were presented in the group and discussed in detail.

Accordingly, the transmission grid has to be extended by 3,000 kilometres of high-voltage transmission lines (380 kV AC + HVDC). Moreover, to optimise the entire power grid the cooperation between the Distribution System Operators (DSO) and the Transmission System Operators (TSO) must be intensified since a growing number of distributed generation technologies also will increase the requirements on the distribution grid. For example, existing distribution system stations in certain regions have to be provided with adequate measuring equipment.

First projects dealing with the design of island grids are in the implementation phase. The main objectives of these projects are to show that local grids can be operated independently of the public electricity grid and that producers of renewables bundled in a «microgrid» temporarily can substitute conventional power plants by providing ancillary services. «Ancillary services» comprise frequency control (primary control, secondary control, tertiary control), voltage support, compensation of active power losses, as well as black start and island operation capability. In this connection the storage technologies described above also will play a major role.

To assist the required measures, smart metering now also will be implemented throughout Germany. The obligatory Smart Meter Roll-out will take place in 2017, depending upon consumption (more than 10,000 kWh/a in 2017; more than 6,000 kWh/a in 2020 for private households). The instrumentation and control systems used for this purpose must meet high IT security standards.

**Biomass**

Sebastian Zimmerling

An evaluation of the national action plans for the use of renewable sources of energy shows that, along with wind energy, hydropower 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 4,000 MW. In the VGB committees and groups more than 40 experts from 35 member companies from 15 countries actively address a variety of biomass-related topics and engage in an intensive exchange of experience.

Technical Group «Biomass»

Sebastian Zimmerling

The Technical Group «Biomass» – jointly with the other relevant VGB committees and groups that deal with biomass – addresses technical issues related to the operation of biomass-fired power plants. The topics include the entire power plant process from fuel production, provision, and storage up to flue gas cleaning. They cover both purely biomass-fired plants and fossil-fired plants with biomass co-firing. The group also deals with measures required to convert fossil-fired power plant units to 100-percent biomass combustion. The topic of ash utilisation, in particular ashes from biomass mono-combustion, is treated separately by the TG «Biomass Ash».

With the assistance of the TG «Biomass» and Fraunhofer Institute for Environmental, Safety, and Energy Technology (Umsicht), VGB organised a workshop in Oberhausen/Germany on «High-Temperature Corrosion in Biomass Power Plants». Conducted in English, the workshop took place on 15 December 2015 and was very well attended with 43 participants from 12 countries.

Following a brief presentation by Fraunhofer Umsicht and an introduction to the fundamentals of chlorine-induced high-temperature corrosion by the VGB materials laboratory, practical examples were explained in detail. This was followed by the description of secondary countermeasures such as fuel additives and flue gas additives. To conclude the workshop, two research projects from the subject area were presented.

An important topic in connection with the surveillance of large biomass piles is the detection and localisation of hotspots. Due to the insulating properties of biomass, fires smouldering in larger storage quantities are detected only at a very late stage. In addition, the natural degradation processes inside the pile give rise to large amounts of carbon monoxide so that the detection of this gas cannot be used as sole indicator for the early detection of fires. With the support of the TG «Biomass» a research project was initiated to solve these problems. First, a comprehensive market study was carried out, supplemented by a survey among operators. The identified technologies will be compiled, suitably evaluated, providing information about the operating conditions, and published as a final report probably at the end of 2016. At present a follow-up project is planned to work out best-practice configurations for detecting and localising hotspots in biomass piles.

Fig. 8: PtG demonstration plant in Falkenhagen (Source: E.ON).
Computational fluid dynamics (CFD) simulations are a familiar tool for analysing flow parameters in furnaces and flue gas ducts and are widely used in conventionally fired power plants. To apply this technology to biomass-fired plants, however, a number of peculiarities must be taken into account. These were thoroughly discussed at two meetings of the TG «Biomass» in relation to pulverised fuel firing and grate firing. The thermal inertia of biomass particles has special significance in this context. The standard CFD approach for coal is based on the assumption that the different phases of combustion take place successively for the entire mass of a particle. Since the poorer thermal conductivity of the biomass material causes the different combustion phases to overlap, the simulations must be modified accordingly. Specifically for grate firing, the behaviour of the fuel bed also must be considered. Here the possibility exists to combine the CFD simulation for mapping flow characteristics with the discrete element method (DEM) to depict the processes taking place on the grate. In consequence, instead of the usual continuum approach the DEM output values are used as input values for CFD. CFD and DEM simulations for biomass-fired boilers also will be a focal topic of the upcoming VGB Biomass Conference 2016.

The European Commission has again taken up the topic of the sustainability of biomass and has initiated the consultation phase on the political framework for sustainable bioenergy for the period 2020 to 2030. VGB and the TG «Biomass» have commented on the reply of the German Association of Energy and Water Industries (BDEW) and participated in formulating the reply of the EURELECTRIC Task Force Biomass. The Task Force Biomass will publish an additional position paper on this subject. Generally speaking, all participating biomass plant operators are calling for uniform European sustainability legislation in order to ensure planning reliability for fuel supply and to make the trade in biomass fuels cost-efficient and legally watertight.

Technical Group «Biomass Ash»
Hans-Joachim Feuerborn

Biomass ashes are produced when biomass of any type is fired in grate-fired furnaces, fluidised bed combustion systems and dry-bottom furnaces, and when larger amounts of biomass are co-fired in coal-fired combustion plants. In some EU member countries the trend to more power generation using biomass is unbroken, while the trend to more co-firing in coal-fuelled plants is stagnating or declining. In view of the relatively limited utilisation and disposal options for the ashes, attention now centres on the improvement of their quality through conditioning or co-firing. Mechanical-mineralogical processes and chemical processes both are used for upgrading the ashes. In these processes, either a specific metal species is obtained or enriched, or the surface condition is influenced in such a way that, among other things, the leaching properties of certain metals/metal compounds are reduced. Apart from that, the possibilities for phosphorus recovery play an important role. Co-firing of biomass favourably influences especially the homogeneity of the ash, along with its chemical composition.

The Technical Group «Biomass Ash» deals with all topics related to the production, characteristics and use of biomass ash. The results of a questionnaire on fuel use, firing techniques and ash analysis as well as on European and national technical rules are being compiled in a status report. In addition, the results of basic research projects and application research projects are evaluated, and developments for use according to the rules and regulations are given intensive support. This concerns in particular the use as an aggregate in roadbuilding, as an ingredient of fertilisers (Figure 10), and for forest liming. The experience and existing applications presented in a workshop in May 2015 partly have been published in the VGB PowerTech journal (11 (2015) and 4 (2016)). The existing uses are based on technical and environment-relevant, application-related rules and regulations and involve established certification systems.

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Biogas

Sebastian Zimmerling

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

As a further possibility, biogas also can be upgraded and fed into the natural gas grid (Figure 11). It can be stored temporarily and then systematically used at locations having a heat sink. The treatment and feeding of biogas into the existing natural gas grid can be considered the decisive advantage of this technology with a view to integrating renewables into existing networks and utilising existing storage potentials. Currently some 22 biogas feed-in plants are operated by VGB member companies. In the VGB Technical Group «Biogas», at present nine group members from eight member companies in Germany and Belgium actively deal with the widest range of topics relating to biogas generation and cultivate an intensive exchange of experience.

Technical Group «Biogas»

Sebastian Zimmerling

In addition to the optimisation and management of existing plants, plant flexibility for the provision of balancing energy is a topic of the Technical Group «Biogas». Basically every plant section – feed-in, biogas production, gas storage, gas utilisation, component dimensioning, control technology – affords possibilities for enhancing flexibility. However, this usually entails additional investment. For this reason, DBFZ, the German Biomass Research Centre, has examined the possibility of optimising the feeding management of a biogas plant with model predictive control, thereby adjusting the generated quantity of gas to the predicted electricity demand. This technique makes it possible to reduce the otherwise necessary additional gas storage volume considerably and to provide balancing energy with an existing plant simply by modifying its operating regime.

The reclassification of formaldehyde under EU law as «presumed to have carcinogenic potential for humans» in carcinogenicity category 1B raises special challenges to the operators of biogas plants which directly generate electricity in cogeneration units. It is planned to reduce the previous limits specified by the Technical Instructions on Air Quality Control (TA Luft) for existing biogas-fuelled pilot injection engines and lean-burn engines to 30 mg per cubic metre by 2020 at the latest; for new installations the limit value in 2020 will be 20 mg per cubic metre. Formaldehyde inevitably originates during the combustion of methane at relatively low combustion temperatures. In order to meet the NOx limits of the TA Luft in the presence of the catalyst poisons that frequently are found in biogas, for biogas engines an operating regime with high excess air and consequently low combustion chamber temperatures is preferred. Compounding the problem is that the methane content of the biogas is subject to strong system-inherent fluctuations which cannot be compensated by the engine controls in every case. To meet both the NOx and formaldehyde limits the plant systems must be retrofitted. This additional investment cost jeopardizes the economic efficiency of most biogas plants. Operators of natural gas engines, mine gas engines, landfill gas engines and sewage gas engines face a similar problem.

Fig. 11: Pressure water scrubbing at biogas plant Hallertau (Source: E.ON Bioerdgas GmbH).
Competence Area
Environmental Technology, Chemistry, Safety and Health

TC Environment
C: A. van Damme
A: S. Göhring
A: H.-J. Meier
A: S. Göhring

TG Emissions/Missions
C: Dr. F. Sulzenböhmer
A: S. Göhring
A: S. Göhring

TG Noise Control
C: K. Knörrer
A: S. Göhring
A: S. Göhring

TG Water Management
C: N. N.
A: Dr. D. Rutschow
A: Dr. H. J. Feuerborn

TG Power Plant By-products
C: Dr. D. Brisch
A: T. Eick

TG By-products of Waste
C: W. Schmidt
A: K.-H. Puch
A: S. Blank
A: S. Göhring

TG Emissions Monitoring
C: Dr. M. Heim
A: Dr. A. Wecker
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TC Chemistry
C: Dr. M. Heim
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TG Chemical Process Engineering
C: Dr. J. Fähkle
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A: Dr. A. Wecker

TG Analytics
C: Dr. M. Heim
A: Dr. A. Wecker
A: Dr. T. Stol
A: Dr. D. Rutschow

TG Chemistry of Light
C: Dr. F. Fugl
A: Dr. A. Wecker

TG Water Reactors
C: F. Wagner
A: K.-H. Puch
A: K.-H. Puch

TG Emission Control
C: Dr. J. Fähkle
A: Dr. D. Rutschow
A: Dr. D. Rutschow
A: S. Göhring

TC Health & Safety (H&S)
C: R. Wurmans
A: K.-H. Puch
A: S. Göhring
A: S. Göhring

TG Fire Protection
C: S. Schwanner
A: S. Zimmerling
A: S. Göhring
A: S. Göhring

TG Health & Safety at Work
C: Dr. K. Wieder
A: K.-H. Puch
A: T. Schnabel
A: Dr. L. Jentjes

TG Industrial and Environment Medicine/Health Management
C: Dr. T. Schnabel
A: Dr. L. Jentjes

TG Health & Safety for Offshore Wind Parks
C: N. N.
A: K.-H. Puch

IC Climate and Environmental Protection
C: Dr. R. Wielert
A: H.-J. Meier
A: S. Göhring
A: S. Göhring

ICE Climate Protection
C: A. Nolden
A: S. Göhring
A: S. Göhring

ICE Greenhouse Gas Monitoring
C: Dr. J. Altenburg
A: S. Göhring
A: S. Göhring

ICE Systems Planning and Licensing
C: Dr. W. Konrad
A: Dr. A. Wecker
A: Dr. A. Wecker

ICE Water and Soil Conservation
C: M. Köser
A: Dr. D. Rutschow
C: H. D. Käsmann
A: T. Eck

ICE Waste and By-products
C: H. Fester
N. H.
A: K.-H. Puch
A: Dr. D. Rutschow

ICE Dangerous Goods/Chemical Agents
C: C. Schäfer
A: K.-H. Puch
A: K.-H. Puch

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

TC «Environment»

Sven Göhring

Reports on developments important for power plants in the individual member states and companies as well as the exchange of experience were the main activities of the technical committee. Constant observation of the developments in other member states provides, inter alia, the possibility to prepare oneself for requirements which may have to be met by one’s own national companies. Solutions identified by foreign member companies might be of benefit for one’s own company. Topics on which experience was exchanged included:
- status of the BREF LCP revision
- energy audits
- provisions on the topic of biocides
- latest European trends in the environmental field

As part of reporting on VGB activities, the technical committee presented and explained the results of the VGB U.S. study «Mercury». The differences in the treatment of this topic in the various member states also were discussed.

Technical Group
«Emissions/Missions»

Sven Göhring

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

At one of the meetings the status of the BREF LCP revision was explained in detail and discussed. Representatives of several member states voiced the fear that their national authorities will focus on the lower end of the emission range presented in BREF when stipulating new emission limit values. Another point for discussion in this connection was measurement uncertainties in comparison with the defined lower ranges of the BAFU.

Under the technical group’s direction the VGB research project «Compliance with new flue gas flow rate standards at power stations. – Flue gas flow rate determination to EN ISO 16911» also was carried out and concluded. The final report for this project, containing the results, will be completed before long.

In May of this year, on behalf of VGB several members of the TG Emissions Monitoring held lectures at the CEM 2016 - International Conference and Exhibition on Emissions Monitoring, in Lisbon. These were presentations, for example, on the topics: «Results of the VGB research project» and «EU regulation for combustion plants – Viewed from the perspective of the power industry».

Technical Group
«Emissions/Missions»

Sven Göhring

The main focus of discussions in the technical group was the drafting of the amendment to the Technical Instructions on Air Quality Control (TA Luft), published in mid-2015 by the German Federal Ministry for the Environment (BMUB). The members of the technical group compiled and discussed comments on the changes contained in the draft amendments. Among other things, the items «Examining the obligation to protect» and «Protection against harmful effects of pollutant deposition on the environment» were examined in detail. As regards the last point, particular attention must be paid to the significance for the operators of the reduced/new deposition values. For the determination of characteristic ambient air quality values, it was pointed out that for new-build plants it is no longer possible to dispense with determining ambient air quality values on the grounds that the mass flows are of a minor nature. On the current status of «TA Luft» it can be said that down to the present time no ministerial draft has been published for a hearing of the German associations.
In the meantime, however, the enforcement recommendation of the German Länder Committee on Pollution Control (LAI) for formaldehyde has been published. This, too, was discussed and analysed in this technical group.

One of the subjects discussed during the exchange of experience was the requirements for Hg monitoring with low limit values. This topic is driven by the BREF conclusions, which specify a mercury limit value of 1-4 μg/m³ (annual average) for existing hard coal fired power plants with capacities greater than 300 MW. Continuous verification of the observance of this limit value is required unless this proof is provided twice annually through fuel analysis. The discussions showed that an instrument suitable for continuous measurement is available. Consequently, from a technical viewpoint there is no reason why such monitoring cannot be realised.

Another topic of exchange was experience in preparing initial condition reports to obtain approval for changes. Several members of the technical group have already gathered experience in this area and reported about it at the meeting of the group. It was pointed out that findings of soil contamination create a site remediation obligation, even if one has not caused such contamination oneself.

Technical Group «Noise Control»
Sven Göhring

On 10 November 2015 the 7th VGB Workshop «Noise Abatement» took place. The presentations dealt among other things with noise abatement measures for large-scale power plants as well as the state of the art in noise control for wind power plants. Other topics addressed at the event included the revision status of DIN 45680 as well as noise abatement issues in urban development planning. With around 35 participants the workshop was well attended; the response to the presentations was very good.

A top issue in the work of the technical group was the background paper for the BREF LCP, including the revised BAT (best available technique) conclusions, published by the EIPPC office in Seville. In the document revision process the technical group emphatically objected particularly to the assertion that surveillance of plant noise three times annually is state of the art. This demand for general monitoring of noise exposure ultimately was deleted from the conclusions now published.

The exchange of experience included a positive report on the establishment of a citizen contact group. This group was invited by the power plant management to exchange information and thoughts and to accompany noise immission measurements. This measure led to a better understanding and greater acceptance among the involved citizens.

Technical Group «Power Plant By-products»
Hans Feuerborn and Thomas Eck

The Technical Group «Power Plant By-products» essentially dealt with regulatory requirements related to the production and utilisation of power plant by-products (Figure 1). Special emphasis was placed on:

- Circular economy and functioning waste market. Problems with country-specific product or end-of-waste statuses especially in cross-border transport
- BREF: influences on quality and the existing opportunities for the use of power plant by-products
- Simulation game of the German Federal Ministry for the Environment (BMUB) on the Framework Ordinance for Recycled Building Materials and Soils. The simulation game was extended to secondary raw materials.

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

- Revision of the EOTA assessment document for fly ash in concrete
- Identification of necessary technical amendments to EN 450-1 for fly ash in concrete: clarification in regard to drying sieving and determining of loss on ignition. The topic «Introduction Essential Requirements ER3 Health, Hygiene» also must be considered.
- Revision of the European testing standards EN 451-1 [Determination of free calcium oxide content of fly ash] and EN 451-2 [Determination of fineness of fly ash]
- Environmental approvals for fly ash for concrete. These mostly were extended to the maximum validity period 04/2020.
- Verwaltungsvorschrift Technische Baubestimmungen (VV TB - Administrative Ordinance, Technical Building Regulations) including requirements for structural works. These give rise to changed constraints for the use of fly ash and bottom ash in concrete.
- Exclusion of bottom ash from rural road construction in the rules of the Road and Transport Research Association (FGSV)
- Creation of delivery terms for fly ash for road construction at FGSV
- Risk modelling in the context of toxicological evaluation of gypsum and gypsum products based on a new exposure scenario

As part of application-oriented research, four new research projects were endorsed for continuation as well as for the investigation of causes in relation to the modified alkali resistance test, for an alternative pozzolanicity test for fly ash, and for the production of special clinker with hard coal and lignite fly ash in the raw meal.

Fig. 1: Mixing plant in Moerdijk, Netherlands.
Technical Group «By-products of Waste Incineration»

Karl-Heinz Puch

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

- Further support for the revision of the BREF Waste Incineration in the environmental Working Group «Residues» of the German Environment Agency UBA
- Legally classification of bottom ash from incineration of municipal waste in accordance with the Waste Catalogue Ordinance, making special allowance for the «H» (hazard) criteria on the basis of the Confederation of European Waste-to-Energy Plants (CEWEP) Bottom Ash Dossier and the legislation on hazardous goods
- Handling of combustion residues in Germany and Europe - Data collection and evaluation
- Research into other possible applications, beyond roadbuilding, for bottom ash from incineration of municipal waste
- Support of current projects e.g. on nanoparticles in bottom ash and flue gas cleaning residues or copper/fluorine/chromium
- Support of current projects on new methods for treating bottom ash and flue gas cleaning residues
- Demands of several member states for a limit value for lead in the fraction < 1 mm of 0.03 % (300 mg/kg) in reference to HP 10
- Currently, elaboration of a recommendation to members as to how bottom ash is to be classified on the basis of the changed legal situation (expiry of transitional periods of Dangerous Substances and Dangerous Preparations directives – new: CLP)

Separting and recycling the metal fractions from the by-products is an overriding objective. However, this has considerable influence on the properties of the remaining mineral fraction as building material. Metal recycling stands or falls with the metal prices (Figure 2).

Recycling aspects are examined at regular workshops and complemented by additional current issues. The next event takes place on 17 November 2016 in Hamburg.

Technical Committee «Chemistry»

Andreas Wecker

The Technical Committee «Chemistry» coordinates the chemicals-related issues dealt with in the technical groups «Analytics», «Chemical Process Engineering», «Chemistry of Light Water Reactors» and «Emission Control», sets the framework for the annual conference «Chemistry in Power Plants» and determines its focal topics. It also deals with chemical issues of the water-steam cycle and chemical influence on corrosion in power plants.

Legionella control and reduction of mercury emissions continued to be central topics of the technical groups’ reports. In both cases the aim is to support the setting of limit values with technical information. On the mercury issue, information additionally was compiled on the situation in the USA.

The committee endeavours to popularise the VGB standards relevant to the water-steam cycle also beyond the borders of Germany. To this end, membership in the International Association for the Properties of Water and Steam is envisaged.

The committee is providing intense support for the drafting of the VGB standard on the preservation of power plant systems, which will be completed this year, while work on a new VGB standard for dosing systems in the water-steam cycle has begun. This standard is intended as an addition to the existing standards VGB-S-006 and VGB-S-010 to round off the topic of chemistry in connection with the water-steam cycle.

The last conference «Chemistry in Power Plants 2015» took place in Berlin. With some 330 participants, it was well attended. The issues ranged from water-steam cycle to flue gas cleaning, water treatment and analytics. Unfortunately, increasingly fewer lectures from the field of nuclear chemistry are presented.

Technical Group «Analytics»

Andreas Wecker

The Technical Group «Analytics» currently is working to complete a VGB standard on analytical procedures in power plants as well as a standard for the standardization of conditions for activity tests on mercury oxidation catalysts.

The round robin test for the determination of mercury in coals, designed to check the comparability of different solids analysers, was completed. As result, it could be shown that no significant differences exist between the standard procedures and other procedures. However, all procedures experience difficulties where low mercury concentrations [<0.05 mg/kg] are involved.
Technical Group «Chemistry of Light Water Reactors»
Dittmar Rutschow

QP Database

The QP Database (QP-DB) is the successor to the supply source directory in which new products can be qualified for use in nuclear power plants. Basis for the evaluation of products finding use is DIN 25493 – «Nuclear facilities – Protection of metallic surfaces of structural parts from damage from assembly aids, gaskets, packings, packaging material and thermal insulating materials». To date, the database has been maintained by AREVA. The cost of database operation and of the respective analyses was shared between all plants concerned. However, the public utility companies had no rights to the analytical data. As more and more nuclear power plants enter the dismantling phase and no longer participate in QP-DB, the costs for the remaining participants increase tremendously. The VGB working group was set up to create, together with AREVA, a more cost-effective solution than now exists and to transfer the rights to the operators.

Through VGB, three different offers for a less costly database were obtained. Services and prices of the three databases available for selection were compared and discussed. In future, operators should be able to enter their own analyses in the database.

What the price would be for taking over the data from the AREVA database, and the costs the participating plants could expect to incur if AREVA were contracted for one year or for ten years were discussed along with the pros and cons to be considered. Allowing for the proposal of the Technical Committee Nuclear Power Plant Operation, the members of the technical group agreed that AREVA could handle assurance of the data quality of the VGB database with a 20% engineering position.

Various proposals for attending to the VGB database (with and without AREVA) were discussed along with the pros and cons to be considered. Allowing for the proposal of the Technical Committee Nuclear Power Plant Operation, the members of the technical group agreed that AREVA could handle assurance of the data quality of the VGB database with a 20% engineering position.

A cost sharing scheme for the new database, the support, the takeover of the data from AREVA and the 20% engineering position AREVA already were decided upon at the TG «LWR Chemistry» extraordinary meeting. The decision still requires the approval of AREVA and the Technical Committee Nuclear Power Plant Operation.

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Caustic embrittlement/stress corrosion cracking on feedwater instrument line

In a power plant a leak of 60 litres per hour was found in the condensate tanks of the fan coil units. An on-site inspection by the shift and the radiation protection unit found a steam leak in the area of the feedwater non-return valve, which could not be isolated. As a result, the plant was shut down. After it cooled down, the mechanical engineers and the radiation protection unit conducted an inspection which discovered a leak in an instrument line upstream of the valve (Figures 1 and 2). The pipe section was replaced. The plant was restarted and could be re-synchronised 54 hours after the leak was first discovered. The removed piece of pipe was examined. It turned out that intergranular cracks had occurred; the pipe presumably had been cold-worked. The same damage pattern could be demonstrated by subsequent corrosion tests also on a cold-bent pipe section.

Legionella

Legionella measurement was begun one year ago in Grohnde. It turned out that in the months of August and September more legionella could be found in the cooling water than in other months. This was also confirmed by other power plants. In the meantime a so-called key issues paper has been published, with the help of which the handling of legionella in cooling towers is to be regulated in the ordinance (BImSchV). The VDI Standard 2047 Part 3, «Hygiene in large natural-draught cooling towers», was revised.

At present, the draft of the 42nd Ordinance (BImSchV) for the implementation of the German Federal Ambient Pollution Control Act (Ordinance governing evaporative cooling systems and wet scrubbers (VerdunstKühlV)), is running through the coordination process.

VGB Guideline VGB-R 401

VGB Guideline VGB-R 401 consists of two parts, one on PWR chemistry and one on BWR chemistry (see also Figure 3 and Figure 4). Both parts currently are being examined for their relevance and revised in the project groups «VGB-R 401 – PWR Chemistry» and «VGB-R 401 – BWR Chemistry». The PWR group currently comprises Dr Böttcher, Dr Drexler, Mr Fandrich, Dr Odar and Dr Stoll. The BWR group is made up of Dr Roth, Dr Drexler, Mr Fandrich, Dr Kilian, Mr Krumpholz, Dr Stellwag and Dr Weber.
Fig. 12: VGB Workshop «Water in Power Plants 2016».

Technical Group «Chemical Process Engineering»
Ditmar Rutschow

Project Group «Microbiology in Cooling Towers»
The project group was formed of members of the technical groups «Cooling Systems in Power Plants» and «Chemical Process Engineering.» Together with BDEW, the German Association of Energy and Water Industries, the project group has commented on the ministerial draft of the 42nd Ordinance «Evaporative cooling systems». Owing to the previous discussions at the state (Jülich) and federal levels, the draft now provides for higher (by a factor of five) action values for natural-draught cooling towers > 200 MW (thermal rating). The finalised ordinance is expected to become effective at the end of 2016.

VDI 2047 Part 2 concerns cooling systems with a thermal rating of less than 200 MW. The large natural-draught cooling towers were removed from Part 2 due to objections by VGB and are to be dealt with in Part 3, which is being drafted together with VGB.

In summer 2016 it is planned to make further measurements in cooling tower plumes and conduct laboratory studies in the framework of a VGB research project.

Project Group «Cooling Water Standard»
The Cooling Water Guideline VGB-R 455 is being reworked by the members of the TG «Chemical Process Engineering» and the TG «Cooling Systems in Power Plants». Revision has made such progress that a draft can be presented at the autumn meeting of the TG Chemical Process Engineering.

Following format adjustment and proofreading by VGB, the guideline probably will go on sale as VGB standard in a printed version next year.

Instruction Sheet VGB-M 405 G – «Water Demineralisation by Ion Exchangers»
The instruction sheet VGB-M 405 G, «Water Demineralisation by Ion Exchangers», currently is being revised; the changes already are being entered in the existing version during the meetings. The last third of the instruction sheet, which deals with measurement and testing, will be reduced, since it currently appears to be too comprehensive. Dr Krebs, BASF, a new member of the TG Chemical Process Engineering, also is interested in reworking the instruction sheet and is already participating in the work of the VGB-M 405 project group. After completion, probably in autumn 2016, the instruction sheet will be available as a VGB-Standard.

Preservation guidelines
The preservation guideline is being elaborated by a project group of the Technical Group «Steam Generators». One member of this project group also is a member of the Technical Group Chemical Process Engineering and has requested the TG to revise the chapters of the preservation guideline from a process engineering viewpoint. The chapters «Preservation of components in water treatment plants», «Membrane systems» and «Amines» were presented and discussed by the TG Chemical Process Engineering. Desired changes were included in the text. The preservation guideline is complete and will be available for sale as a VGB standard at the end of this year or the beginning of next year.

Workshop «Water in Power Plants»
The «Water in Power Plants 2016» workshop took place this time in March, in Leipzig, with 72 participants. Fifteen presentations dealing with operating experience and technical advances in the area of power plant chemistry were submitted. Much of the programme was taken up by the topics: use of film forming water treatment, biofilm formation, use and generation of chlorine dioxide, corrosion occurring in power plants, and removal of heavy metals from wastewater. A joint exchange of experience with stimulating discussions followed the presentations.

Technical Group «Emission Control»
Andreas Wecker

Besides exchanging experience, in particular the European technical group prepared and conducted the workshop «Flue Gas Cleaning 2016» in Copenhagen. To involve the participants in an even deeper dialogue, at the end of the event a roundtable discussion on several key issues was offered and met with interest.

Possible research projects in the field of mercury reduction in the flue gas of power plants were discussed. The operators have much experience in this area that can be contributed to the projects. Due to restructuring in the research divisions of enterprises, the further pursuit of concrete measures had to be put off for the time being.

In some countries, currently a change from coal to wood firing is taking place. The problems which this creates for air pollution control were discussed.

To attain the limit values for emissions presented in the draft from the BREF LCP process, many plants in Europe must be retrofitted especially for NOx control. Various options for primary and secondary measures are under discussion.

Technical Committee «Safety & Health at Work»
Karl-Heinz Puch

The definition and interpretation of key performance indicators (KPIs) is a central topic. An indicator is needed that is unambiguously defined and internationally comparable. The Technical Commission «Safety & Health at Work» therefore has decided in favour of the lost time injury frequency (LTIF). This is the number of accidents with lost time of one day or more per one million hours worked. The advantage of this most frequently used definition is its lack of ambiguity. Neither presentation to a doctor, nor various stages of unconsciousness, nor measures beyond first aid require more exact definition. In contrast, the accident-induced absence on the day following the accident (and
The handling of working materials gets special attention. The focus is on the rules for dust. The power plant operators have instituted a number of arrangements for dealing with partner firms. However, they differ in their approach to implementation and are subject to constant adjustment. With Security-Safety-Management (SeSaM), VGB PowerTech e.V. makes a tool available for assessing the safety and health management systems of partner firms. Certified companies are included in a list that is made available to VGB member companies online, free of charge.

Occupational safety and health management systems are a continuous item on the agenda of the meetings. The aim is to maintain and improve the high standards at energy utilities.

Technical Group «Industrial and Environmental Medicine/Health Management»

Lena Jentjens

The six-monthly meetings of the TC «Industrial and Environmental Medicine/Health Management» focus on an intensive exchange of experience and the events and developments in health, safety and environmental management.

One permanent item on the agenda for the meetings 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.

A focal issue at present is the implementation of the German Act to Strengthen the Promotion of Health and Prevention of Disease (Prevention Act – PrävG), which the German parliament passed on 18.06.2015. The health insurance funds will invest more in health promotion and prevention in future. One major component of that is workplace health promotion.

- With a series of statutory measures, the Prevention Act promotes prevention of disease by vaccination. Vaccination continues to be voluntary, but the provision of advice on vaccination is to be significantly expanded. Company medical officers in Germany are also to be able to perform general protective vaccinations in future. Health insurance funds are invited by the Prevention Act to conclude framework agreements with company medical officers.

- Special attention was paid to shift workers, for whom it is to be made easier, as a result of their special stress situation at work, to take up primary prevention and precaution measures.

- On the subject of medical examinations, the health insurance funds could enter into contracts with the company medical officers. As the extent of this cannot yet be predicted, there will presumably be no decision taken this year.

Report for 2015 (based on input from all members). Overall result.

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Tab. 1: PI Report for 2015 (based on input from all members). Overall result.

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

Current discussions concern the planned cancellation of radiation testing in Switzerland. There are to be no more routine radiation tests in Switzerland from mid-2016 onwards. In future, the burden is to rest on the responsibility of the employer and the responsibility of the employees for themselves.

The question of how to deal with cross-border deployment (especially in Germany) has not yet been clarified. Swiss personnel will then no longer be able to submit documentation on medical examinations for suitability. Information on this topic is to be passed on through the TG Medical Scientists at Nuclear Power Plants.

As a result of the push by Swiss insurance organization SUVA to do without routine testing, the argument of the «healthy worker effect» would no longer apply. That very «healthy worker effect» is the result of a current epidemiological study on the effect of small doses of radiation in persons exposed to radiation at work, to which German power supply utilities have also contributed data.

Another study which is currently receiving critical attention (the INWORKS study) deals with the effects on health of ionizing radiation in the low dose range at nuclear facilities in France, the UK and the USA.
Technical Group «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 2017.

The project group that is preparing the VGB Standard «Fire Protection in Wind Power Plants» in cooperation with the Technical Committee Wind Energy has taken up its work. The first meetings were spent establishing a common view between the fire protection specialists and the wind turbine operators. So far, an example of a fire protection concept has been worked out, a comprehensive case study on the rescuing of persons in the event of a fire has been prepared, and a list of the fire risks and the possible countermeasures has been compiled. The VGB standard will describe the topic in its entirety and recommend concrete options for protecting wind power plants and individual components against fire hazards. Publication is scheduled at some time during 2017.

The Technical Group Fire Protection discussed the technical requirements for fire protection and specific procedures for power plant sites put in reserve or being decommissioned and dismantled. Especially for the dismantling of nuclear power plants, the great administrative effort, plus the typical challenges involved in coordinating external firms, in combination with one’s own limited personnel resources, poses a particular challenge. Once the plant is radiation-free, the fire protection regulations for conventional plants and construction sites become effective until all fire loads have been eliminated and the remaining plant parts are secured and can be taken down. To effect the transition from the legal requirements for nuclear power plants to conventional fire protection, in the examples discussed we could draw on the assistance of the colleagues responsible for fire protection in coal-fired plants was very welcome. For conventional power plant units in reserve, relaxing of the fire protection regulations is not a real option since it must be possible to put the plants back into service safely and at short notice. Merely an extension of the inspection intervals appears feasible.

A further topic taken up was the use of thermographic measurement for early fire detection. A major advantage of this infrared technology is the insensitivity of detection to poor visibility (smoke, steam), which makes the use of this technology possible while fighting a fire. The once frequent false alarms caused by light reflections or vehicle traffic meanwhile could be eliminated by new evaluation software. In addition, an all-in-one solution as combination of IR camera, alarm system and fire monitor has been developed. The technology thus now provides a good means of surveilling chiefly larger areas, as for example in open-cast lignite mines, and directly initiating first response firefighting in combination with remote-controlled fire monitors.
Technical Services

Technical Services/ Engineering Consultancy

Christian Ullrich and Oliver Then

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

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

Engineering consultancy

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

- Regular peer reviews within the scope of the erection and commissioning of various new build projects by an international VGB member company
- Performance of risk and hazard analysis (Safety Integrity Level, SIL) for the boilers at a chemical site
- Support in formulating the invitation to tender for an operation and maintenance contract for the energy supply facilities of a German university
- Compilation of a valuation for a wood-fired power plant on behalf of the financing bank
- Damage assessment of the internal insulation of a waste gas duct for an international chemical company operating in Germany
- Final editing of the order specification for a new steam turbine for a waste-to-energy plant
- Determination and assessment of damage on steam and gas turbines of different sizes and for different applications, including distorted casing, damaged blades and axial bearings
- Optimization of turbine operation to prevent casing distortion and resulting impermissible vibrations
- Auditing of a non-OEM workshop on behalf of an operator
- Joint assessment and discussions with the VGB department «Supervision of Construction and Assembly» and the water chemistry laboratory concerning the ingress of salts into a turbine.

Maintenance

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

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

Turbine condenser

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

Steam generators

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

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

In the period under review, around 240 damage cases were investigated with state of the art laboratory equipment by the VGB materials laboratory. The scanning electron microscope (field emitter) and the X-ray diffraction system are worthy of special mention.

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

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

During the period under review, special was attached to damage caused by unexpected crack formation in the austenitic material HR3C, occurring in reheater 2 of several new build power plants after only a short operating time. The VGB Materials Laboratory performed the damage investigations on several cracked weld seams from the first two power plants affected.

Intergranular corrosion was clearly identified as the cause of the damage. Intergranular corrosion arises in low-chromium areas along the grain boundary when impacted by a corrosive medium. Depletion of chromium is caused by the input of welding heat. Several laboratory tests were carried out to confirm the root cause. Special corrosion tests like the Strauss test proved that the welded connections are generally susceptible to intergranular corrosion. Numerous tests were then made at the power plants sites for verification. It was found that condensate which is created during boiler heating, such as was performed for the T24 heating surfaces, was responsible for the damage.

Water chemistry

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

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

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

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.

The share of operator funds spent on these new projects amounts to 16%, raised through 5% project contributions of individual companies (full VGB members) and 11% joint research contributions of full VGB members (VGB research levy). «Other funds», including manufacturer contributions, amount to 46%. A good third of the total project volume was raised through public funding (38%).

Fig. 1: Organisation of R&D coordination.

Project funding in 2015

Table 1 shows the status of project funding as of May 2016. 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 2015 VGB took part in a total of 30 projects with a total volume of 64.9 million € (last year: 35 projects with a volume of 65.1 million euros). Of these, 7 projects with a volume of 3.7 million € were started in 2015 (last year: 12 projects and 6 million €).

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### Tab. 1: Projects funded by VGB since 2011, completed projects are highlighted in grey (as of 05/2016).

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<thead>
<tr>
<th>No.</th>
<th>Abbreviated title</th>
<th>Duration</th>
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<td>Efficiency of air filters at high humidity</td>
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<td>Investment requirements in European electricity-generating infrastructure towards 2050</td>
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<td>New Materials for Steam Turbines V (Continuation</td>
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<td>New 12% chromium steels</td>
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<td>334</td>
<td>KSR - Variation of Prestress Time</td>
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<td>352</td>
<td>Hybrid High Solar Share Gas Turbine System</td>
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<td>Bank-related costs among employees in wind turbines</td>
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<td>HOSEP - Self-ignition of biomass</td>
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<td>Market analysis of control loop performance CMS</td>
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<td>Reliability indicators with KISSY</td>
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<td>Calculation methods</td>
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<td>Sulphate resistance - literature research</td>
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<td>Knowledge to avoid coarse grain structure in austenitic materials</td>
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<td>366</td>
<td>Standardised remote terminal unit for wind power plants</td>
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<td>MACPLUS-COMTES/DOET/TV-Corperation</td>
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<td>368</td>
<td>Further investigations of the sulphate resistance of NH4</td>
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<td>Final report in progress</td>
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</table>
Nuclear power engineering

The subcommittees and panels of the General Committee «Nuclear Power Plants» fund operation-related research and development projects for nuclear power plants. They are financed by the nuclear power plant operators according to the cost-sharing principle across all the plants involved in each project. In 2015, 39 projects with a total funding volume of 3,484,277 euros (last year: 33 with 2,666,272 euros) were awarded.

Collaboration with universities and promotion of vocational training

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

Supported by the Scientific Advisory Board and financed by the VGB RESEARCH FOUNDATION, a summer school course was again held for advanced students from 10 to 21 August 2015. The summer school POWER PLANT 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 2015, 19 students from eight German, Greek and Slovenian universities took part (Figure 2).

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

VGB Innovation Award

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

- Markus Rabensteiner, for his study of CO₂ solvents in the post-combustion pilot plant of the hard-coal-fired power plant Dürnrohr in Austria, and to
- Dr Martin Schiemann, for his study of the pyrolysis characteristics and char burnout of solid fuels, which has led to a better understanding of the burn-up kinetics of coal and biomass fuel (including torrefied biomass).

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 Congress POWER PLANTS 2015 in Vienna, Austria (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 2016 awards presentation, is available online at www.vgb.org.
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 for almost 60 years. Plant operators all over the world trust KWS to provide training and advanced training to their specialists, and benefit from expert advice on technical matters and problems of organisation and human resources development. In 2015 more than 2,500 participants took advantage of the offer of roughly 320 events. KWS as reliable partner thus contributes to a safe, environment-friendly, affordable supply of energy.

Training at KWS

Conventional power plant technology

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

Renewables

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

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

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 competence team Organisational Development addresses these requirements and offers process analyses, best practice workshops, reviews of shift manning levels, 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 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 performing virtual commissioning prior to the real commissioning of power plants. The training models used in the simulators are constantly being improved to reflect the increased demands of grid operation.

Nuclear power engineering/radiation protection

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

The competence team Nuclear Power Engineering/Radiation Protection offers a broad range of officially recognised courses for training the responsible nuclear power plant personnel and maintaining their 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 both for acquiring and upgrading knowledge and skills. Relevant issues in connection with disassembly and idle operation of nuclear power plants also are taken into account. This is a growth market, and with the opportunities afforded by its partner power plant Zwentendorf, KWS has a unique selling point for practical training.

International activities

KWS has the ability to support members’ activities in foreign countries and can carry out simulator training and theoretical training worldwide. KWS is familiar with many of the structures of training and advanced training outside Germany. Additionally, KWS elaborates operational solutions jointly with the companies. The lecturers’ expertise is supplemented by linguistic skills; instruction can be given in English and Dutch. A complete series of publications covering all topics of relevance to power plants is available in English and Dutch.

Apartment house and conference venue

With the new apartment house opened in mid-July 2013, KWS now also bundles the accommodations for course participants at the Deilbachtal Energy Campus in Essen-Kupferdreh. KWS thus can offer a venue – also over several days – for conferences of any kind in state-of-the-art conference rooms that meet the demands of modern communication.
VGB: Events and Publications

VGB Events
Angela Langen

In the period under review, July 2015 to June 2016, VGB hosted 24 events attended by a total of 2,871 people. 768 of these took part in seminars and workshops, while 2013 attended the conferences and the congress.

Six events were accompanied by trade exhibitions, at which 235 companies presented their products and services.

VGB Congress «POWER PLANTS 2015» in Vienna
The VGB Congress «POWER PLANTS 2015» took place in Vienna from 9 to 10 September 2015. Under the motto of «Energy Transition – Opportunities for Power Generation», over 500 participants from 26 countries discussed the challenges and also the opportunities facing the energy sector. In the specialist sections, over 22 speakers delivered presentations on the following focal topics and were available for detailed discussions.

- Solutions to the demand for power generation – Developments in conventional generation
- Solutions to the demand for power generation – Developments in renewables-based generation
- Ensuring system stability
- Increasing the flexibility of existing plants

Furthermore, 71 exhibitors presented their products and services on a net area of 750 m² at the Vienna Congress Center.

VGB Conference «Chemistry in Power Plants 2015» in Berlin
The long-established VGB Chemistry Conference with trade exhibition took place in Berlin from 27 to 29 October 2015. The topics focused on the preservation of power plant systems, legionnaire’s disease, and mercury. 39 corporate exhibitors presented their products and services at the sold-out exhibition, and 248 conference participants exchanged notes on their experience.
Tab. 1: VGB events July 2015 to June 2016.

<table>
<thead>
<tr>
<th>Date</th>
<th>Place</th>
<th>Kind of event</th>
<th>Title</th>
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<tbody>
<tr>
<td>9 and 10 September 2015</td>
<td>Vienna, Austria</td>
<td>Congress with exhibition</td>
<td>Power Plants</td>
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<tr>
<td>11 and 12 September 2015</td>
<td>Emden</td>
<td>Workshop</td>
<td>Offshore Wind Power Plants – Occupational Health</td>
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<td>15 and 16 September 2015</td>
<td>Egestorf</td>
<td>Training</td>
<td>QS Requirements of Nuclear Processing of Orders/Purchase</td>
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<td>6 to 8 October 2015</td>
<td>Essen</td>
<td>Seminar</td>
<td>Chemistry in the Water Steam Cycle</td>
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<td>27 to 29 October 2015</td>
<td>Berlin</td>
<td>Conference with exhibition</td>
<td>Chemistry in Power Plants</td>
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<tr>
<td>10 November 2015</td>
<td>Essen</td>
<td>Workshop</td>
<td>Noise Protection</td>
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<td>11 and 12 November 2015</td>
<td>Ludwigshafen</td>
<td>Workshop</td>
<td>Training for Immission Control and Incident Commissioners (German national law. only)</td>
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<td>1 December 2015</td>
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<td>2 and 3 December 2015</td>
<td>Niederstetten</td>
<td>Training</td>
<td>VGB Training for Advanced Learners – Module 2 Building Inspection and Module 3 Documentation</td>
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<td>7 and 8 December 2015</td>
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<td>Workshop</td>
<td>Design of Shift Schedule – Experiences and Ideas …</td>
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<td>15 December 2015</td>
<td>Oberhausen</td>
<td>Workshop</td>
<td>Workshop High Temperature Corrosion in Biomass Power Plants</td>
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<td>23 and 24 February 2016</td>
<td>Bielefeld</td>
<td>Workshop</td>
<td>Screw and Seal Technology</td>
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<td>2 and 3 March 2016</td>
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<td>Maintenance in Power Plants Maintenance of Wind Power Plants</td>
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<td>10 and 11 March 2016</td>
<td>Leipzig</td>
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<td>Water in Power Plants</td>
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<td>6 and 7 April 2016</td>
<td>Potsdam</td>
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<td>Seminar</td>
<td>Water treatment and chemistry in power plants [German]</td>
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<td>Workshop</td>
<td>Safety &amp; Health in the Wind Energy Industries</td>
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<td>10 to 12 May 2016</td>
<td>Cologne</td>
<td>Conference with exhibition</td>
<td>KELI</td>
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<td>11 and 12 May 2016</td>
<td>Copenhagen, DK</td>
<td>Workshop</td>
<td>Flue Gas Cleaning</td>
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<td>8 and 9 June 2016</td>
<td>Dresden</td>
<td>Conference with exhibition</td>
<td>Steam Turbines and Operation of Steam Turbines</td>
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<tr>
<td>15 and 16 June 2016</td>
<td>Berlin</td>
<td>Workshop</td>
<td>Mercury Control</td>
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<tr>
<td>15 and 16 June 2016</td>
<td>Kassel</td>
<td>Conference</td>
<td>Fuel Technology and Combustion</td>
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VGB «KELI 2016» Conference in Cologne

The «Conference on Electrical Engineering, Instrumentation and Control, and Information Technology», known as KELI for short, took place this year in Cologne from 10 to 12 May. The VGB presentations on «Integration of energy from renewable sources in the electricity grid (system stability, deployment regimes and market models)» and «Requirements for the functions of electrical, I&C and information systems in all types of generation» were once again accompanied by matching presentations from the manufacturers (exhibitors). The topic of education and training and next-generation engineers was dealt with in a student forum with lectures and discussion rounds.

VGB Conference «Steam Turbines and Operation of Steam Turbines 2016» in Dresden

Every two years, operators, manufacturers, insurance companies, authorities and experts from the field of R&D discuss current issues concerning steam turbines and their operation. As in previous years, the cooperating companies present their products and services in an accompanying trade exhibition. Both in discussions at the booths and during the background programme, around 380 participants and 40 exhibitors had the opportunity of a brisk exchange of ideas and the establishment and development of business contacts on 8 and 9 June 2016. At this point we should like to thank all the participants, sponsors, cooperating part-
nners and exhibitors for their support and attendance in large numbers. We look forward to further good cooperation and future events.

Energy fairs 2015

VGB took part as an exhibitor in Husum Wind in Husum from 15 to 17 September 2015, in ICCI in Istanbul from 27 to 29 April 2016, and in POWER-GEN Europe 2016 in Milan from 19 to 21 June 2016, and used these opportunities to make new contacts and attract new members.

VGB Publications

Christopher Weßelmann

VGB PowerTech Journal

From 1 July 2015 to 30 June 2016 a total of 161 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 completed during the year under review:

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

- VGB-S-002-2012-04-DE Termes fondamentaux du secteur de l'électricité
- VGB-S-002-01-2015-10-DE Elektrizitätswirtschaftliche Grundbegriffe
- VGB-S-002-02-2014-06-EN Hydropower
- VGB-S-002-05-2016-04-DE Windenergieanlagen (WEA) Definitionen und Kennwerte
- VGB-S-002-05-2016-04-EN Wind Turbines (WT) - Definitions and Indicators
- VGB-S-012-00-2016-02-DE Prozessgüte in der Energiotechnik
- VGB-S-019-00-2015-08-DE Training4Future
- VGB-S-021-00-2016-03-DE Korrosionsschutz von Offshore-Windenergieanlagen und Windparkkomponenten
- VGB-S-037-00-2016-06-EN Lehrangsempfehlung für die Weiterbildung zum/zur Geprüften Kraftwerker/ Geprüften Kraftwerkerin
- VGB-S-041-00-2016-04-DE Standards für professionelles Führungsverhalten
- VGB-S-043-00-2016-06-DE Konzept für die (Wiederholungs-)Schulung zur Durchführung von nicht routinemäßigen Tätigkeiten in deutschen KKW
- VGB-S-115-00-2016-01-DE Empfehlungen für die Revision von Dampfturbinen
- VGB-S-120-00-2016-02-EN Exclusion of foreign material ingress into opened systems/components of nuclear power plants
- VGB-S-120-00-2016-02-DE Vermeidung von FremdkörperEintrag in geöffnete Systeme/Komponenten von Kernkraftwerken
- VGB-S-163-00-2015-07-EN Operational safety in electrotechnology
- VGB-S-163-00-2015-07-DE Betriebssicherheit in der Elektrotechnik
- VGB-S-166-00-2014-02-EN Quality Assurance in the Manufacture of Generators
- VGB-S-169-11-2015-11-DE Qualitätsanforderungen für Mineralöle in Transformatoren
- VGB-S-210-00-2015-07-EN Characterisation of Power Plant Coal
- VGB-S-210-00-2015-07-DE Charakterisierung von Kraftwerks Kohlen
- VGB-S-504-00-2015-12-EN Inspection and Testing of Large Forgings and Castings for Steam and Gas Turbine Generator Sets
- VGB-S-504-00-2015-12-DE Prüfung von großen Schmiede- und Gusstücke für Dampf- und Gasturbinensätze
- VGB-S-823-31-2014-12-EN RDS - Application Guideline, Part 31: Hydro Power Plants
- VGB-S-831-00-2015-05-EN Provision of Technical Documentation (Technical Plant Data, Documents) for Energy Supply Units
- VGB-S-831-00-2015-05-DE Lieferung der Technischen Dokumentation (Technische Anlagendaten, Dokumente) für Anlagen der Energieversorgung

VGB-standards

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

AGFW | Der Energieeffizienzverband für Wärme, Kälte und KWK e. V.
Arbeitsgemeinschaft Kernmaterial-Überwachung (AKÜ)
Arbeitsgemeinschaft Druckbehälter (AD)
Arbeitsgemeinschaft warmfeste Stähle
ASME American Society of Mechanical Engineers
Association of European Gypsum Industries
Bundesverband der Energie- und Wasserwirtschaft (BDEW)
BDI Bundesverband der Deutschen Industrie
Berufsgenossenschaft der chemischen Industrie
Berufsgenossenschaft Feinmechanik und Elektrotechnik
Bundesverband der Gipsindustrie e. V.
BVK Bundesverband Kraftwerksnebenprodukte e. V.
CEN – Europäisches Komitee für Normung
CENELEC European Committee for Electrotechnical Standardization
Deutsche Akkreditierungsstelle «Stahlbau und Energietechnik e. V. (DASET)»
Deutsche Elektrotechnische Kommission (DKE)
dena – Deutsche Energie-Agentur
Deutsche Gesellschaft für chemisches Apparatewesen e. V. (DEHEMA)
Deutsche Vereinigung für Verbrennungsforschung e. V. (DVV)
Deutscher Ausschuss für Stahlbeton (DAFSb)
Deutscher Verband für Schweißtechnik e. V. (DVS)
Deutsches Atomforum e. V. (DAF)
Deutsches Institut für Bautechnik
Deutsches Institut für Normung e. V. (DIN)
Deutsches Komitee Instandhaltung (DKIN)
ECOBA European Coal Combustion Products Association
EIPPCB European Integrated Pollution Prevention and Control Bureau
EnergieAgentur NRW
Entsorgungskommission (ESK)
EPPSA, European Power Plant Suppliers Association
EPRI Electric Power Research Institute
ENTSO European Network of Transmission System Operators for Electricity
EUUnited 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/DEHEMA-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 Weltenergierates 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 Städteentwicklungsverbandes (VKS)
Verband der Industriellen Energie- und Kraftwirtschaft e. V. (VIK)
Verein Deutscher Ingenieure (VDI)
Verein Deutscher Zementwerke (VDZ)
Wirtschaftsverband Kernbrennstoff-Kreislauf und Kerntechnik e. V. (WKK)
World Association of Nuclear Operators (WANO)
World Energy Council (WEC)
Power Plant Statistics

Stefan Prost and Jean-François Lehouge

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 603 power plants and 168 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 2006 and 2015.

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

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

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. 2: Operating diagram and performance indicators.
Fig. 3: VGB member units evaluated in 2015.

Fig. 4: Energy availability and energy utilisation. Data for 2015 and mean values for 2006 to 2015.
Fig. 5: Energy unavailability. Data for 2015 and mean values for 2006 to 2015
*) French nuclear power plants without “unplanned disponible energy unavailability”
<table>
<thead>
<tr>
<th>Power Plant Type</th>
<th>Unavailability in %</th>
<th>Availability in %</th>
<th>Available but not in operation in %</th>
<th>Utilisation in %</th>
<th>Available but not in operation in %</th>
<th>Utilisation in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 399 MW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 400 MW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressurised water reactor</td>
<td>17.3</td>
<td>81.1</td>
<td>28.1</td>
<td>17.5</td>
<td>82.7</td>
<td>17.9</td>
</tr>
<tr>
<td>Boiling water reactor</td>
<td>17.6</td>
<td>82.4</td>
<td>71.9</td>
<td>82.5</td>
<td>30.8</td>
<td>19.9</td>
</tr>
</tbody>
</table>

Fig. 6: Nuclear power plants: availability data year 2015 and mean values 2006 to 2015.

Fig. 7: Hard coal-fired power plants: data for availability year 2015 and mean values 2006 to 2015.

Fig. 8: Lignite-fired power plants: data for availability year 2015 and mean values 2006 to 2015.

Fig. 9: Fossil-fired power plants: data for availability and unplanned unavailability 1993 to 2015.
**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 466,000 MW of the VGB PowerTech members is represented in the following power plants (as of 30 June 2016):

- 246,000 MW fossil-fired power plants
- 120,000 MW nuclear power plants
- 100,000 MW hydro power plants and other renewables

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

In the reporting period 2015/2016, 25 companies joined the VGB with a total capacity of 29,000 t/h. 35 companies with a total capacity of 12,000 t/h withdrew from VGB.

The installed steam generating capacity of the members at that point increased by 15,000 t/h or 1.1 % to a total of 1,340,000 t/h as a result of the steam generating capacity of the new members and after the drop in the steam generating capacity of the withdrawn companies.

The headquarters of 346 members are located in Germany, the country in which VGB PowerTech was set up in 1920. The headquarters of 132 members (28 %) are located in further 33 countries in Europe and other parts of the world.

---

**Fig. 1:** VGB memberships according to European countries.

Outside of Europe, another 13 companies in 10 countries are VGB members.

<table>
<thead>
<tr>
<th>Country</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>1</td>
</tr>
<tr>
<td>Australia</td>
<td>1</td>
</tr>
<tr>
<td>Austria</td>
<td>32</td>
</tr>
<tr>
<td>Belgium</td>
<td>5</td>
</tr>
<tr>
<td>Brazil</td>
<td>1</td>
</tr>
<tr>
<td>China</td>
<td>1</td>
</tr>
<tr>
<td>Croatia</td>
<td>2</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>1</td>
</tr>
<tr>
<td>Denmark</td>
<td>7</td>
</tr>
<tr>
<td>Finland</td>
<td>10</td>
</tr>
<tr>
<td>France</td>
<td>3</td>
</tr>
<tr>
<td>Germany</td>
<td>346</td>
</tr>
<tr>
<td>Greece</td>
<td>1</td>
</tr>
<tr>
<td>Ireland</td>
<td>1</td>
</tr>
<tr>
<td>Israel</td>
<td>2</td>
</tr>
<tr>
<td>Italy</td>
<td>3</td>
</tr>
<tr>
<td>Japan</td>
<td>3</td>
</tr>
<tr>
<td>Latvia</td>
<td>1</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>2</td>
</tr>
<tr>
<td>Mongolia</td>
<td>1</td>
</tr>
<tr>
<td>Netherlands</td>
<td>18</td>
</tr>
<tr>
<td>Norway</td>
<td>2</td>
</tr>
<tr>
<td>Poland</td>
<td>6</td>
</tr>
<tr>
<td>Portugal</td>
<td>1</td>
</tr>
<tr>
<td>Romania</td>
<td>2</td>
</tr>
<tr>
<td>Russia</td>
<td>2</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>1</td>
</tr>
<tr>
<td>Slovenia</td>
<td>2</td>
</tr>
<tr>
<td>South Africa</td>
<td>1</td>
</tr>
<tr>
<td>Spain</td>
<td>2</td>
</tr>
<tr>
<td>Sweden</td>
<td>7</td>
</tr>
<tr>
<td>Switzerland</td>
<td>7</td>
</tr>
<tr>
<td>Turkey</td>
<td>2</td>
</tr>
<tr>
<td>USA</td>
<td>1</td>
</tr>
</tbody>
</table>

478 Companies from 34 countries
Size of members with thermal power plants according to installed steam capacity:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 200 t/h</td>
<td>34.0</td>
<td>33.0</td>
<td>1.3</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>201 to 500 t/h</td>
<td>22.0</td>
<td>21.5</td>
<td>1.3</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>501 to 1,000 t/h</td>
<td>9.0</td>
<td>8.5</td>
<td>1.2</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>more than 1,000 t/h</td>
<td>35.0</td>
<td>37.0</td>
<td>96.2</td>
<td>96.4</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

On June 30, 2016 VGB had the following membership:

<table>
<thead>
<tr>
<th>Companies</th>
<th>Number in %</th>
<th>Steam capacity in t/h in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public supply companies (utilities)</td>
<td>166</td>
<td>64.8</td>
</tr>
<tr>
<td>Industrial supply companies</td>
<td>90</td>
<td>35.2</td>
</tr>
<tr>
<td>Total (supply companies)</td>
<td>256</td>
<td>100.0</td>
</tr>
<tr>
<td>Affiliated members</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Sponsoring members</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>478 members</td>
<td></td>
</tr>
</tbody>
</table>

The installed capacity of the 90 industrial member companies is divided over the following branches of industry:

<table>
<thead>
<tr>
<th>Industry</th>
<th>2014/2015 in %</th>
<th>2015/2016 in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining</td>
<td>10.7</td>
<td>10.7</td>
</tr>
<tr>
<td>Chemical industry</td>
<td>26.8</td>
<td>27.0</td>
</tr>
<tr>
<td>Iron and steel industry</td>
<td>17.9</td>
<td>17.7</td>
</tr>
<tr>
<td>Textile industry</td>
<td>2.2</td>
<td>2.2</td>
</tr>
<tr>
<td>Paper and cellulose industry</td>
<td>17.2</td>
<td>17.1</td>
</tr>
<tr>
<td>Potassium, aluminium, glass and cement industry</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Oil refineries, petrol industry</td>
<td>10.3</td>
<td>10.3</td>
</tr>
<tr>
<td>Apparatus industry, electrical and automotive industry, shipyard</td>
<td>10.5</td>
<td>10.5</td>
</tr>
<tr>
<td>Rubber, linoleum and leather industry</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Breweries, food and washing-agent industry</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Waste management and recycling</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

List of ordinary, affiliated and sponsoring VGB Members
(Status: June 30, 2016)

Ordinary members

Abfallwirtschaftsbetrieb des Landkreises Neu-Ulm, Weißenhorn, Germany
Abfallwirtschaftsbetrieb Stadt Nürnberg, Nuremberg, Germany
Air Liquide Industrie B.V., Rotterdam, Netherlands
AK ENERGIE GmbH, Osnabrück, Germany
Akzo Nobel Industrial Chemicals B.V., Hengelo, Netherlands
Allesa GmbH, Frankfurt am Main, Germany
AMK – Abfallentsorgungsgesellschaft des Märkischen Kreises mbH, Iserlohn, Germany
AS Latvenergo, Riga, Latvia
AVA Abfallverwertung Augsburg GmbH, Augsburg, Germany
AVA Velsen mbH, Saarbrücken, Germany
AVBKG Abfallverbrennungs- und Biokompost-Gesellschaft mbH, Tornesch-Ahrenlohe, Germany
AWEA 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 Pharma AG, Bergkamen, Germany
Bayer Pharma AG, Berlin, Germany
Bayer AG, Leverkusen, Germany
BEKW Bioenergiekraftwerk Emsland GmbH & Co. KG, Emlichheim, Germany
Berliner Stadtreinigungsbetriebe, Berlin, Germany
BioMa Energie AG, Salzburg, Austria
Biotherm Hagenow GmbH, Hagenow, Germany
BKW ENERGIE AG, Berne, Switzerland
BMC Moerdijk BV, Moerdijk, The Netherlands
Boehringer Ingelheim Pharma KG, Ingelheim am Rhein, Germany
BP Europa SE, Lingen/Ems, Germany
Brauerei Beck GmbH & Co. KG, Bremen, Germany
Braunschweiger Versorgungs-AG & Co. KG, Braunschweig, Germany
Bremerhaven Entersorgungsgesellschaft mbH, Bremerhaven, Germany
Carmel Olefins Ltd. Haifa, Israel
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 KEMA, Arnhem, Netherlands
Donausäge Rumplmayr GmbH, Enns, Austria
DONG Energy Power A/S, Fredericia, Denmark
Dow Deutschland Anlagengesellschaft GmbH, Walsrode, Germany
DREWAG – Stadtwerke Dresden GmbH, Dresden, Germany
DS Smith Paper Deutschland GmbH, Aschaffenburg, Germany
DSM Nutritional Products GmbH, Grenzach-Wyhlen, Germany
E.ON Climate & Renewables GmbH, Essen, Germany
E.ON Kernkraft GmbH, Hanover, Germany
EdeA v.o.f., Geleen, Netherlands
EDP Gestao da Producao de Energia S. A., Lisboa, Portugal
EEN Energie from Waste GmbH, Helmond, 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
Electricité de France, Paris, France
ELETTRONUCLEAR S. A. Dept.: Assessoria de Segurança Nuclear – A.S.E.O, Rio de Janeiro, Brazil
EnBW Energie Baden-Württemberg AG, Karlsruhe, Germany
EnBW Energie Baden-Württemberg AG, Stuttgart, Germany
EnBW Kernkraft GmbH, Obrigheim am Neckar, Germany
ENEL Ingegneria e Ricerca S.p.A., Roma, Italy
ENERGIE AG Oberösterreich, Linz, Austria
Energie und Wasser Potsdam GmbH, Potsdam, Germany
Energiedienst AG, Rheinfelden, Germany
Energieservice Westfalen Weser, Kirchlengern, Germany
Energieversorgung Oberhausen AG (EVO), Oberhausen, Germany
Energieversorgung Offenbach AG, Offenbach am Main, Germany
Enertec Hameln GmbH, Hameln, Germany
ENTEKA AG, Darmstadt, Germany
envia THERM GmbH, Halle, Germany
EPZ, Vlissingen, Netherlands
ERZ Entsorgung + Recycling Zürich, Zürich, Switzerland
ESB Electricity Supply Board, Dublin, Ireland
ESKOM Johannesburg, South Africa
Essent, Eindhoven, Netherlands
EVN AG, Maria Enzersdorf am Gebirge, Austria
Evonik Industries AG, Marl, Germany
EWN Energiewerke Nord GmbH, Lubmin, Germany
Fernwärme Ulm GmbH (FUG), Ulm, Germany
Fjervarme Fyn A/S, Odense, Denmark
Forums Kraftgrupp AB, Oathammar, Sweden
Fortum Power and Heat Oy, Fortum, Finland
Fraunhofer Institut Umwelt, Sicherheits, Energietechnik UMSICHT, Oberhausen, Germany
Freudenberg & Co. KG, Weinheim, Germany
GDF SUEZ – ELECTRABEL, Brussels, Belgium
Gebr. Lang GmbH Papierfabrik, Ettringen, Germany
Gemeinschaftskraftwerk Weser GmbH & Co. oHG, Emmerthal, Germany
Gemeinschafts-Müll-Verbrennungsanlage Niederrhein GmbH, Oberhausen, Germany
GFA – Gemeinsames Kommunalunternehmen für Abfallwirtschaft, Olching, Germany
GKS Gemeinschaftskraftwerk Schweinfurt GmbH, Schweinfurt, Germany
Glunz Holzwerkstoffproduktion GmbH, Horn-Bad, Germany
Grace GmbH & Co. KG, Worms, Germany
Grosskraftwerk Mannheim AG, Mannheim, Germany
Gunvor Raffinerie Ingolstadt GmbH, Ingolstadt, Germany
Heizkraftwerk Pfaffenwald der Universität Stuttgart, Stuttgart, Germany
Heizkraftwerk Pforzheim GmbH, Pforzheim, Germany
Heizkraftwerk Würzburg GmbH, Würzburg, Germany
Heizkraftwerksgesellschaft Cottbus GmbH, Cottbus, Germany
Helen Ltd., Helsinki, Finland
Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany
HIM GmbH, Biesheim, Germany
HOFOR A/S, Copenhagen, Denmark
Huntsman P&A Germany GmbH, Duisburg, Germany
INEOS Manufacturing Deutschland GmbH, Cologne, Germany
Infraserv GmbH & Co. Höchst KG, Frankfurt a.M., Germany
Infraserv GmbH & Co. Gendorf KG, Burgkirchen, Germany
Infraserv GmbH & Co. Wiesbaden KG, Wiesbaden, Germany
Iskenderun Enerji Üretim Ve Tic. A. S., Ankara, Turkey
Javo Podjete Energetika Ljubljana p.o., Ljubljana, Slovenia
JELD-WEN Deutschland GmbH & Co. KG, Mittweida, Germany
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