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Lignite mining and electricity generation in the Lusatia (Lausitz) area of Germany: Report on SASEG's first stand-alone excursion

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[O] Organizer; [C] SASEG Committee member; [M] SASEG member; [W] SASEG Website Manager; [N] Non-member; [N/M] Non-member joining SASEG as a member after the excursion.

1 Introduction: Motivation and goal of the excursion

Since its redirection and name change in summer 2011 the Swiss Association of Energy Geoscientists (SASEG) has been increasingly involved, mainly through Committee members, in aspects of energy where geology plays a key role. In Switzerland, Committee members either gave talks to very diverse audiences or organized talks with external speakers for association members and others. Abroad, the association's president, Peter Burri, has been active, on behalf of SASEG, in expert groups of EASAC (European Academies Science Advisory Council, who advises EU governments) and of acatech (German Academy of Technical Sciences), both of which published their findings (EASAC 2014, acatech 2015).
Also, at some of the excursions of recent SASEG annual conventions geological aspects of energy played a prominent role, not the least at the 2015 Annual Convention, during which the Mont Terri Rock Laboratory (Opalinus Clay Formation) was visited, where international consortia carry out generic experiments for a better understanding of deep geological disposal of radioactive waste in a clay formation (Bürgisser 2016, Bossart 2016).
While SASEG committee members have considerable expertise in e.g. oil and gas, hydraulic fracturing and geothermal energy, knowledge of another fossil energy source, lignite, is low. Yet, lignite is the source of 26% of the electricity produced by Switzerland's northern neighbour, Germany (e.g. Häring 2015). Germany is the country with currently the highest lignite production of the world (185 million tons per year). In absolute amounts, Germany's electricity produced from lignite alone is three times the amount of all electricity produced by Switzerland (Fig. 1).
The proposal to visit one of the large opencast lignite mines in Germany and the associated electricity generation was the brainchild of Committee member Ueli Seemann, driven by his motivation to increase the know-how and expertise of the Association for contributing to the public debate on energy matters (SASEG By-laws, Art. 2), and also by a strong personal curiosity. The key question the organizer raised prior to the excursion was: How would the German, the European and the Swiss electricity market be structured without the contribution of German lignite?

1 SASEG Committee member

Such a dedicated excursion (outside those run during the annual conventions) was a first in the Association's history. It was planned as a small-scale test for possible larger excursions in the future. In the first place, Committee members were targeted as participants. Afterwards, the remaining slots were offered to all members; also, the organizer created interest for the excursion amongst his network, which resulted in a few non-members participating, of which two have become members in the meantime.

2 The excursion

The 17 participants travelled individually from four European countries to the university town of Cottbus and assembled in a hotel during the late afternoon of October 4th. Right from the beginning the lively group embarked on «coal talk» on that evening, even before the excursion had officially started – a rather good omen for the excursion...

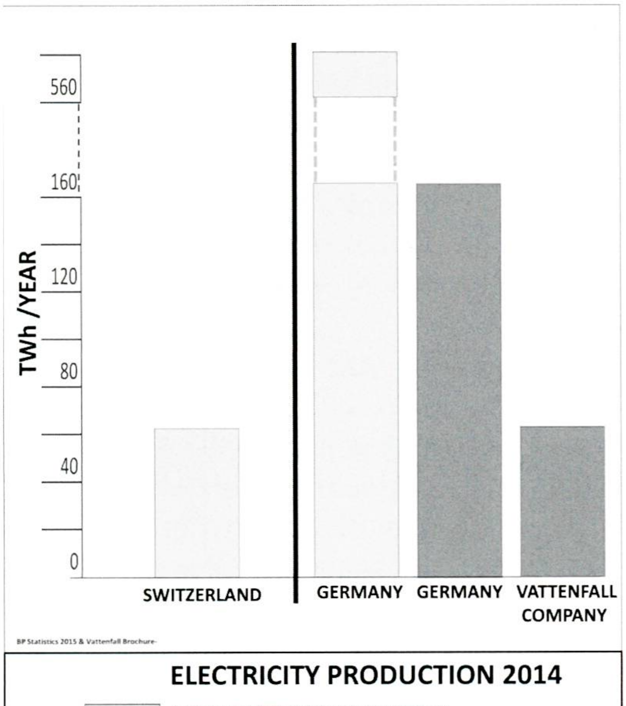

Fig. 1: Electricity production 2014: Switzerland vs. Germany; lignite share of German production; Vattenfall's share of German lignite electricity.

Monday October 5th was the single excursion day, a long day out (nearly 11 hours), with visits to three different sites of lignite mining and electricity generation in the Lusatia area south of Cottbus (Fig. 2). At the first two sites we were guided by staff of the operator, Vattenfall, who also arranged our transport and discounted hotel accommodation.

2.1 Welzow-Süd open-cast lignite mine

In less than an hour we reached the Welzow-Süd day facilities, where we transferred from a luxurious coach to a bus-truck, a vehicle suitable for touring the mine. The information below is from our tour guide Mr. Bernhard Köchel and a flyer of the operator (Vattenfall 2013).

This lignite mine has been in operation since 1966. Before the start of production the groundwater level had been lowered for 7 years and the overburden removed for 4 years. During the period of the German Democratic Republic (GDR) the mine produced a total of about 500 million (metric) tons of lignite. After 1990 the yearly production dropped to 10 million tons; currently it is 20 million tons, a third of Vattenfall Europe Mining AG's production. Operations are 24/6, i.e. 24 hours per day, with Sunday being a rest day. Production is from a single seam (2nd Lusatia Seam), which is 10–16 m thick and Lower Miocene in age (there are other Miocene lignite seams that are not worth exploiting). The extraction machinery is fed by a 30 kW power supply. Only 2% of the produced lignite's energy is used for overburden removal and lignite production; this increases to 4% by including the energy for running the lignite trains to the power station and for operating the 600 groundwater pumps.

Stop 1 was devoted to the removal of the overburden, on average 100 m thick. A bucket-wheel excavator (BWE; *Schaufelradbagger*), built in 1982 in the former GDR, did this work; this machine, with a height of 70 m and a bucket wheel of 17 m diameter and operated by 4 staff only, removes 10,000–14,000 m^3 overburden per hour (Figs. 3/1, 3/2). The material is transported by a conveyor belt to an already exhausted part of the mine and re-deposited. Most impressive was the BWE's slow but steady movement on giant crawlers.

Stop 2, on the short side of the rectangular active part of the mine, allowed an overview of its deepest part, which is a mere 20 m above sea level. Two bucket-chain excavators (*Eimerkettenbagger*), with buckets on a revolving chain, removed chunks of the lignite seam (1,000 t/hr); these machines, however, were dwarfed by the 500 m long overburden conveyor bridge (OCB; *Abraumförderbrücke*) that spans the deepest part of the mine (Fig. 3/3).

At **Stop 3** we got close to the operating OCB, one of five of the F60 series (cutting height is 60 m) built by the GDR. These are the world's largest movable industrial machines on land. Four of these five giants are still in operation (see chapter 2.3 for the fifth); the Welzow-Süd F60 has been in operation since 1972. The central span measures 272 ± 13 m; on each side there is a support structure with wheels, allowing the OCB to move on rails – there are more than 1,000 wheels under each of the two support structures (Fig. 4/13). The OCB, operated by 14 staff only, removed overburden simultaneously at three locations at a rate of 18,000 m^3 per hour. A special equipment can move 10-m sections of the rails of the OCB by 60 cm at one time, to follow the progress of the overburden removal perpendicular to the rails (10–15 m/week). OCBs can only operate where the seam and the overburden have a very low dip and the lignite is not too deep below surface; e. g. the lignite mines west of Cologne operated by RWE are generally not suitable to utilise OCBs due to the higher dip of the lignite seam.

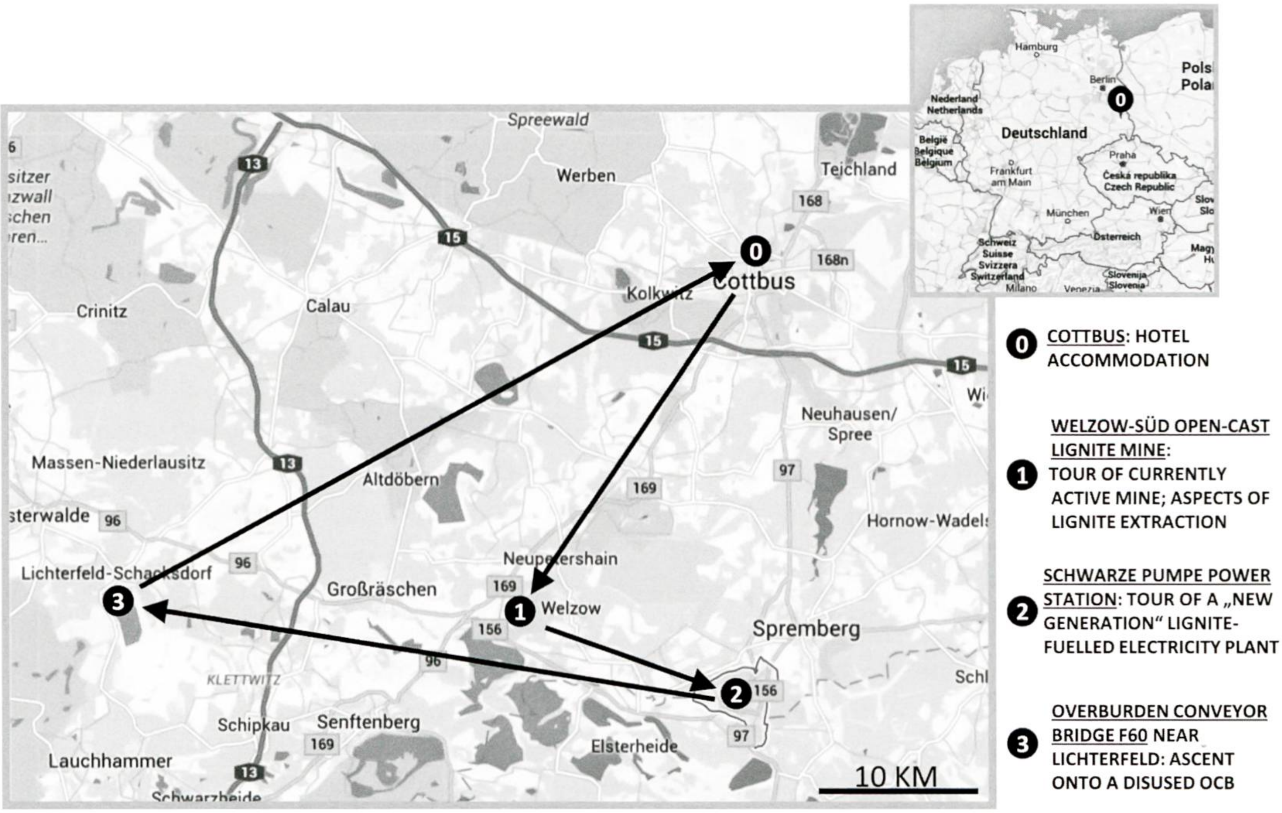

Fig. 2: Locations visited during the October 5th, 2015, excursion. The town of Cottbus lies 130 km southeast of Berlin.

Stop 4 was at a bucket-wheel excavator digging up lignite at a rate of 1,800 t/hr, which was removed by a 5 m/s conveyor belt and ultimately loaded onto railcars. Here we could pick up pieces of fossil wood which resembled pieces of recent wood despite the age of 17 million years (Fig. 3/4), due to the thin overburden the seam has experienced. Welzow-Süd yielded the most extensive wood flora of the 2nd Lusatia Seam, dominantly conifer wood types, but also a variety of angiosperm morphogenera (Dolezych-Mikolai 2005). The plant material accumulated in wide depressions under a subtropical climate. The average material of the lignite seam contains 54–57% water, 5% ash and 0.6% sulfur; its heating value is approximately 9,000 kJ/kg.

Stop 5: After a climb our bus-truck reached the rim of the mine at the former site of the village of Wolkenberg, one of the 17 villages (with about 3,500 inhabitants in total) that had to be vacated and then demolished for the lignite production at the Welzow-Süd mine. Here we were briefed on the post-mining landscape reconstruction. A SSW-facing slope of 11 degrees was selected as the site for a vineyard (Fig. 3/5), where on an area of 6 hectares grapes for five types of white and two types of red wine are being cultivated. Large areas have been reforested, currently with mixed deciduous forests. Also here the numbers were impressive: The recultivated area covers already 26 km^2, nearly equalling the working area (28 km^2).
Around noon we were back at the day facilities, from which we did a short coach ride to the site visible already from far away by two vapour columns, where electricity is produced from the lignite.

2.2 Schwarze Pumpe Power Station

This power station was built 1993–1997 at a cost of 2 billion Euro at the site of the former *Gaskombinat Schwarze Pumpe*, which comprised 3 «dirty» lignite-fired power stations, one 5 billion m^3/y gas factory, 3 factories producing 10 million metric tons charcoal briquettes per year, a factory (notorious for its odour nuisance) to distill 1.5 million tons fuel coke and an adjoining industrial area; altogether a workplace for 15,000 people. At the time it was the world's largest lignite refinement factory.
Contrary to common belief that the name «Schwarze Pumpe» was newly assigned to the industrial complex by the authorities of the German Democratic Republic, it has a much older history. In medieval times, the doors of houses infected with the plague used to be painted black, as a sign of danger. Almost 400 years ago, during the Thirty Years' War (1618–1648), Swedish troops were marauding in this part of Germany whilst also the bubonic plague was threatening the population. Outside a countryside inn along a Lusatia high road there was a water pump for the horse troughs. Legend has it that the pump was painted black as well, in the hope to keep the Swedish troops away. Thereafter the inn was called «Zur Schwarzen Pumpe» (Black Pump). Only in the late 19th century a settlement («Kolonie Pumpe») grew near the inn, and eventually the name of the inn survived in the name of the industrial complex that the GDR government developed after the mid-1950s. Right after arrival we duly visited a symbolic rebuild of the black pump at the entrance area of the power station.

The present-day Vattenfall facility (Fig. 4/6) is one of the first lignite power stations of the «new generation». The double-block facility has a nameplate capacity of 1.6 MW and was, in 2015, good for 20% of Vattenfall Europe Mining & Generation's electricity generation. The main purpose of the power station is the base-load provision of electricity to the public power supply. Electricity is transported via 380-kV overhead power lines to a transformer station. Schwarze Pumpe is a cogeneration power station by also providing heat and steam for use by

some of the 82 factories in the adjoining industrial park, where approximately 4,200 people work. The park straddles the boundary between Germany's federal states of Saxony and Brandenburg.
First we enjoyed a hearty lunch in the staff canteen of the power station (Fig. 4/7). Then Vattenfall's Mr. Lutz Picard started the tour, explaining first a relief map of the Lusatia area and then the Schwarze Pumpe facilities. Lignite is delivered by train from three mines and transported to the central building by a large, completely enclosed conveyor belt (Fig. 4/6). A process panel indicated that 1.24 MW of electricity (78% of the nameplate capacity) was being produced at the time of our visit, good for 1.5 million households.
On our request Mr. Picard gave a special talk on the oxyfuel pilot plant, part of a carbon capture storage project. The pilot was carried out on this site from 2008 to 2013 and successfully segregated more than 10,000 tons CO_2 of 99.7% purity; it was the world's first CO_2-segregating pilot. The 30 MW capacity plant used the oxyfuel process, during which coal burns with nearly pure oxygen instead of air. However, the entire CCS project never got operational because key other parts of the project (pipeline transport of CO_2 and its storage in underground salt caverns) never got accepted by the local population; also, overall project economics were negative.
We then continued touring the main parts of the power station. A lift brought us to a height of 162 m above ground, from where we had a great view of the entire industrial area, and also of the two cooling towers where on average 31,000 m^3 water/day are being released as steam into the atmosphere. Back to ground level we entered the heart of the power station, where daily 36,000 tons of lignite (600 wagonloads) are burnt, using 72,000 m^3 water (pumped away from the open-cast mines) and 1,000 tons of limestone. We could get close to the afterburners, through which the efficiency of the electricity generation is increased (Figs. 4/8, 4/9). We also passed the operations centre from which all processes are controlled and the power production is adjusted according to demand; an adjustment of ± 40 MW is possible within seconds. Stepping outside, we walked past the transformers. 95% of the electricity produced can be delivered; only 5% is used by the power station itself. Full of impressions we stepped into the coach again after 3 p.m., for a longer drive to the third site (Fig. 2).

2.3 Disused Overburden Conveyor Bridge F60 near Lichterfeld

This is an F60 OCB similar to the one we saw in operation in the morning, at Welzow-Süd. However, lignite was excavated here for 15 months only, in 1991-92, after which the Klettwitz-Nord mine was closed. Now it is a tourist attraction. We knew that our itinerary included a visit to this huge structure (60% longer than the Eiffel Tower tall); what some us did not know that we were asked to walk up to the far end of the bridge (to a height of 74 m above ground), over a total walking distance of 1,300 m and thereby managing 460 steps. However, under the guidance of Mrs. Zarina Donath all of us climbed the walkways with open steel-grid floors and made it to the top (Figs. 4/10 - 4/13).
From there we had a magnificent view over the former lignite excavation area that has been filling by rain- and runoff water for the last 14 years and is earmarked as a recreation area when full. From this disused «brown coal» structure we observed an array of solar panels and in the distance a wind farm, the green successors / alternatives to generate electricity. Only by walking the OCB one truly appreciates the size and complexity of this piece of machinery, which, like its counterpart at Welzow-Süd, was able to displace itself through about 1,000 wheels on rails (Fig. 4/13).

Fig. 3: Welzow-Süd open-cast lignite mine. [1] A bucket-wheel excavator moving on crawlers removes the overburden of the lignite. Cars and participants (with white helmets) for scale (Photo: H. M. Bürgisser); [2] The 17 participants have full confidence in the lignite excavation hardware and technology (Photo: B. Köchel using P. Reichetseder's camera); [3] Current lignite extraction site; bucket-chain excavator in foreground, 500 m long overburden conveyor bridge at the horizon (Photo: U. Seemann); [4] Fossil wood from 2nd Lusatia Seam (Photo: H. M. Bürgisser); [5] Vineyard at Wolkenberg, on SSW-facing reconstructed slope (Photo: H. M. Bürgisser).

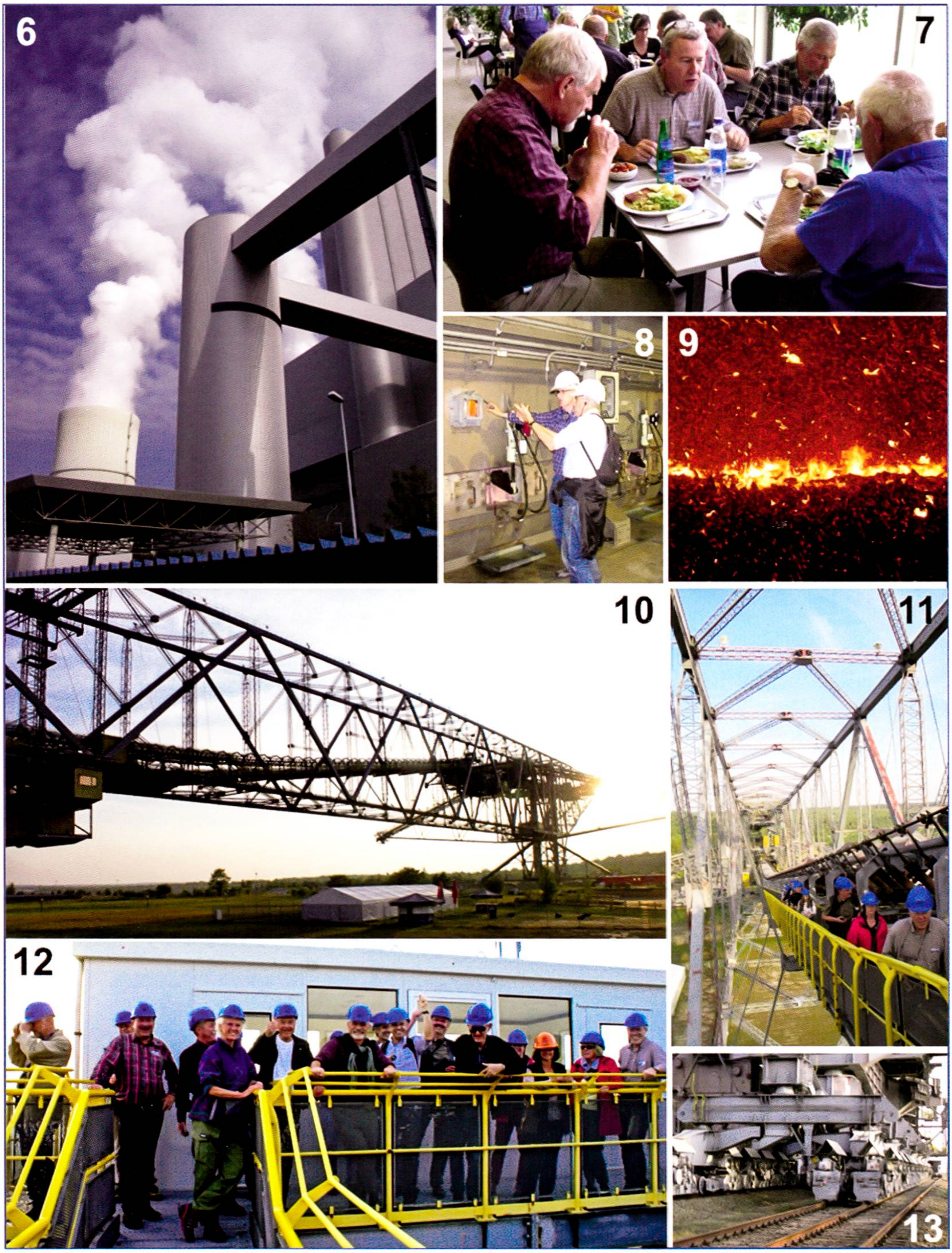

Fig. 4: [6–9] Schwarze Pumpe power station. [6] Foreground: Lignite is transported on a completely enclosed conveyor belt to the processing plant; cooling towers in the background. [7] Lunch at staff canteen; [8] U. Seemann and H. M. Bürgisser at one of the afterburners, where… [9] …granular lignite is burnt at 850 °C (photograph [8] by B. Gunzenhauser, others by H. M. Bürgisser). [10–13] Disused Overburden Conveyor Bridge F60 near Lichterfeld. [10] OCB with walkway on which… [11] …we walked to the… [12] …highest point of the structure, 74 m above the ground; [13] More than 1,000 wheels allowed movement of the support structure and the entire OCB as excavation progressed. (Photographs: [10], [12] P. Reichetseder, [11] B. Gunzenhauser, [13] H. M. Bürgisser).

3 Conclusions and Outlook on German lignite-produced electricity for Switzerland

Content-wise and logistically the excursion was very successful. The three parts of the visit were well chosen by the organizer, we had competent guides, and the good weather and low degree of muddiness contributed to the good spirits of the participants as well. Also the broad spectrum of the participants' background (oil and gas industry, engineering geology, geothermal energy, electricity industry, teaching, politics, government administration) and the international mix contributed significantly to the success of the excursion; there were many interdisciplinary discussions widening the perspective of each of us.

The size of the operations was mind-boggling; everybody agreed that seeing this with our own eyes gave a different dimension than when viewing pictures or even a film of the operations.

Our visit happened just days after Vattenfall had advertised, in the «Financial Times», the sale of its four power stations and five associated lignite mines in the Lusatia area (see e.g. NZZ 2015), including the Welzow-Süd mine and the Schwarze Pumpe power station. Although Vattenfall's lignite exploitation has been optimised, its electricity generation is efficient and lignite reserves within the exploitation permit are sufficient to last until 2040, the short-term future of lignite for generating electricity has become uncertain in Germany. Already now, with the electricity sector leading the way towards a decarbonised energy system (IEA 2015), German coal- and lignite-fuelled power stations are often asked these days to reduce electricity output considerably when high amounts of wind and solar power are being produced and fed into the network, making the running of such power stations less economic. As a result, the German government has proposed to compensate the lignite producers with billions of Euros for not producing electricity regularly yet having the plants ready to produce when needed. Even with this proposal Vattenfall has decided to make an attempt to leave Germany's lignite-fuelled power generation. However, this will not solve «Germany's Electricity Problem». Lignite will and has to be an important source for the electricity requirements of Germany's near future, because green sources in Germany will be unable to provide the demand at all times even when further developed. The development of additional indigenous gas resources – one possible alternative source for Germany's non-green electricity (and cleaner than lignite) – is frequently blocked by the authorities through fracking moratoriums.

Has the excursion brought the participants closer to an answer of the initial key question by the organizer: How would the German, the European and the Swiss electricity market be structured without the contribution of German lignite? There was no plenary discussion of this question during the excursion, and we did not consider it appropriate to ask our two Vattenfall tour guides. However, shortly after the excursion an exchange of facts and opinions amongst participants highlighted the following regarding the Swiss electricity market:

Switzerland has been so far a surplus producer of electricity though not for all 12 months of a year. The surplus is in summer; in winter Switzerland imports electricity, mainly from French nuclear power plants and – indeed – from German environmentally unfriendly lignite plants. With the scheduled closing of the Swiss nuclear power plants this import will have to increase, and Switzerland's current overall surplus is expected to turn into an overall deficit. Already now the German network is stressed at times, even with the use of large batteries, through the considerable share of flickering power («Flatterstrom»), i.e. the electricity produced by wind and solar energy that is very intermittent as to its delivery. It is therefore far from certain that Switzerland will get sufficient (lignite-produced) electricity from Germany when needed because also Southern Germany is likely to have the same need at the same time.

References

acatech (Ed.) 2015: Hydraulic Fracturing. Eine Technologie in der Diskussion (acatech POSITION). Herbert Utz Verlag, München.

Bürgisser, Heinz M. 2016: Bericht der 82. Jahresversammlung der SASEG vom 20. bis 22. Juni 2015 in Baden. Swiss Bull. angew. Geol. 20/2, 97–109.

Bossart, Paul 2016: The Mont Terri rock laboratory: international research in the Opalinus Clay. Swiss Bull. angew. Geol. 20/2, 41–46.

Dolezych-Mikolai, Martina Andrea 2005: Koniferenhölzer im 2. Lausitzer Flöz und ihre ökologische Position. Ph.D. thesis Utrecht University, see also http://www.academia.edu/6584867/.

EASAC 2014: Shale gas extraction: issues of particular relevance to the European Union (Executive Summary). European Academies Science Advisory Council, see also: http://www.easac.eu/home/reports-and-statements/detail-view/article/shale-gas-ex.html.

Häring, Markus O. 2015: Der 2'000-Watt-Irrtum. Münster Verlag, Basel.

IEA 2015: World Energy Outlook 2015 (Executive Summary). International Energy Agency, see also http://www.iea.org/publications/freepublications/publication/world-energy-outlook-2015---executive-summary---english.html.

NZZ 2015: «Vattenfall bietet Braunkohle feil». Neue Zürcher Zeitung, 23.9.2015.

RBB 2016: 2016-07-04 online article at http://www.rbb-online.de/wirtschaft/thema/braunkohle/beitraege/Vattenfall-bereitet-Uebergabe-vor-EPH.html (retrieved 2016-08-01).

Vattenfall 2013: Aus Braunkohle wird Energie. Braunkohlentagebau Welzow-Süd, Braunkohlenkraftwerk Schwarze Pumpe. Vattenfall Flyer, March 2013.

Postscriptum

Since the finalization of the manuscript the Czech consortium of Energetický a průmyslový holding a.s. (EPH) and its financial partner PPF has reached agreement with Vattenfall to buy four lignite mines and four lignite-fuelled power stations in the Lusatia area. According to research by the magazine programme «Klartext» of Rundfunk Berlin Brandenburg (RBB), EPH speculates that the price for lignite-generated electricity will rise after the shutdown of Germany's last nuclear power plants in 2023 (RBB 2016). In early July the Swedish government approved, as the owner of Vattenfall, the sale, despite domestic and foreign lobbying for a complete closure of Vattenfall's lignite activities in Germany instead of selling them to a successor company.