Minutes of Meeting

VGB-Technical Committee:	Generation and Technology
VGB-Technical Group:	PGMON Power Generation Maintenance Optimisation Netzwork **56th Meeting on 17/18 May 2018 in Amsterdam**

Participants:

Andrejkowic	Milan	CEZ
van den Bos	Adjan	NUON
Duijn	Ton	NUON
Galant	Arkadiusz	ESB
Krickis	Otto	Latvenergo
Le Bris	Yves	EDF
Sheehan	Richard	ESB
Wels	Henk	DEKRA

VGB Secretariat:

Göhring	Sven	VGB
Grimmelt	Heinrich	VGB

Agenda

Welcome (Henk Wels)

TOP 1: Optimization of the short-term and long-term operation of the power plant and maintenance planning in accordance with optimization results
Otto Krickis, Latvenergo

TOP 2: Coal mills condition monitoring vs performance and HFO usage
Arkadiusz Galant, ESB

TOP 3: On the relation between condition and failures, for boilers & condensers
Henk Wels, DEKRA

TOP 4: Technical Services of VGB
Sven Göhring, VGB

TOP 5: Development of a Web-based Application for Risk Management in Generation
Richard Sheehan, ESB

TOP 6: Managing risk at power stations & Effectiveness of condition monitoring (Generator)
Milan Andrejkovic,CEZ

TOP 7: Handling the risk at power plants
Ton Duijn, NUON

TOP 8: On condition maintenance issues on GT's
Yves Le Bris, EDF

TOP 9: Asset Health
Arjan van den Bos, NUON

TOP 10: Predicting asset degradation by oil and magnet plug analysis
Henk Wels, DEKRA

TOP 11: Place and date of next venue

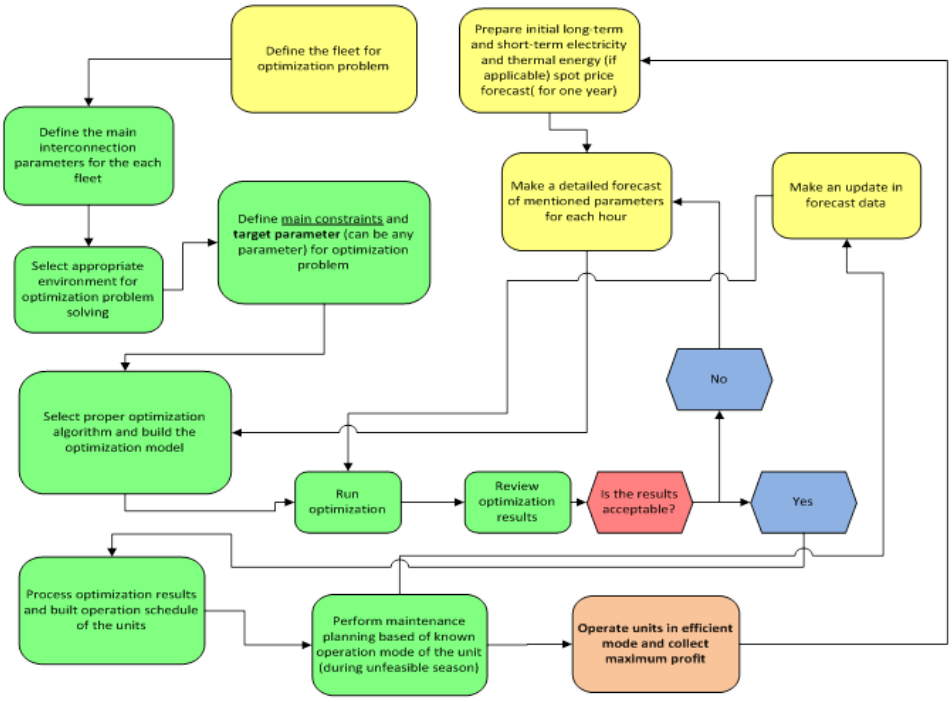
TOP 1: Optimization of the short-term and long-term operation of the power plant and maintenance planning in accordance with optimization results

Otto Krickis, Latvenergo

Operation planning and dispatching problems usually are solved by trading departments of the companies. In the same time the long-term as well as short-term maintenance planning should be based on real operation forecast data, otherwise maintenance plans will significantly deviate from initial plans.

To improve and prepare well-balanced maintenance schedules is necessary to perform operation optimization of the generation unit on-site. Such optimization results should be combined with trading forecast plans, based on which should be built correct maintenance schedules.

The structure of the optimization algorithm and its integration to maintenance schedules is shown on the process diagram below:



TOP 2: Coal mills condition monitoring vs performance and HFO usage

Arkadiusz Galant, ESB

At last PGMON meeting ESB presented on the progress of increasing mills performance and reducing HFO consumption project. During the first couple of minutes the presenter talked about Moneypoint Plant and their technical capabilities and also site setup in the

context of fuel deliveries and fuel combustion issues related to poor coal quality and mills issues.
ESB was talking about their experience with wet coal and impact of the machines and increase of HFO burn to be able to sustain at the dispatched loads. Prior discussion on initiative introduced, design of mills installed in the station was explored and explained to the PGMON audience.
As part of the improvements coal flow measurement was installed on each U1 PF line U1 and any issues within this application were discussed, also potential achieved improvements on O2 decrease, Efficiency, Less Carbon in Ash, CO2 reduction, Ability of assessing Mills condition and NOx reduction were discussed. Further to this change mills balls size management was explored and impact of balls size on crushing bad and good quality coal. Stockyard Management improvements were listed and discussed in context of

- Station drains improvement s in 2016/2017 as part of drainage programme allowing better water removal from Stockyard- big improvement on coal wetness
- Regular meeting between station and EMC on coal stockyard management and coal quality held and ways of storing
- Looking at the options of applying light barrier on the top of coal. This product is to be sprayed on the coal to reduce moisture penetration- one VGB member expressed his concerns about the product and impact of combustion chemistry.
- Seam analysis and Petrography analysis discussed

Mill Level measurement difficulties when wet coal loaded and ways of trying to improve were mentioned.

TOP 3: On the relation between condition and failures, for boilers & condensers
Henk Wels, DEKRA

Based on legacy KEMA and DNV-GL damage investigations, failure trees have been further analyzed. The format for the trees was taken from the well-known Causual Factor and Event Chart allowing linking KKS-codes, influence factors, failure mechanisms, direct causes, consequences and measures. By coupling the chart both to the damage under investigation and all other known damages, it shows whether the damage is an incident or a type of damage that occurs more often. Examples of “normal” damages are fatigue in steam turbines, corrosion and creep in boiler evaporators and creep in superheaters. The timing shows that the pattern for manufacturing versus design fault and a failure because of operating conditions is clearly different, although manufacturing and design faults can appear at over 50.000 hrs of operation. It was thought that degraded and incipient failures as per OREDA definitions would show in time as a pattern before the pattern of failure. However, investigated damages are a special subset of all failures. Therefore no such pattern showed. However, for many failure types, degradation must have occurred before failure. Evidently for circulation errors in evaporators due to obstructions etc. degradation is fast. Therefore only for specific degradation mechanisms condition monitoring is feasible. The statistical distribution for

failure times varied between uniform, a simple triangular distribution and a Weibull distribution.
The condition of a condenser of an inland power plant was investigated using eddy current measurements. We had 3 sets of measurements with a 2 year interval for analysis available. The dataset showed that the condition of between condenser sections varies much. Condition is spatially correlated: if a pipe is bad there is a large probability that a neighboring pipe is bad also, therefore sampling makes sense. Spatially correlated models are applied for instance at steel bridges and pipelines. For this specific condenser the detoriation was fast, therefore a Markov Model is difficult to apply. Finally, a damage class based on surface material loss not necessarily says much about depth of pits and the probability of leakage. How to extrapolate eddy current measurements to the probability on a leak should be further investigated.

TOP 4: Technical Services of VGB
Sven Göhring, VGB

Sven Göhring presented an overview about the Technical Services that can be offered by the VGB laboratory for its members. There are three types of laboratories under the umbrella of VGB:

- Team Materials Laboratory
- Team Oil Management
- Team Water Chemistry

Information about the special work done in these teams and many examples can be found in the enclosed presentation. For more detailed information please see the VGB website or contact the Head of Technical Services Mr. Christian Ullrich.

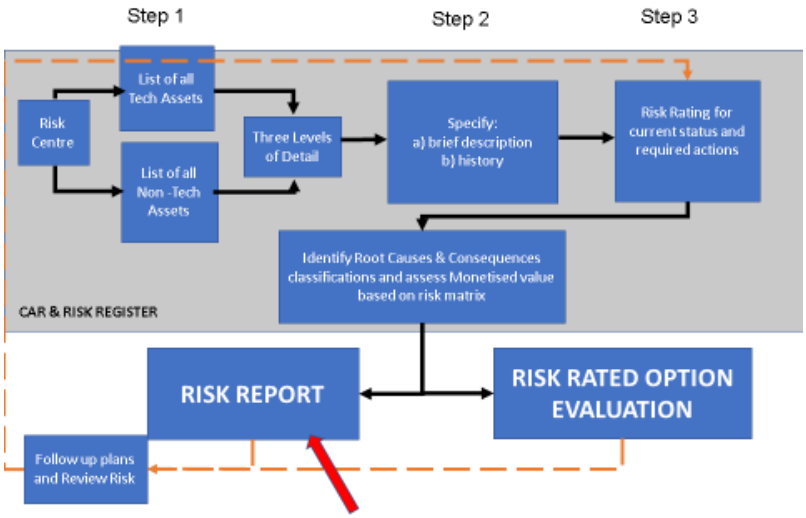
TOP 5: Development of a Web-based Application for Risk Management in Generation
Richard Sheehan, ESB

At previous PGMON meeting it was reported that ESB Generation had a risk system and risk process but that there were several challenges such as

- System being perceived primarily a ‘governance’ tool
- Risk management not a baseline for asset management
- Disconnected risk systems (primarily technical versus non-technical)

The objective of the current risk project is development of a single asset/risk register which encompasses all business risks into a single dynamic source. The outputs to include (i) Risk Reports and (ii) Risk-based evaluation of investment decisions.
The approach adopted is to develop an in-house IT tool (prototype) using a web-based solution. The system to be used to evaluate investment decisions on the basis of

monetised risk exposures (system thus requires ability to trend exposures/conditions over time).
An overview of the system is shown in below figure.



The next steps involve further development of cost-benefit calculations / Investment options analysis; development of prototype tool; subsequent development of final operational tool. To be presented at next PGMON meeting.

TOP 6: Managing risk at power stations & Effectiveness of condition monitoring (Generator)
Milan Andrejkovic,CEZ

Managing risk at power stations

Risk management is as an integral part of asset management. It’s an area of management focused on risk analysis and risk reduction, using various methods of prevention and techniques that eliminate existing or reveal future risk factors.

Our goal is to operate our power plants economically and especially in safety way. In a situation with low electricity prices and pressure to decarbonize and reduce emissions from combustion sources we are forced to spend money effectively but we also very focus to avoid accidents and negative phenomena.

Risk analysis reveals the level of impact and probability. The impact and probability is evaluated by the scale 1-2-3-4-5. The impact is assessed in the safety area (risk of injuries), environmental area (risk of breaking limits), commercial consequences (loss of availability) and financial consequences (consequential damages, direct damages – fines).

Our risk management is especially used for strategic decision making process, prioritization of maintenance and investment, prioritization of possession of strategic spare parts, technical standards - life time management and conceptual approach across power plants.

Effectiveness of condition monitoring (Generator)

CEZ introduced the portfolio of generators it currently operates. Portfolio of generators types corresponds with the historical development of generators in Czech Republic. CEZ currently operate 7 major types of generators with nominal range of 50 to 660 MW with different types of stator and rotor cooling system.

The general data of overall generators failure were presented. Data showed that from the historical point of view, generators contribute a little to the overall failure rate of CEZ units. From analysis of the failure sources, key part for condition monitoring represents stator winding of generator.

In CEZ, condition monitoring of generators is applied through two main approaches – off-line testing and on-line monitoring. The basic tool applied within CEZ for condition monitoring is off-line testing. Main off-line testing methods were presented. Key methods are electrical measurements (Riz, tg δ, polarization index), visual inspection and NDT methods for retaining rings inspection. If required, additional methods are applied (noise analysis, ozone indication).

To evaluate the effectiveness of condition monitoring, historical data were available for electro-diagnostics measurement and retaining ring inspection. Application of electrical measurements is very effective to determine current state of the generator´s isolation system. Electrical parameters can be used very specifically to future status prediction. NDT inspection of retaining rings is the basic material diagnostics of generator. An overview of the historical results of these inspections shows a very low probability of defect finding. In case of finding an unacceptable defect, there is a risk of long term unit outage. This risk is reduced by setting a spare parts strategy for the each unit.

In conclusion, condition monitoring of generators CEZ is historically set very conservatively, based on the offline testing with the result of a very low overall failure rate. The results of generators condition monitoring are very effective for detecting the device actual status. The predictions of future status development or failure prevention are more complicated with reserves in results.

TOP 7: Handling the risk at power plants
Ton Duijn, NUON

NUON/Vattenfall has over the years developed an integrated Asset Management system and Process Safety system that balances risk, performance and cost. Essentially there are only a few main steps, that is Asset Strategy driven by Stakeholder requirements, NPV and technical KPIs, translation into an Asset Guideline and translation into maintenance Concepts using RCM, FMEA, etc. resulting in a Maintenance Schedule to be executed and updated.
The crux of the Structured Maintenance Review (SMR) is to find the right balance between risk of failure and maintenance costs taking the cashflow effect into account. The SMR defines 5 categories of maintenance costs and also takes into account maintenance costs in previous years. Based on the categories a risk assessment is executed for these activities where a risk appetite can be applied. In the categories

critical systems for Safety and or License to operate are defined where the decision is to execute these measures in order not to jeopardize safety and compliance towards the License to operate.
The maintenance budgets are defined in a yearly business cycle rolling forward for a 5 years period. In the Risk assessment a risk matrix is used in which also non-financial criteria are used such as H&S effects, Reputation and Environment.
NUON/Vattenfall has succeeded in successfully rolling out the approach for the Dutch plants as well as the plants in Germany, of which most of these plants are essential for district heating of large cities. One of the observations is that the risk assessments that are done by the technical specialists for similar parts in the plants are showing differences, this will be further investigated.

TOP 8: On condition maintenance issues on GT's
Yves Le Bris, EDF

The management of Gt’s maintenance is closely linked to long term contracts generally with Original Equipment Manufacturers.

To realize condition based maintenance on those machines is not easy.

This presentation tries to summarize the basic rules of such LTSA and MMP contracts, and to point out some monitorings which can be and should be made by the owner or its O&M company in order to achieve a best control on performances and costs.

From Capital parts up to auxiliary systems and spare parts those slides try to give EDF fleet feedback showing typical items to be monitored for condition based maintenance.

TOP 9: Asset Health
Arjan van den Bos, NUON

For the heat grid Almere we started a project to gain more insight in the life span of the heat grid Almere. The heat grid is an underground network of pipelines to deliver the central heating to the buildings in the city. To achieve this we first started a pilot project to know what is needed for the project in terms of capacity and time span. The goal is to make an estimate about the integrity of the system and the remaining life of the system. The heat grid is built up during 39 years in several stages. The pilot project looks at the buiding stages of the years 1979 till 1989. For this project we made a plan of attack achieve the goals. The plan of attack is the following:

- Make an inventory of the design and actual used components and their specifications in the system
- Analyse the maintenance and process history
- Make a risk analysis of the system and the design
- Point out interesting inspection topics
- Inspect the system at the high risk locations

When the data is combined we know what the design criteria are (how long the system theoretically can last). Futher we know what happened in the system with the maintenance and the process history. And we know the high risks in the system. With this information combined we know the health status of the system and we can make a prediction of the future.

TOP 10: Predicting asset degradation by oil and magnet plug analysis Henk Wels, DEKRA

DEKRA operates already for a long time its oil laboratory using traditional standard lab methods and optimized lab methods. Thanks to the large number of gear boxes measured and investigated when its oil had become substandard or when failed, we have entered the field of data analytics. We are constructing dashboards for rail customers to predict the behavior of individual gear boxes as well as fleet survival using SAS data mining software. The derivation of a so-called wear coefficient allows evaluating single component degradation in practice. The difference in patterns for oil scrapers, worn out gear, broken bearing cage and bearing fractures clearly show. Fleet analysis shows at present 93 % correct prediction of failures and improving. It is thought that such analysis would apply also to other sectors for instance power plants, wind turbines, etc.

TOP 11: Place and date of next venue

The next meeting will be held on 11./12. October 2018 in Dublin.