Lessons Learned for Maintenance to mitigate risks on ageing coal fired power plants

Stefan Thumm

Optimising performance of conventional power plants for a sustainable and secure future” event on 8th September
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Allianz

Allianz Group is one of the world’s leading insurers and financial services providers

- Founded in 1890 in Berlin, Allianz companies now extend to over 70 countries with approximately 148,000 employees and 85 million customers
- Insurer financial strength rating of AA (‘Very Strong’) from S&P and A+ (‘Superior’) from A.M. Best*
- International network of strong brands, with first-class products in the fields of:
  1. property and casualty insurance
  2. life and health insurance
  3. asset management

For more information visit www.allianz.com

*Ratings refer to Allianz SE and are correct as at 02/2015
Allianz Global Corporate & Specialty SE, 2015
Allianz Turkey has become a major player in the market in recent years due to exclusive agency establishment with Yapı Kredi Bank that provides investment credits for many privatized thermic power plants.

Participation to Yearly Production Between 01.10.2014 and 02.09.2015 by plant type

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Participation (MW)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>83,641.923</td>
<td>39.63%</td>
</tr>
<tr>
<td>Coal, Lignite</td>
<td>59,442.102</td>
<td>28.17%</td>
</tr>
<tr>
<td>Hydro</td>
<td>50,425.550</td>
<td>23.89%</td>
</tr>
<tr>
<td>Wind</td>
<td>9,082.493</td>
<td>4.30%</td>
</tr>
<tr>
<td>Geothermal</td>
<td>2,338.130</td>
<td>1.11%</td>
</tr>
<tr>
<td>Other Thermic</td>
<td>6,106.192</td>
<td>2.89%</td>
</tr>
</tbody>
</table>

Public vs Private Electricity Production (Capacity Installed)
Allianz Turkey Power Business

- Total number of insured power plants: 150
- Allianz Turkey is the leading insurer in the wind industry for Turkey
- Hydro leads the book, similar to the Turkish market
- AGC&S support available
- Close cooperation between Allianz Turkey and AGC&S

Allianz insurance per plant type

- Hydro: 44%
- Wind: 24%
- Gas Fired: 18%
- Thermic: 9%
- Geothermal: 5%
We are one of the few specialist corporate insurers with a genuine global market presence who can provide “one carrier” insurance solutions across the whole spectrum of corporate and specialty risks.

- Diversified product portfolio
- Wide range of complementary services, including specialist non-traditional risk transfer solutions provided by our subsidiary ART
- Financial strength: €5.4 billion GWP (2014)*
- Global reach: integrated in the Allianz network of more than 160 countries worldwide
- Extensive international experience: manages some 2,300 International Insurance Programs
- More than 3,600 dedicated employees

*All AGCS companies
AGCS was set up in 2006 to bring together Allianz’s large corporate and specialty business into one unified global company under a shared vision and coordinated management:

“To be the leading global provider of corporate & specialty risk solutions, meeting clients’ individual needs with our employees’ unequalled industry expertise and knowledge.”

To achieve this vision, we have built our business around five core elements:

- **A truly global culture and approach**
- **Developing in-depth expertise**
- **Offering the strongest network**
- **Focusing on excellence**
- **Backed by strength and long-term commitment**
AGCS is a leader in satellite and space insurance through our SpaceCo team in Paris.

- One global team of dedicated specialists in corporate and specialty risk
- Over 3,600 staff of more than 70 nationalities in core client locations
- Local experts supported by global resources
- Extensive multi-national experience, supporting clients in new markets worldwide
- One global carrier and culture with consistent processes and standards
AGCS presence in
Australia · Austria · Belgium · Brazil · Canada · Denmark · Dubai · Finland · France · Germany · Hong Kong · India · Ireland · Italy · Japan · Mexico · Myanmar · New Zealand · Norway · Portugal · Russia · Singapore · South Africa · Spain · Sweden · Switzerland · The Netherlands · United Kingdom · United States

- AGCS teams in 29 key countries
- Allianz’s own offices in 70 countries
- A combined Allianz and partner network in over 160 countries
- Specialists in global programs: some 2,300 programs active (as of March 2015)
- Rapid response capability for urgent and catastrophic claims worldwide
Focus on excellence

AGCS Key Account Managers take personal responsibility for delivering client service

- Key account management and dedicated sector teams, with significant investment in research and development
- Global operations, claims and underwriting to globally coordinated standards
- Insuring the majority of the Global Fortune 500® companies
- An innovative and flexible approach to brokers and distributors – from global brokers to mono-line specialists
- Access to the full Allianz service portfolio: from credit risk and assistance to investment management and retail insurance
Strength and commitment

AGCS’s combination of AA S&P and A+ A.M.Best ratings are among the highest in our sector

- One of the highest rated global P&C insurers
- Consistently strong solvency ratios: 255% for AGCS SE as at Dec 31, 2014
- Security through diversification: by geography and by risk type
- High capacity for the largest, most complex risks
- Prudent investment strategy for long term sustainable strength
- Part of Allianz Group, the largest P&C insurer worldwide
- Proven track record of long term client partnerships
The Allianz Center for Technology is a unique research facility for industrial risks.

- Allianz’s center of excellence for large or complex business risks
- Sector specific teams, with in-depth know-how across key client industries
- Over 260 risk engineers, specialists in complex corporate risks
- The Allianz Center for Technology – a unique loss analysis team
- A full service capability across multiple product lines including Allianz Risk Transfer – our specialists in alternative risk transfer solutions
- Long-term investment in attracting and developing expert staff
Technical expertise within Allianz Global Corporate & Specialty: Claims, the Allianz Risk Consultants Network (ARC) and role of Allianz Zentrum für Technik (AZT)

- Common support for underwriters, clients and loss adjusters with pre- and post loss expertise and services.
- ARC Global network of more than 260 engineers, specialists and industry experts.
- AZT services include in-depth failure analysis, failure prevention and evaluation of prototypical technologies
- AZT is an independent service provider within the ARC network. Services are provided to AGCS clients and independently via the Allianz Risk Consulting GmbH
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Power Plant Insurance

- **Start of works**: Erection
- **Start trial operation**: Trial Operation
- **Handover**: Commercial Operation

- **Erection All Risk**
- **Advanced Loss of Profit**
- **Machinery Breakdown**
- **Guarantee**
- **Business Interruption**

**Others**: Liability (Product~, Planning), Elektronic, Cyber, BOT-Models

Allianz Global Corporate & Specialty SE, 2015
The Role of Insurance - Risk Sharing Model

- Design Risk
- Wear & Tear
- Unforeseen and Accidental Events

Power Plant Testing (EAR) and Operation (MB)

- OEM
- Owner
- Insurer

➢ How to deal with ageing plants, what's the significance of maintenance?
Risk Considerations for Power Plant Operation from the insurance perspective

- Management
- Technology
- Loss Prevention
- External Exposure

Maintenance related considerations
Risk Considerations for Power plant operation

Management: Maintenance Aspects

- **Maintenance Organisation**
  - procedures, site resources

- **Maintenance Budget**

- **Staff Qualification and Responsibilities**

- **Maintenance KPIs**
  - availabilities, efficiencies, Health and Safety

- **Information Management**
  - lessons learned, non-conformance, service bulletins, manuals

- **Management of service providers**
## Risk Considerations for Power plant operation

### Management: Maintenance Aspects

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<td>procedures, site resources</td>
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<th>Management of service providers</th>
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| Staff Qualification and Responsibilities | |
|------------------------------------------| |

| Maintenance KPIs | |
|------------------| |
| availabilities, efficiencies, Health and Safety | |
Risk Considerations for Power plant operation

Technology: Maintenance Aspects

- Field and Loss Experience, Fleet Issues (OEM, Plant)
- Technology Level complexity, redundancies, techn.issues
- Equipement and Plant layout and design
- Operation Parameters
- Maintenance Service Providers
# Risk Considerations for Power Plant Operation

## Technology: Maintenance Aspects

<table>
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<th>Field and Loss Experience, Fleet Issues (OEM, Plant)</th>
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<td>Technology Level</td>
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| Operation Parameters                               |
| Maintenance Service Providers                      |
Risk Considerations for Power plant operation

Loss Prevention: Maintenance Aspects

- Handling of maintenance and loss history
- Level of Condition Monitoring
- Spare Parts Availability
- Standard of Documentation
- Standard of quality control
- Access / Logistics (internal/external)
Risk Considerations for Power plant operation

Loss Prevention: Maintenance Aspects

- Handling of maintenance and loss history
- Level of Condition Monitoring
- Spare Parts Availability
- Standard of Documentation
- Standard of quality control
- Access / Logistics (internal/external)
Transfer into standardized risk assessment tool

- identical and consistent for all lines of business
- providing qualitative and quantitative results
- Global network management, Expert Teams and Lessons Learned provide best practice and consistency

Local risk information captured by ARC engineers

.. transformed into risk quality describing ..

.. and processed to the business

Portfolio
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The German Capacity of hard coal Power Generation is 36 Years old

Ref.: Public data of Umweltbundesamt, Bundesnetzagentur
Age of Power Plants EU and Turkey

Major thermic plants in Turkey:
27% older than 30 years
45% between 20 and 30 years
Accumulated Steam Turbine Damages at AGCS Germany of the last 10 years, dated 2008

Accumulated percentage of damages after long term operation: 66%
## Special Risk Aspects of Ageing Power Plants

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Allianz Global Corporate & Specialty SE, 2015
### Special Risk Aspects of Ageing Power Plants

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Change of operation conditions due to changed energy markets

1. Decreased low and minimum loads
2. Increase of operation in low and minimum loads
3. Increased number of starts
4. Increased load gradients
5. Increased number and longer time of outages

**Flexibility:**
- 1. Load ramp →
- 2. Load range →
- 3. Number of starts →

Leistungsbereich

| "past" | 100 % | 50 % |
| "present" | 110 % | 105 % | 100 % | 105 % | 110 % | 50 % | 25 % | 15 % |

Allianz Global Corporate & Specialty SE, 2015
Consequences of changed load conditions

Increase of:
- wear and tear
- corrosion
- fatigue
- damage risk
Summary of additional Risk Aspects due to change of operation conditions in changing energy markets.
### Special Risk Aspects of Ageing Power Plants

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**Special Damage Mechanisms for ageing equipment**
- Protection Concepts (design and condition)
- Documentation
- Low Cycle Fatigue
- Creep cracks and deformations
- Corrosion
- Erosion
- Erosion corrosion

Age related operational problems, Predamaged components, Crack initiation at manufacturing defects accelerate the mechanisms!
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Erosion

This is not easy and not fast to repair. Adequate Repair Solutions are available. Regular Inspections can avoid Business Interruption.
Creep Damage

pipe diameter 300 mm
20 bar, 530 °C
Creep Damage

- Extension of pipe diameter
- Microstructure with creep damage characteristics
- Oxide layer thickness corresponds to operation time
- Calculated end of life time

_pipe was subjected to steam for complete operation time of plant!

Identifying and monitoring the critical components is crucial.
Corrosion Fatigue: Blade Failures on feed water pump turbines

Detachment after 80,000 to 130,000 operation hours

First free standing blade row
Corrosion Fatigue

Fatigue fracture caused by accumulated periods of resonance due to modified speed range (load uprate of main turbine)

Avoidance of stand still corrosion is crucial for a healthy blading

+ corrosion fatigue

+ pitting corrosion due to stand stills
LCF in Rotor groove cracks

L-2 after 170,000 h / 1,500 Starts

L-1 after 100,000 h / 1,000 starts

LP turbine rotor grooves and balde roots often require attention and special maintenance efforts.

Increase of starts will reduce years of component usage.
Optimizing a 40 year old mid size power generation turbine for secondary load control

Normal Operation
“4” closed, 3 MW/min

Optimization for 12 MW/min: "4"
rapid open and closing,

550°C
180 bar

Did the additional load cycles of optimization cause the cracks in the valve inlet section of the outer casing?
Resulting stress

Ageing components need special considerations in case of changed operation conditions considering actual lifetime consumption and manufacturing quality.

Location of highest stress matches with observed crack location

- Optimization of operation leads to crack growth,
- But: Value of stress amplitude shows that additional factors need to increase the stress locally.
- Stress amplification can be caused by low casting quality.
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Lessons Learned – Maintenance and Risk

- Maintenance has a significant impact on the risk
- Risk adequate Maintenance is an important precondition for efficient operation and insurance
- The maintenance and refurbishment concept is preferably subject to an open dialog between operator and insurance and preferably also the manufacturers and service providers

Risk adequate Maintenance = condition, knowledge and prediction based
Lessons Learned – Loss Control Programs

Technical risk assessment

- Underwriting services
  - DTR (Desk Top Review)
  - MFL/PML calculation and risk evaluation
  - Risk Survey
  - Recommendation tracking

Loss control programs

- Monitoring and Advice on revisions and replacements/refurbishment concepts
- Risk improvements and loss mitigation concepts
- Business Continuity

Special services

- Claims- and operational support
  - Loss analysis & support
  - Laboratory forensics
  - Repair Concept Evaluation
  - Troubleshooting (e.g. vibration diagnostics)

Core Service/
Portfolio protection

- Additional Services bundled / unbundled

- Loss Control programs further help mitigate risks of ageing plants
Identification of critical components regarding lifetime

Lifetime Evaluation and Prediction by Calculations

Lifetime Evaluation by replica and crack testing

Regular monitoring and documentation of corrosion, erosion, droplet erosion in high risk areas such as LP-turbine blades or known weak points (endoscopy, visual tests)

Usage of thermography to detect leakages or Hot-Spots

Oil analysis (lube oil systems, transformers)

...
Lessons Learned - Technical Aspects

- Regular and systematic analysis of operational data
- Condition Monitoring systems for identification of critical component conditions
- Implementation of online-lifetime monitoring Systems
- Usage of plant balance programs to detect technical issues
- Ultrasonic testing of LP turbine rotor grooves and blades
- Continuous monitoring of pipe thickness
- Helium Leackage testing

...
Lessons Learned – some more experience from our daily work with ageing power plants

- I&C and Protection and Control Systems have to be maintained at the state-of-the-art

- Fire Protection concepts and functionality of fire protection is a key requirement for safe operation

- Proper state-of-the-art water chemistry has a big impact on the operational risk

- Usage of opportunities for additional inspections on critical/selected components in case of standstills due to planned or unplanned maintenance activities on other plant components is recommended
Conclusion

- Awareness about the plant condition and required measures is most important

- Ageing plants need high attention regarding maintenance and individual maintenance concepts

- Ageing plants need special and individual concepts of component refurbishment and replacement

- Risk adequate maintenance is a major factor for efficient and safe long-term operation with acceptable risks

- Regular knowledge exchange within operators and with insurance and other technical institutions (e.g. local power plant associations) help to reduce risks
Contact

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