Challenges in the power industry: Machinery breakdown on the rise?

Various challenges currently emerging in the power industry call for systematic risk management to prevent a marked increase in machinery breakdown and business interruption losses. Power companies and their insurers must work together to revise existing insurance arrangements and build an economically sustainable environment for all stakeholders.
The scenario of a major breakdown at a power station has always been a key concern among power companies and their insurers. If an event occurs, the loss amount will climb relentlessly until the damaged unit is repaired or replaced and back in operation – and lead times for repair and replacement are particularly long in this sector. This scenario deserves our full attention today, as challenges currently emerging in and around the sector may aggravate machinery breakdown and business interruption losses in the future.

The risk landscape of the power industry is indeed changing rapidly. While prices in the energy supply market have plummeted in the wake of the current economic slowdown, industry projections indicate that the appetite for power will return and push prices up again in the long term. The same behaviour is expected with raw materials, thus continuing to confront power utilities with acute shortages, higher replacement values and even longer lead times for new parts. In developed markets, the ageing of utility plants is a key systemic challenge for the power industry, with unscheduled and costly maintenance measures or even plant failures likely to increase as a growing number of plants approach the end of their originally designed lifespan. Experienced operating staff are also in short supply. Almost half of the utilities workforce in developed markets are approaching retirement age, and there already is an acute shortage of skilled staff to operate new plants in emerging power markets.

This focus report examines these industry developments and their potential implications for property and business interruption covers. It provides insight into loss patterns in the power industry and the key triggers of machinery breakdown, and proposes measures for the power industry and insurers to mitigate the risks and adjust their insurance arrangements.

Industry challenges driving machinery breakdown exposure

Machinery breakdown is the most common type of loss in the power industry. According to Swiss Re underwriting data, the more recent machinery breakdown events show a marked increase in both the property damage values and the business interruption portion of the loss, indicating that new factors are emerging in the sector’s risk landscape. The key drivers of this development are emerging from various areas both within the industry and its market environment:

Growing world energy demand and supply

The current financial market crisis has caused prices in the energy supply market to collapse. Even so, according to long-term projections released by the International Energy Agency, world energy consumption is expected to grow by as much as 45 percent by 2030, some 80% of which will be covered by fossil fuels. A look into the recent past supports this forecast. Every year since 2003, average world prices for fossil fuel and raw materials such as steel have been sharply higher than in the previous years, peaking at an all-time high in mid-2008. Consequently, costs for new power plants and the generated electricity also increased substantially. The current financial market crisis has brought prices for energy and raw materials down dramatically, but the International Energy Agency (IEA) considers this decline to be temporary and expects the overall long-term trends to remain broadly unchanged.

Figure 1: Increased replacement costs for power plants

The power capital costs (PCCI) index published by CERA tracks the costs of building coal, gas, wind and nuclear power plants indexed to the year 2000. It is a proprietary measure of project-cost inflation similar in concept to the consumer price index (CPI). The PCCI now registers 224 index points, indicating that a power plant that cost USD 1 billion in 2000 would on average cost USD 2.24 billion today. This figure is in line with Swiss Re’s estimates based on information provided by original equipment manufacturers and among other aspects underlines the need for re-evaluating the declared sums insured.

Fossil fuel price developments have a direct impact on demand and prices for electricity, and this in turn may potentially affect business interruption values in the power industry. As it is becoming more difficult to forecast the development of fuel prices, there is considerable uncertainty regarding the gross profits and earnings figures policyholders declare to their insurers. These figures are also strongly influenced by the fuel hedging strategy of the insured parties, who do not usually share this information with their insurers. If a business interruption loss occurs, insurers might thus find themselves confronted with a much higher loss-of-profit exposure than was originally calculated. This effect may be exacerbated by seasonal demand and supply fluctuations triggered, for example, by unusually hot summers or cold winters, or by insufficient precipitation in regions which are largely dependent on hydro-electric power generation. To protect themselves against such unpredictable earnings fluctuations, insurers should break down the declared insured annual gross profits and earnings figures to monthly values which are used as caps for their indemnity or limit their exposure through other means, such as USD/MWh caps.

Building the skills of a new workforce
While figures published in the media vary, the US Bureau of Labor Statistics estimates that about half of the approximately 400,000 employees in the US power industry will be nearing retirement by 2016. The energy utility industry has the second-highest average employee age among 54 industries studied. Demand for entry-level line workers, power plant operators and other positions that require technical skills is expected to grow rapidly over the next few years, as baby boomers begin to retire in large numbers. Newly emerging power markets face a similar problem, as a much larger skilled workforce will be required to run and maintain the rapidly growing number of power plants.

From an insurance perspective, the impending shortage of skilled employees is likely to heighten the risk of maintenance errors or incorrect power plant operation, which in the worst case may lead to the failure of entire facilities. To mitigate the risk of running short of skilled labour, utility companies should build up an active knowledge transfer system among players in their own sector as well as with other industries and the education system. One immediate goal should be for utility companies to identify key staff members approaching retirement, and to arrange mentoring programmes with them to ensure that they pass on their expertise to the next generation of operating staff.

Ageing power plant fleet
The failure rate of power plants varies in the course of their service life. It tends to be relatively high in the first few months of the facilities being online, and then declines sharply, remaining at a much lower level for most of the originally designed lifespan. Wear and tear begins to set in as the utilities or components approach replacement, and the ageing process takes its toll with unscheduled and expensive maintenance measures. More than a fourth of the world’s power generating utilities will have reached this stage within the next decade, and many plants are already running well beyond their originally designed lifespan. Huge investments for upgrades and replacements — including measures to reduce the environmental impact of old plants — will become necessary to maintain reliable operations. The International Energy Agency estimates that the worldwide power generation sector will require a total of USD 6.8 trillion of capital expenditure for new plants, replacements and upgrades by 2030.

Power companies need to adopt a long-term view to effectively address the issue of ageing plant and equipment. Lifetime assessment or life cycle management programmes must be in place, and critical components must be replaced in good time. The main deterrent to implementing industry best practice is that inspecting a power plant is extremely costly, especially if it involves stripping down major plant components. However, more affordable and equally effective measures have been available for some time now. On-line condition monitoring tools to assess the current state of power plant components also help to reduce maintenance costs significantly.

All technical equipment, not only in power plants, has a limited life span. As a case in point, the original design lifetime of the rotor of a gas turbine is around 100,000 equivalent operating hours (EOH) while hot gas path parts have a shorter lifespan and need to be replaced earlier. Since the maximum number of EOH depends on the number of turbine starts and the service factor, or fired hours, the original designed lifetime may vary between 12 and 25 years. Again, some mature products are within this age band now, and a growing number of gas turbines will have completed this time span in the next few years. To evaluate the potentially remaining lifetime of gas turbines, original equipment manufacturers offer lifetime extension inspections (LTEs) which are extremely thorough and greatly exceed the scope of a major overhaul during the turbine’s design lifetime. LTEs involve dismantling the rotor to requalify each of its components, and conducting non-destructive examinations to screen the turbine for any critical defects. To ensure maximum operational reliability, LTE inspections must be conducted by the original equipment manufacturer, and their recommendations must be strictly implemented. LTE information should also be disclosed to insurers in the form of risk reports.
Supply bottlenecks for critical components

The production of generators, transformers, and other critical plant components, such as hot gas path parts, is in the hands of a small number of manufacturers worldwide. The limited production capacity and the shortage of raw materials are becoming painfully apparent with the strong growth in energy demand. Lead times for new equipment or spares are lengthening, and waiting periods of up to 24 months are no longer the exception.

Tightening competition in the power industry has also prompted many operators and original equipment manufacturers to buy new equipment on price-driven criteria rather than on considerations of long-term operation, quality and reliability. Today, suppliers tend to be selected on the basis of the first cost principle, according to which the supplier providing the lowest cost offer that meets the specifications wins the business.

As price pressure rises on the production side, manufacturers are increasingly challenged to maintain a sustainable balance between price and quality. Exporting production to low-cost countries is rarely an option, because tailor-made equipment, such as transformers and generators, require a highly skilled workforce.

Raw materials: shortages and soaring prices

In the power industry, copper is a vital raw material for generating, transporting and conducting energy. Its qualities as a highly efficient conductor with low resistance make it virtually irreplaceable. Alloyed steel is also important in this sector, where it is mostly used for a power plant’s heavy construction parts, such as boilers, heat recovery steam generators and turbines.

Long-term global demand for steel and copper is expected to show strong growth, particularly in emerging markets. The resulting pressure on the supply side, and escalating freight and energy costs, have caused prices for copper and steel to soar in recent years – a trend which is expected to continue in the long term despite the current economic slowdown. Moreover, copper is scarce compared to other metals, and various studies indicate that, even if it is recycled, the supply of this raw material may eventually fall short of the needs of the global population.

Rising demand and a shortage of raw materials inevitably leads to longer lead times for spares and thus increases business interruption exposure. Effective mitigation measures include ensuring sufficient spares are available, arranging pooling or leasing agreements and establishing contingency plans. Some manufacturers offer contingency solutions for tailor-made equipment, such as multi-purpose transformers. Insurers tend to honour investments of this kind by assessing the company as a better risk, which will be reflected in the premium.

Re-evaluating property damage values

Business interruption is not the only concern for insurers. When prices for raw materials and labour costs again begin to increase, the risk that originally declared property damage values no longer reflect real replacement values will grow, even if the values are adjusted annually using a common cost index. Most of these indexes do not properly reflect the cost development in a specialized niche.

Figure 2: Specific power plant construction costs

<table>
<thead>
<tr>
<th>Power Plant Type</th>
<th>Construction Costs (USD/kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STPP</td>
<td></td>
</tr>
<tr>
<td>STPP coal</td>
<td></td>
</tr>
<tr>
<td>STPP oil/gas</td>
<td></td>
</tr>
<tr>
<td>CCPP &lt;100MW (GT)</td>
<td></td>
</tr>
<tr>
<td>CCPP &gt;100MW (GT)</td>
<td></td>
</tr>
<tr>
<td>CCPP &lt;100MW</td>
<td></td>
</tr>
<tr>
<td>CCPP &gt;100MW</td>
<td></td>
</tr>
<tr>
<td>Hydro (incl. dams)</td>
<td></td>
</tr>
<tr>
<td>Wind onshore</td>
<td></td>
</tr>
<tr>
<td>Wind offshore</td>
<td></td>
</tr>
<tr>
<td>Geothermal</td>
<td></td>
</tr>
<tr>
<td>Solar</td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td></td>
</tr>
</tbody>
</table>

Key: STPP: steam power plant; CCPP: combined cycle power plant; SCPP: simple cycle power plant; IGCC: integrated gasification combined cycle power plant

Comments: 1) at the higher end of the range for coal power stations, including flue gas cleaning and complex coal handling facilities; 2) lower end without carbon sequestration, higher end with carbon sequestration; 3) at the higher end of the range for large and complex projects with cavern power-houses and dams and dikes, at the lower end of range for river power stations.
The sum insured (or property damage value) is a key figure for both the insured party and the insurer, as it is used as the basis to calculate the indemnity following a loss event and to determine the premium in rating models. It is in the interest of the insured parties to declare accurate values of their insured property, as this will grant them full replacement if a loss occurs. Understated replacement values inevitably lead to underinsurance and potentially to inadequate policy limits. Experience has shown that the effects of underinsurance invariably emerge at the worst possible moment, when an insured party sustains a severe property loss. Lengthy discussions tend to ensue between the two parties precisely when the insured party is most urgently in need of insurance cover.

The so-called average clause was originally introduced to define the ultimate indemnification amount if there was any underinsurance. The clause was removed from many industrial insurance policies in soft market conditions, however, with the result that the risk of underinsurance was effectively shifted to the insurance industry. If values are understated, insurers are likely to charge an insufficient premium, and may need to raise premiums significantly from one insurance period to the next. To help the insured avoid any unpleasant surprises, insurers should therefore re-examine declared values in the light of ongoing price developments.

Key triggers for machinery breakdown

While fire and natural catastrophe losses are typically characterised by low frequency and high severity, machinery breakdown losses occur more frequently, but trigger a smaller loss on average. Most power utility losses are triggered by machinery breakdown. The figures below illustrate loss patterns in the power industry in terms of accumulated loss amounts and loss frequency. Property damage (PD) and business interruption (BI) are combined to machinery breakdown (MB).

Property damage and business interruption loss potential

As outlined in the discussion on industry challenges above, many developments in the power industry could lead to increased failure rates. To obtain a more detailed understanding of how these potential failures are triggered, this section provides a brief vulnerability analysis of various key utility components based on Swiss Re’s own underwriting data.

A comparison of as settled, worst case and best case loss scenarios serves to put the underwriting data into context. While as settled is based on the actual loss data, worst case and best case scenarios are economic assessments using claims handling data. Best case describes the loss scenario where spare parts are on site or available at short notice. In a worst case scenario, the replacement parts have to be newly manufactured, as there are no new or used spares available in the market.
Transformers

Since transformers do not have any moving parts, one might assume that their inherent loss potential is low. This is not the case, however, particularly with large generation step-up transformers, which are greatly exposed to damage from the combination of high voltages and currents and the large fire load of insulation and cooling oil.

Even minimal sparking and leak currents triggered by faulty insulation within a transformer may cause the oil to decompose into gaseous components. Transformers should therefore be continuously monitored for the presence of gas and disconnected from the grid immediately if any excessive gaseous components are detected. Still, even with this precaution in place, a powerful and sudden arc could prompt the gas volume to increase abruptly, causing the transformer tank to burst and the leaking oil to catch fire. Transformers are prone to total loss due to this high fire load.

As a rule, large transformers are tailor-made and not fully interchangeable. Spare transformers are not commonly available, although manufacturers have begun to offer multi-purpose equipment suitable for various plants of a power company. While the property damage loss potential of transformers is relatively small at up to USD 5 million, the resulting business interruption losses may be much higher, as repair or replacement periods may take up to 24 months due to the limited number of manufacturers available worldwide. Most losses examined in Swiss Re’s study were settled below the worst-case scenario. Although no spare transformers were on site in any of the cases, spares could either be bought from a competitor or were available out of the manufacturing process within a reasonable period of time. Still, these must be considered fortunate exceptions, as transformer losses—particularly the business interruption—are expected to become more of a threat with ageing equipment and the growing shortage of raw materials, and the demand for transformer components or the replacement of entire transformers. Spares and contingency plans are key to mitigating the inherent loss potential.

Gas turbines

Gas turbine technology has been pushed to the limits of metallurgical constraints in recent years, and increasingly sophisticated design and cooling are now required to operate the new systems. Computer technology has been a key driver of this progress, particularly for aerodynamics and the design of individual gas turbine components. At the same time, the number of losses involving new or upgraded machines has increased.

Gas turbines have a large property damage loss potential due to expensive replacement parts and a high loss frequency, but they are not prone to total losses and can normally be repaired within a reasonable period of time. According to our experience, as settled business interruption loss values are small compared to the maximum possible loss potential, and most losses are settled close to the best case scenario. There are several reasons for this:

- solid business interruption deductibles are generally in place (60 days for large combined cycle turbines)
- power companies and manufacturers are well aware of new technology issues and have instituted preventive inspections
- many operators have spare parts on site or participate in pooling arrangements for spares
- long-term service agreements grant quick access to spare parts from the manufacturer and are common among gas turbine plant operators

However, this relatively low business interruption exposure could change rapidly with a generic failure in a fleet of a manufacturer which leads to a general shortage of spare parts.

Figure 5: Transformer losses

Source: Swiss Re

Figure 6: Gas turbine losses

Source: Swiss Re
Generators

Similar to transformers, generator rotors and stators also need a cooling system, and air or hydrogen are the most commonly used cooling agents. Hydrogen-cooled generators provide the best cooling efficiency. These cooling systems are generally smaller in size and, as they are totally enclosed, they reduce the risk of contamination within the generator to a minimum.

Operating generators at excessive load can lead to overheating and expedite ageing. Therefore, to avoid extensive machine failure, excess temperature protection must be ensured for rotor windings, cages, and bars, and ground fault detection must be installed for generators. These early warnings of a generator overheating make the difference between a brief shut-down for minor repairs and a major overhaul necessitating weeks, or even months, of costly downtime.

Today, generators are mostly tailor-made items of machinery. This may change in the longer term, as promising efforts have recently been made to standardise these components. Spares are not normally kept in stock, with the exception of rotors in some rare cases. They are highly prone to total loss and repairs are time consuming, involving up to 12 months for rewinding mainly due to the long lead times for required repair materials.

The best-case scenario in the example above is based on the assumption that a spare generator (rotor) can be bought from a pool or from a competitor at a so-called opportunity fee within three to four months. In the worst-case scenario, the spare first needs to be manufactured, which leads to an interruption period of around 18 months. As settled scenarios are close to the worst case due to the long lead times and the scarcity of spare parts for generators. Although the number of generator losses has increased in the past few years, it is still too early to confirm whether this is a new industry trend. Losses incurred in the past clearly demonstrate that supply bottlenecks generate a huge business interruption loss potential for generators.

Taking action to avoid surprises

The risk landscape of the power industry is changing rapidly, and power companies and manufacturers are being exposed to a growing number of risks from various areas in and around the industry. Many of the challenges in this sector are long-term in nature and can be successfully addressed using a prudent and systematic risk management approach. Prevention and mitigation measures do involve additional expenses. In the long run, however, inaction will prove to be far more expensive than taking action.

At the same time, this is a rapidly developing industry, with new technologies such as carbon capture or coal gasification creating new insurance challenges in rapid succession. Specialists on the insurance side must stay abreast of these developments and ensure that any new risk aspects are taken into account appropriately in the insurance cover they provide to their clients. At Swiss Re, industry specialists work in underwriting teams and in close contact with the industry to ensure that this is achieved on an ongoing basis.

To ensure the reliable long-term operation of their plants, power companies must be able to rely on the financial protection provided by their insurers. This has become more challenging in view of the current market price developments and long-term industry predictions. Industry players and insurers must therefore work together to ensure transparency, and re-evaluate the potential impact of these challenges to avoid any underinsurance. Swiss Re encourages all stakeholders involved to join forces to establish a stable and profitable operating environment for the power and insurance industries.

Figure 7: Generator losses

<table>
<thead>
<tr>
<th></th>
<th>Average PD</th>
<th>Average BI</th>
<th>Average PD &amp; BI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best case</td>
<td>1</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>As settled</td>
<td>1</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Worst case</td>
<td>1</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

1 PD replacement value for best case reflects the solution selected (e.g. opportunity fee for spares) to achieve the lowest combined loss figure.

Source: Swiss Re