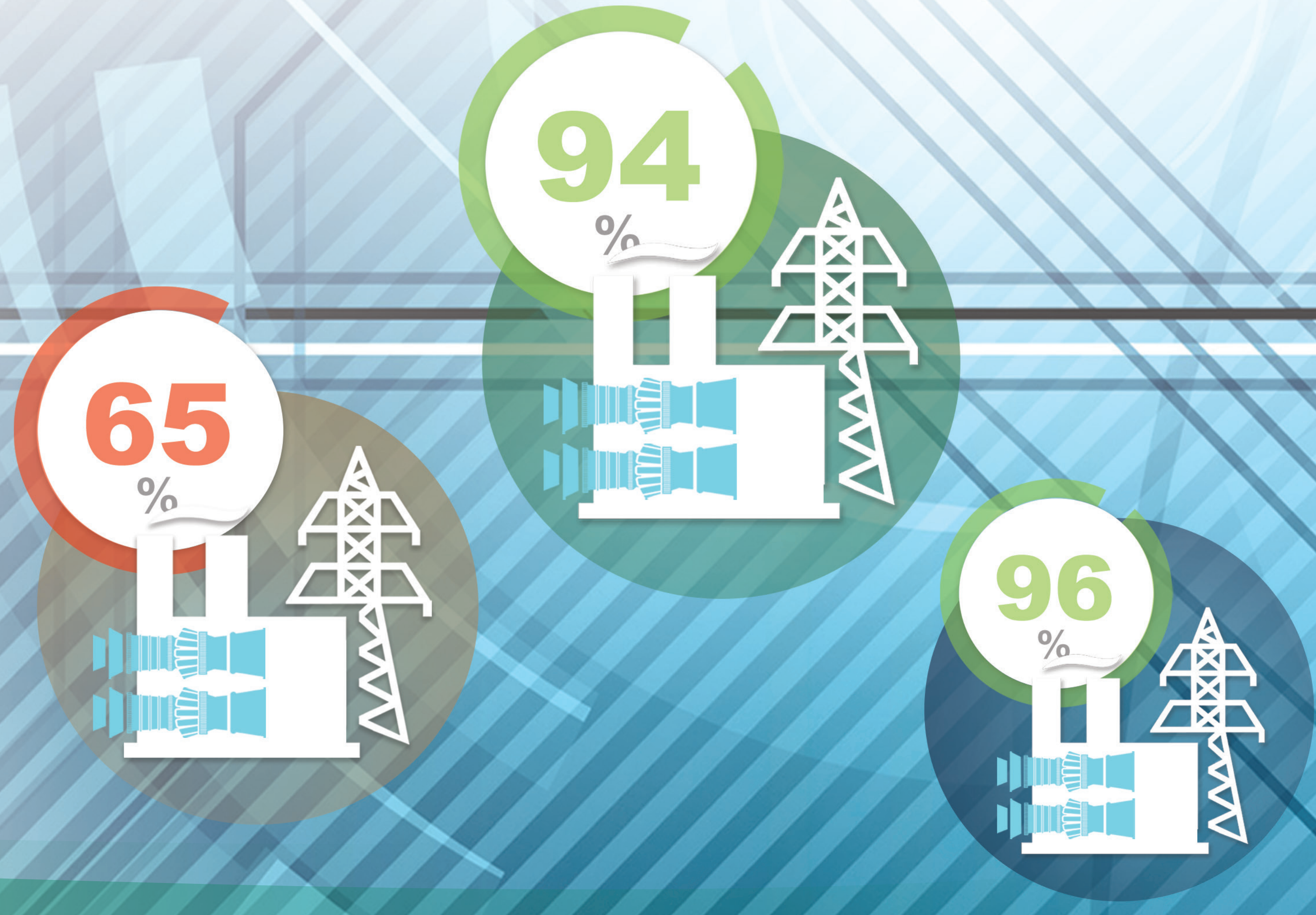
WHITEPAPER

Monitoring the impact of ambient conditions on GT performance improves maintenance practices and maximizes operating profits



Improve maintenance practices and maximize operating profits

Abstract

Power plant operators understand that air quality impacts gas turbine performance. For example, gas turbines will foul over time from sub-micron dust penetrating through the filters, leading to a reduction in compressor efficiency. In addition, as air inlet filters load from capturing ambient dust, pressure drop increases and net turbine output decreases. However, few in the industry monitor changes in ambient conditions and accordingly re-adjust maintenance practices.

This white paper examines how monitoring the effects of ambient conditions and filter performance on gas turbine functionality can improve maintenance decisions and reduce operating costs.

Short-term operations: power prediction

It is common practice for operators to include weather forecasts such as temperature and relative humidity to forecast power. However, monitoring filter pressure drop and current state of the engine can improve forecast accuracy. Keeping track of these important conditions can enable operators to confidently bid on the energy market, meet contractual obligations and avoid penalties and other costs associated with falling short of predicted power availability.

Engine degradation

As turbine engines age, the power output drops due to non-recoverable degradation over time. This degradation can be caused by vibration, aging parts and dust reaching the engine causing erosion, corrosion and plugging of cooling channels. For example, a five-year-old turbine that produced 200 MW when it was new may now only produce 190 MW in its best state.

In addition to non-recoverable degradation, your engines are also subject to a certain amount of recoverable degradation caused by fouling. The higher the ambient dust concentration in the air, the more dust will pass through the filters and deposit on the internal parts. This then causes fouling, which can have several negative effects on the turbine – decreasing compressor efficiency, increasing heat rate resulting in higher carbon intensity, and robbing your engine of power.

Filter degradation

All filters, even in their cleanest state, will increase the pressure drop of the system. As a filter ages, or if it is nearing the end of its lifecycle, it becomes more susceptible to ambient conditions such as relative humidity. In such cases, pressure drop can significantly increase from one hour to the next, as shown in Figure 1. Generally, 1" (25mm) of pressure drop (250 Pa) impacts the gas turbine power output negatively by approximately 0.38% when running full load.

Knowing the current state of the engines and how they react to the influences of filter pressure drop, air temperature, density and relative humidity provides baseline data to accurately calculate power output.

Long-term operations: filter and water wash optimization

Continuous monitoring of ambient dust and turbine conditions, combined with analytics on the cost of current and future filter and turbine degradation, provides a financially sound approach for scheduling filter change-outs. Looking at how dust impacts the rate of fouling, valuable insights are gathered to optimize

Figure 1: Daily pressure drop variations due to humidity

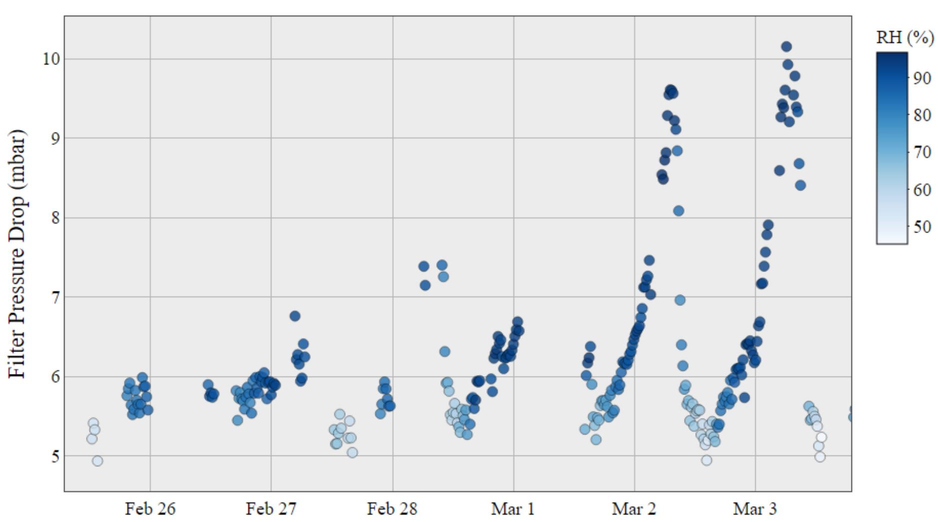


Figure 2: Spread of California forest fire (2020)

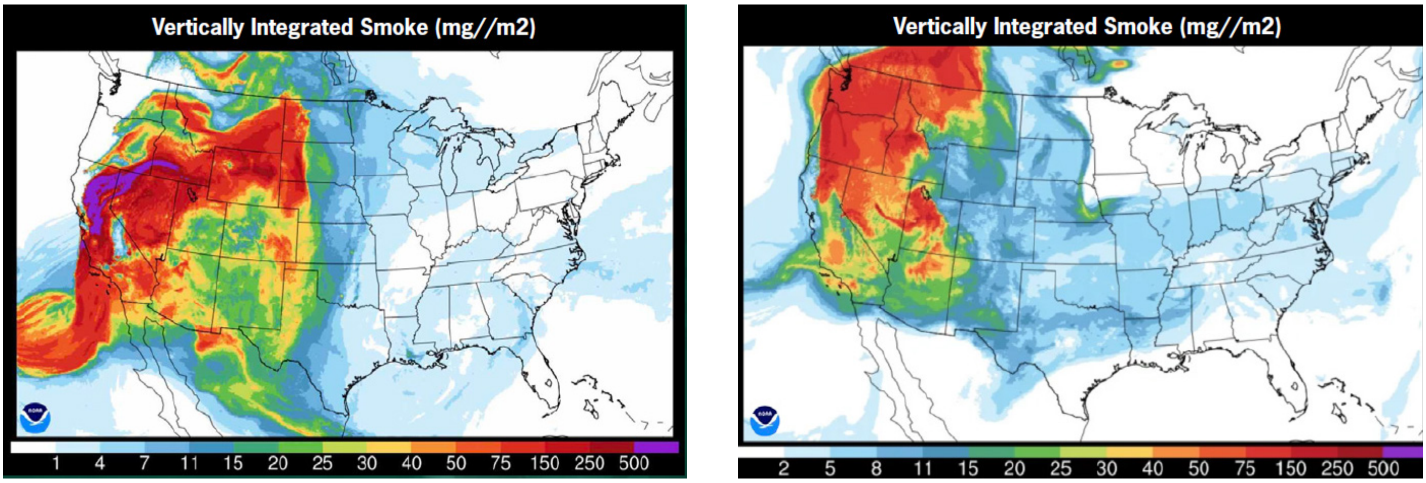


Image courtegsy of the National Oceanic and Atmospheric Administration

filter selection as well as water wash frequency. There are various methods of measuring ambient dust at a certain point in time; however, the challenge is that environmental conditions are constantly changing. These changes are mainly caused by natural events, seasonal changes, and local pollutants resulting from unexpected activity.

Natural events

Large, unforeseen events like wildfires, dust storms, or even infrequent volcanic eruptions can drastically change ambient dust levels for long periods of time. Often these events impact more than the surrounding area, and it is not uncommon for effects to be felt thousands of miles away. Figure 2 shows radar images from the National Oceanic and Atmospheric Administration that demonstrate how the smoke from large forest fires in California can send plumes of particulates into the atmosphere that impact air quality thousands of miles away.

Because seasonal environmental conditions vary geographically, needs and challenges differ from site to site:

• For example, tropical storms bring unusually large amounts of moisture and rain to very large geographic areas. During heavy storms, filters are subject to high humidity and possibly water as well (depending on the intake system design), which can impact filter efficiency and pressure drop if filter drainage is not properly designed or the media is not sufficiently water repellent.

• If the environment is prone to seasonal or overnight fog, the moisture causes dust-loaded filters to become more susceptible to pressure drop spikes, which also increases the risk of tripping or derating turbines.

• Certain regions around the world experience seasonal sandstorms that can have a devastating impact on operational performance. If the system is not designed for these extreme conditions, engines are at a higher risk of trips or derating because filter pressure drop could increase at unexpected rates.

• Pollen is a pollutant that many facilities might not consider but should monitor. Seasonal plumes expel sticky, fluffy pollen particles in the air that can increase the particulate load and force filter change ahead of schedule.

Figure 3 shows how seasonal dust load impacts filter pressure drop increase.

Figure 3: Impact of seasonal dust variations on pressure drop

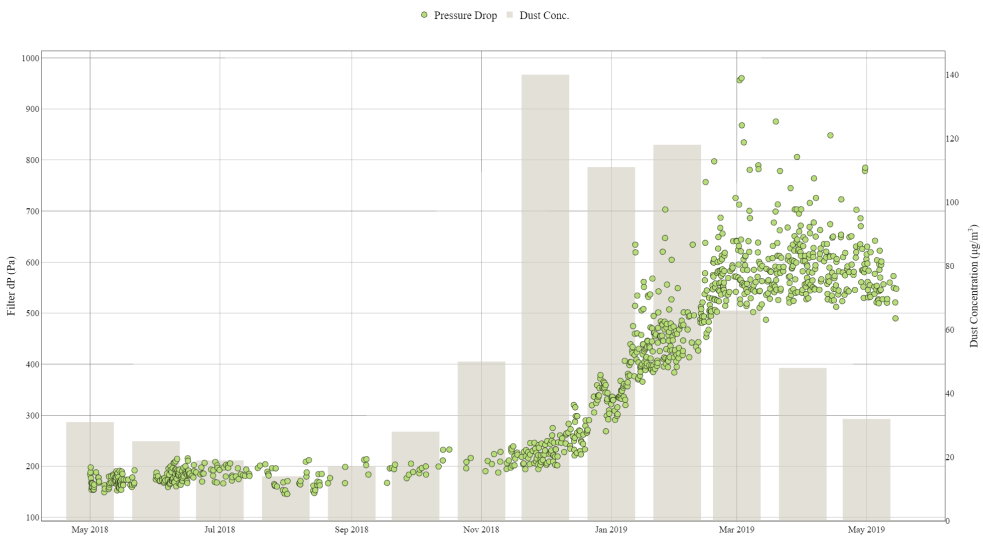
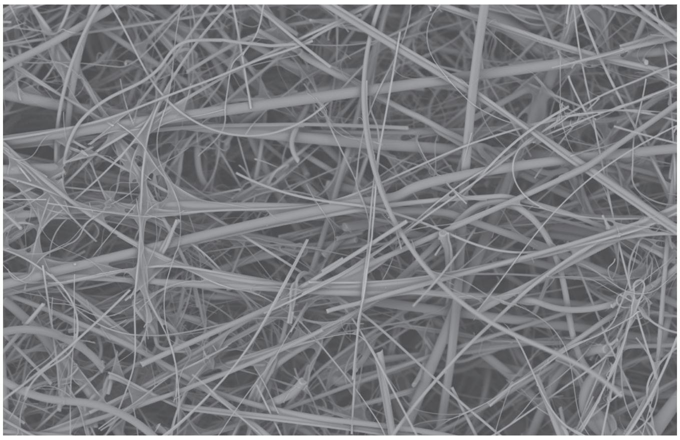
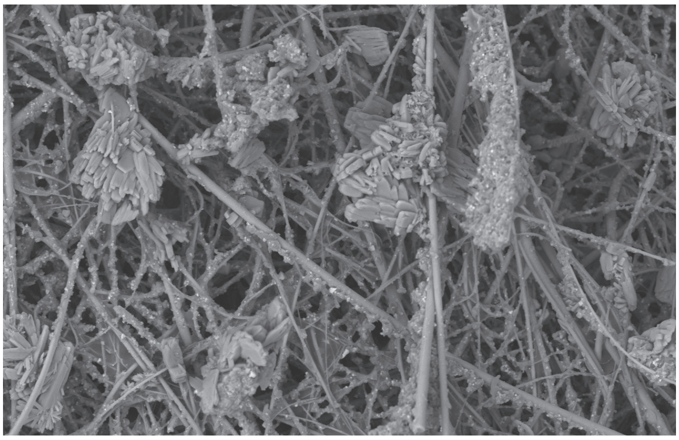


Figure 4: Scanning electron microscope (SEM) images of clean versus loaded filter media (zoom 350X)





Local pollutants

Besides the particulate matter created by natural events or seasonal variations, weather conditions and man-made pollutants can also impact filter behavior and engine performance over time. This can vary greatly from site to site.

For example, industrial activity and new construction in the area around a facility can add dust and other pollutants to the air that threaten filters and engine parts. Figure 4 shows images from a scanning electron microscope (SEM) that shows a magnification of a clean filter versus a filter that has caught gypsum and cement particles.

Such pollutants will shorten the expected life of the filter and if not stopped by an adequate filter solution, could create havoc to the gas turbine.

Filter replacement optimization

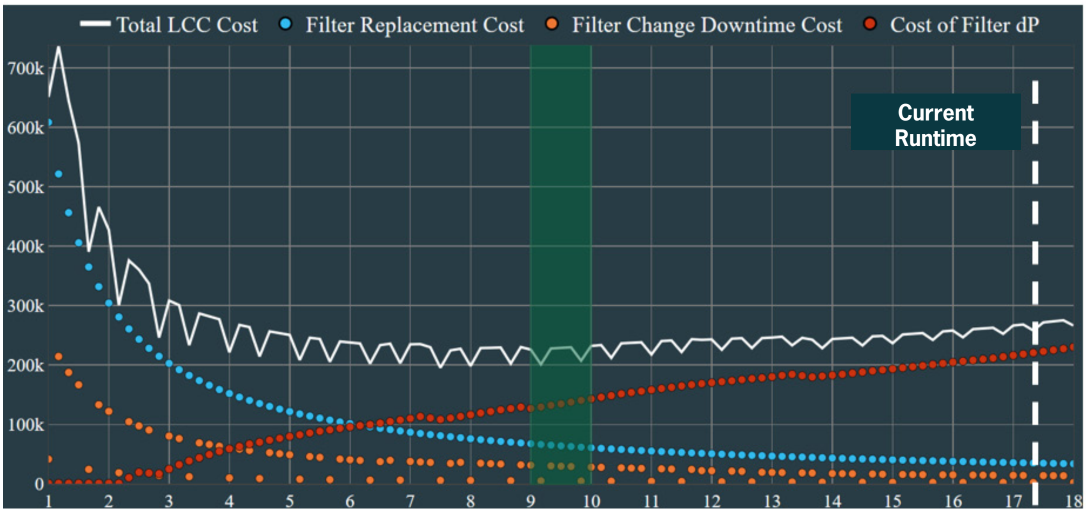
Power plants routinely budget for filter replacement and determine the change-out schedule based on major outages and past filter life experience. But these methods can increase operational cost because there is a point in time when the cost of replacing filters is outweighed by the cost of running them.

As described above, filter pressure drop is not constant and increases at varying rates based on different ambient conditions, primarily relative humidity. Depending on the age of the filters, type of dust they are challenged with and the magnitude of these daily variations, the filter pressure drop can increase significantly and disrupt filter change-out timing. Filters that might have lasted two years may suddenly need to be replaced much earlier.

While variables like temperature and humidity are easy to measure, quantifying dust is much more difficult. Fluctuations in the particulate load in the air are hard to detect. However, through careful and constant monitoring of pressure drop trends when environmental conditions are constantly changing, operators can predict changes over the long-term. With this information, they can prevent unexpected degradation that forces an unplanned outage and make more efficient decisions regarding change-out schedules.

By understanding the cost of replacement filters, change-out downtime and filter pressure drop, operators can optimize the change-out schedule. Figure 5 illustrates these costs and the corresponding estimated optimal change-out time, for a given filter installation. The plant has been running for approximately 17 months. It typically runs these filters for 24 to 36 months. Even at 18 months, the figure shows that if operators had replaced their filters at the optimal 9.5 months, they would have been able to save approximately $200 USD/filter or a total of $100 000 USD for the plant.

Figure 5: Optimal time for filter replacement and associated costs



Combining filter and ambient conditions monitoring with accurate predictive filter models can also provide a precise evaluation of the risk of sudden increase in filter pressure drop. Closely monitoring pressure drop and the magnitude of spikes as the filter ages can help avoid surprises and mitigate the negative consequences of sudden important rises that would put the turbine at risk of derating, or worse a trip.

Optimization of filter selection and water wash frequency

Offline water washes can partially recover lost output caused by fouling but never 100%. More frequent offline water washes will keep the engine cleaner, but as this goes hand in hand with a high associated cost, it may not be the best way forward. One single offline wash can easily represent thousands of dollars in lost production alone, besides the direct related cost of the washing activity itself.

Monitoring compressor efficiency and filter efficiency will allow you to better understand the correlation between them and enable you to optimize your filter selection and reduce your water wash frequency. Never forget that washing here is only a reactive mode, trying to remedy an issue, whereas filtration is a pro-active mode, treating the cause and preventing your gas turbine from degrading in the first place.

Conclusion

Power facility operators can reduce costs and improve maintenance procedures by monitoring the impact of ambient, environmental conditions on the performance of their air inlet filters and related performance of their gas turbines. Facility managers can more accurately predict power availability when they understand the current state of their gas turbine and filters, as well as how they react to changing conditions like temperature, relative humidity, seasonal occurrences, natural events and local pollutants.

Over the long term, continuous monitoring of ambient dust, air quality and seasonal environmental conditions at plant locations and how they impact filter and engine performance enables plant personnel to make more informed decisions regarding filter replacement and filter upgrades.

Power plants are subject to a complex system of constantly changing variables. Camfil's PowerEye™ predictive analytics engine measures and quantifies the impact of ambient conditions on the performance of air inlet filtration and combustion turbines. These insights address the effects on turbine performance summarized above including driving higher power output and reducing operational expenses.

With this constant, careful monitoring, PowerEye provides operators with the needed data to make the best, most financially sound decisions regarding filter management and engine output. In addition, with intelligence from PowerEye, they can conduct predictive maintenance and address potential issues before they become costly problems.

Learn more about the innovative PowerEye predictive analytics service and how it can provide additional actionable insights, at https://www.camfil.com/powereye.

Camfil – a global leader in air filters and clean air solutions

For more than half a century, Camfil has been helping people breathe cleaner air. As a leading manufacturer of premium clean air solutions, we provide commercial and industrial systems for air filtration and air pollution control that improve worker and equipment productivity, minimize energy use, and benefit human health and the environment. We firmly believe that the best solutions for our customers are the best solutions for our planet, too. That's why every step of the way – from design to delivery and across the product life cycle – we consider the impact of what we do on people and on the world around us. Through a fresh approach to problem-solving, innovative design, precise process control and a strong customer focus, we aim to conserve more, use less and find better ways – so we can all breathe easier.

The Camfil Group is headquartered in Stockholm, Sweden, and has 30 manufacturing sites, six R&D centres, local sales offices in 30 countries, and 4,500 employees and growing. We proudly serve and support customers in a wide variety of industries and in communities across the world. To discover how Camfil can help you to protect people, processes and the environment, visit us at www.camfil.com.

www.camfil.com
For further information please contact your nearest Camfil office.
CAMFIL – Clean Air Made for Improving Life