Lack of spare capacity in South Africa's electrical grid has led to blackouts.

BY DAVE SCOTT

Electricity demand in South Africa has grown rapidly in recent years, and the country's power grid has had difficulty keeping up. The strain on the system has resulted in frequent blackouts and even cuts to the mining sector – a large and vital segment of the economy.

To counter this problem, the country's main electric utility, Eskom, is in the midst of an aggressive campaign to increase generating capacity. The company has stated, though, that addressing only the supply side of the equation will not be enough; eliminating power shortages will require conservation, as well.

"The sustainable reduction in power consumption by all is one part of an overall strategy to reduce the overall need for more power," Leslie Barker, chief engineering advisor for Eskom Generation Business Engineering, said in April at the Tribology 2011 International Conference in Pretoria. "All areas of consumption need to be analyzed, and every small incremental saving can contribute to a reduced new capacity requirement."

With that in mind, Eskom has embarked on a campaign that encourages awareness about energy efficiency and which promotes various means of conservation – both internally and among electricity consumers. Initially the campaign focused mostly on savings by residential or industrial consumers, for example getting users to switch to energy efficient lighting and households to install insulation. However, the program has recently been extended to seek process efficiencies that reduce power consumption by industry, including Eskom itself. Internally the company set a goal to save 1 billion kilowatt-hours per year. One approach is to reduce friction in power generation.

At the conference, which was organized by the South African Institute of Tribology, Barker discussed a study of savings that could be achieved by changing lubricants used in gearboxes. The study involved lubricants for helical gear drives on air condenser cooling fans at a coal plant near the country's northern border. It found that switching to polyalphaolefin-based lubes yielded energy savings that were incremental but that could be significant on a broad scale.

FANS PLAY IMPORTANT ROLE

State-owned Eskom is the world's ninth-largest power utility. It supplies 95 percent of the electricity consumed in South Africa and 45 percent of that consumed in all of Africa, although almost all of its sales are domestic. It operates a variety of types of power stations, including coal-fired, hydroelectric, natural gas-fired, nuclear, pumped storage and wind farms.

Eskom utilizes three main types of lubricants, with turbine, hydraulic and gear oils accounting for 90 percent of lube consumption across its Generation Group. An in-house analysis identified gearing functions as a prime area for potential friction reductions that could yield energy savings.

The gear oil study was conducted at Eskom's Matimba power station, located near Ellisras, in South Africa's Limpopo Province, near the Botswana border. It has capacity to generate 3,690 megawatts of power. According to Eskom's website, the station obtains its coal from large deposits extracted by the adjacent Grootegeluk Colliery. Although abundant in coal, the area is scarce in water, so it uses large fans to cool the plant's air condenser. In fact, it is the largest direct dry cooling power station in the world.

Matimba was identified as an ideal site to test gear oils due to the large number of gearboxes in the condenser: 288.

"These gearboxes operate continuously and form part of the drive train that powers large nine-meter-diameter cooling fans," Barker explained. "The fans are used to provide cooling air to the condenser radiator banks where steam from the turbines is condensed before returning to the boiler."

COMPARING GEAR OILS

To compare the ability of different lubricants to reduce friction, Eskom decided to conduct its study in two parts. First it would subject a variety of oils to lab tests designed to measure energy consumption in gearboxes. Then it would install the top performers in gearboxes at Matimba, measure their performance and compare that to performance of conventional lubes over a similar period of time.

Barker explained why Eskom needed

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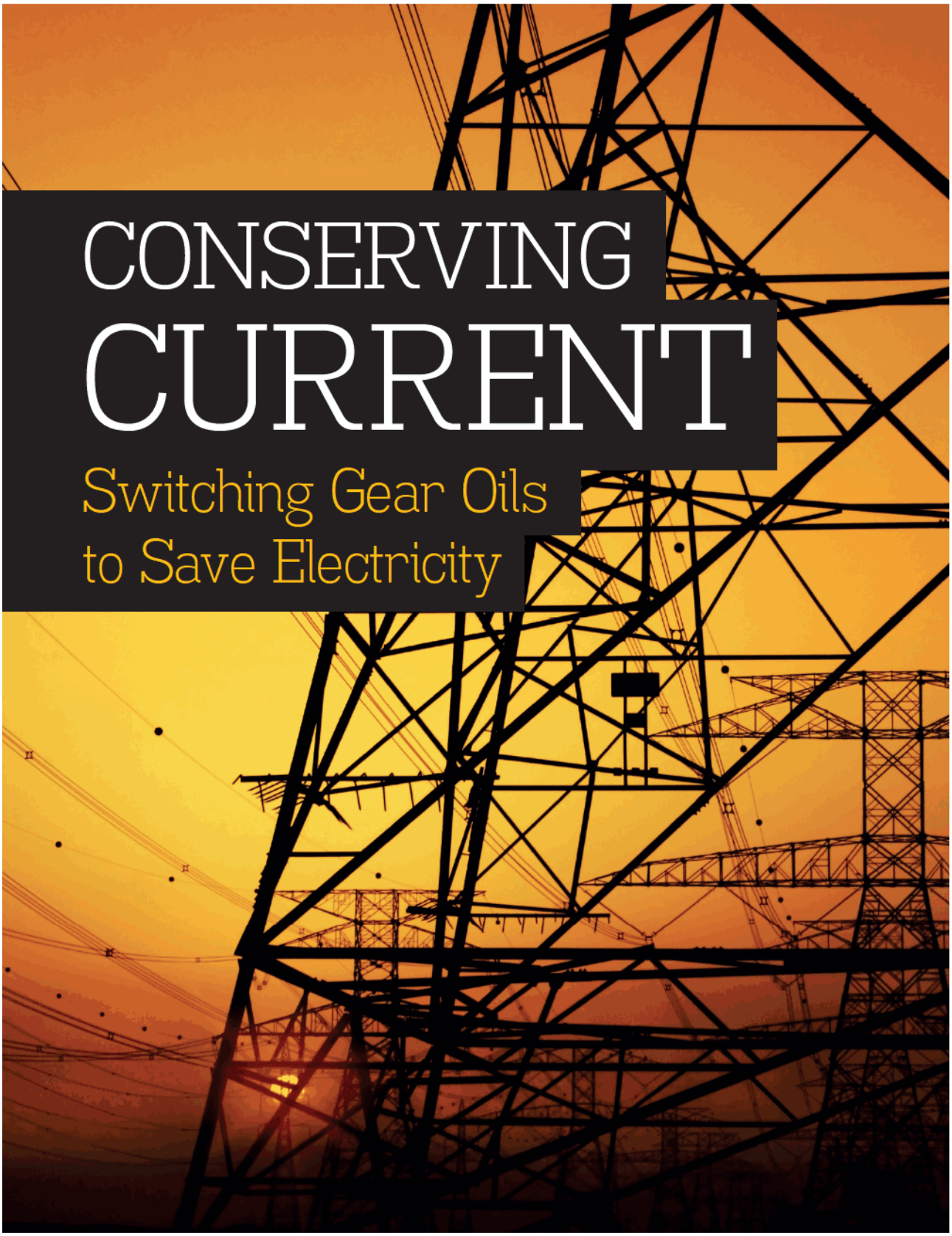
CONSERVING
CURRENT
Switching Gear Oils
to Save Electricity

South Africa's large mining industry could save enormous amounts of electricity if it employed energy-conserving gear oils. At left, conveyors at the famed Cullinan diamond mine east of Pretoria. Below, Eskom's Matimba power station.
Photo below courtesy of Eskom

to do so much work on its own.

"Literature surveys revealed little guidance as to the extent of savings actually achievable," he said. "Most data was produced by lubricant vendors in laboratory tests, and the few in-service tests described concentrated mainly on worm gearing or single applications. Based on the known mechanical efficiencies of helical gearboxes, a saving of about 0.5 percent to 0.75 percent per gear stage was considered possible."

The South African market is "open season" for gear oils, with a large number of vendors offering a wide range of lubricant technologies. Eskom selected 19 different oils, including some products made with mineral base oils, synthetics made with polyalphaolefin or ester base stocks or a blend of both, and semi-synthetics. ISO viscosity grade for all oils was 220, 320 or 460.

For the lab tests, the reference oil was an SAE 50 diesel engine oil because most the station's gearboxes were already using it. The engine oil was recommended by Eskom's oil vendor due to high operating temperatures experienced by the gearboxes. Sample donations were not allowed. All lubricants were purchased via the normal channels. A few synthetics made with polyglycol base stocks performed well in the lab test but were excluded from the in-service trial for compatibility reasons. No aftermarket additives were considered as the use of these products is generally prohibited in Eskom.

The lab trials were performed on a modified FZG machine at the Tribology Laboratory of the Department of Chemical Engineering at the University of Pretoria. The FZG machine is designed to measure energy consumption by open gears. The modification, added by Pretoria University for a previous Eskom project, also allows constant temperature measurement. Eskom says it has found that change in temperature can be a more reliable indicator of change in energy usage so long as the percent change is relatively low.

CHOOSING PAOS

A few patterns stood out from the lab tests. In general, synthetic oils formulated with PAOs were among the best performers, requiring the least amount of energy, Barker said. Those made with mineral base oils were among the worst, although one containing a molybdenum additive scored around average. Most of the PAO-ester blends scored in the bottom half. The diesel reference oil was about average, Barker said.

The three top performers – different brands all based on PAOs with ISO viscosity grade 220 or 320 – were selected for the in-service trial. These oils were installed in 13 of Matimba's gearboxes, 10 of which were new models and three of

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older design. The new gearboxes, which will be used in two new Eskom stations now under construction, are much lighter than the older boxes and have an oil sump that is one fourth the size. The smaller sump size means they are prone to operate at higher temperatures.

Eskom tracked energy consumption and temperature of the test gearboxes from October to December 2010. The results were compared to data that the same gearboxes generated during the previous three months using a standard extreme pressure gear oil that was used as a base line for the in-service test.

The results showed a clear trend of lower temperature using the PAO fluids. "On average there is a six degree C drop in operating temperature, and it appears that the percentage drop in oil temperature is roughly three times the drop in power consumption," Barber said After adjusting for seasonal differences in ambient temperature, Eskom concluded that the PAO gear oils lowered energy consumption by an average of 2.2 percent. Barker added that even better performance could be achieved by choosing lighter grade oils.

"Due to the higher viscosity index associated with the synthetic oils and the lower operating temperature, it should be possible to further reduce the oil grade and achieve higher savings without compromising gear protection."

HURDLES FOR NEW OILS

Barker noted that switching to PAO gear oils is not a step to be taken lightly. One major consideration is that the use of these oils would require a significant change in mindset and maintenance practices to allow the oil to achieve its full service life. In addition, switching oils just for all gearboxes in Matimba's air condenser would be a logistical nightmare.

On the other hand, Barker confirmed, synthetics would bring an environmental benefit. "Yes, drain intervals can be extended," he said, "but this was not the major objective in these tests – it's a by-product benefit."

More importantly, the potential energy savings are very significant, he said, especially if the synthetics were employed on a wide scale. If all 288 gearboxes were converted to PAO lubes, potential energy savings at Matimba would be 1,425 kw – or roughly 11.5 megawatt-hours per annum, Barker said. Converting all major gearboxes in Eskom to a suitable synthetic oil could conservatively provide savings as high as 20 mw or 140,000 gigawatt-hours.

"In the South African market Eskom's oil usage is estimated at less than 0.5 percent, while the mining industry alone accounts for at least 15 percent to 20 percent," Barker said. "This makes the potential for energy savings… 30 times higher in the mining industry.

"It is difficult to estimate all sectors, but potential savings in gearing applications alone could exceed 200 mw and be as high as 600 mw. It is not likely that all these applications would be converted, but even a low percentage uptake would have a significant impact in reducing power consumption."

Barker said Eskom should move toward installing synthetic lubes in gearboxes, though he added that the company first needs to establish new practices for changing those fluids, along with a clear test protocol for choosing which fluids to use. He said the company should also encourage electricity consumers to take the same steps and that Eskom should explore opportunities for savings in other applications, too.

If those things can be accomplished, the results of Eskom's study suggest lubricants will help South Africa solve its energy problems. □

Leslie Barker

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