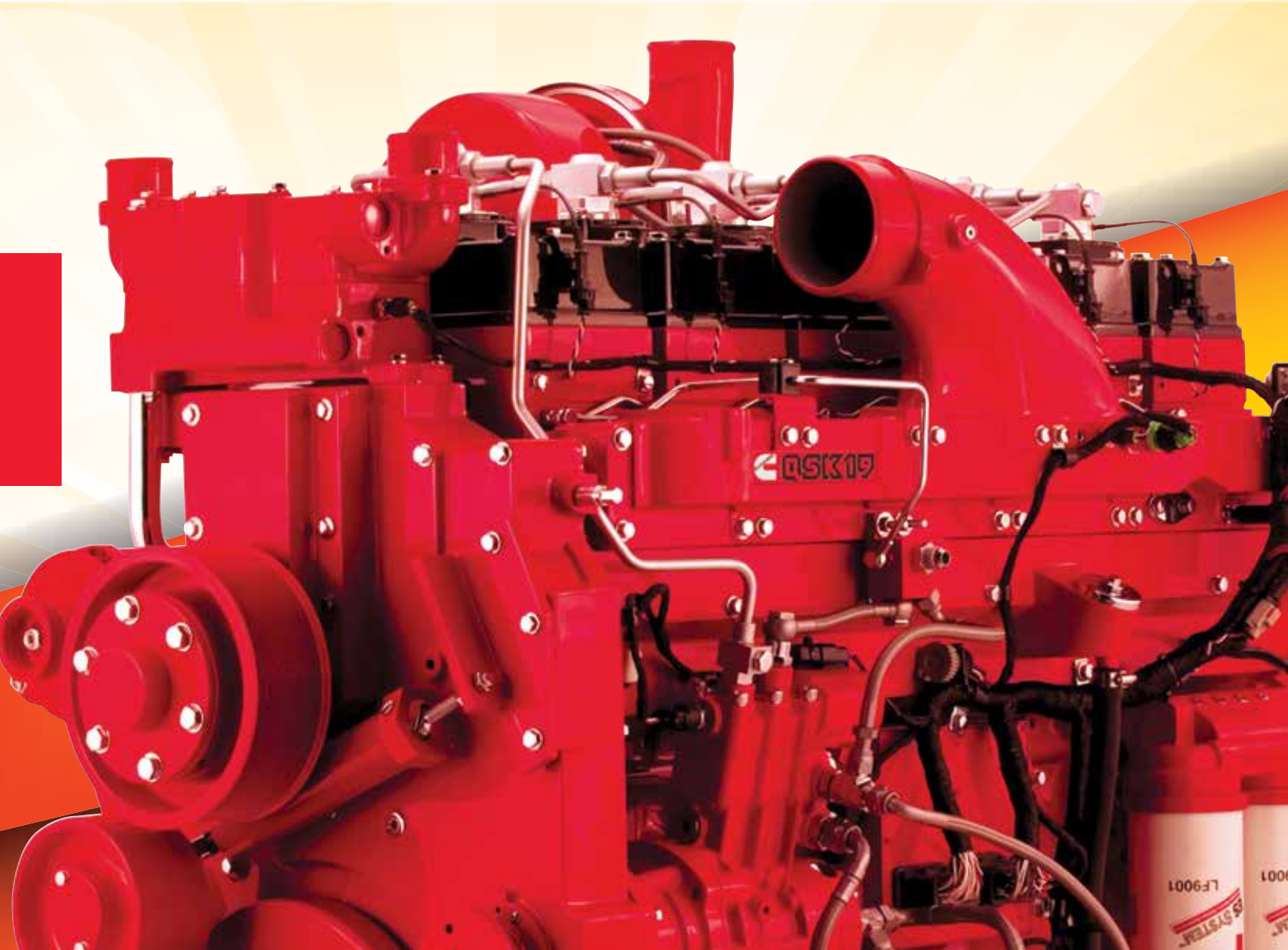
Harvesting Free Power from High Speed Electrical Machines

Many governments have developed legislation to try and reduce our dependency on fossil fuels like petrol, diesel, oil, coal and natural gas, in an attempt to try and offset the human contribution to global warming. Evidence of these initiatives may be seen in our everyday lives in the form of wind turbines and solar panels. While many governments have aggressive targets to reduce our dependency on fossil fuel the sheer scale of the energy challenge is much larger than most people realise requiring many decades of significant investment.

A potential middle ground in the quest for a more environmentally friendly solution would be to improve the efficiency of existing systems. A typical modern-day diesel engine achieves no more than 35% Brake Thermal Efficiency (BTE).

BTE being the ratio between the energy available at the engine's flywheel and the energy present in the fuel in the tank. So where's all that 'spare' energy going? The majority is simply lost as waste heat, either through the exhaust pipe or cooling system, or radiated from the engine block itself. Then there are mechanical 'parasitic' losses to the air-compressor, water and steering pumps plus the alternator. To top it all off, there are frictional losses in the engine too.

For diesel engine manufacturers the challenge is to make more use of that wasted energy, and one way of doing that is to harness it through the use of high-speed electrical machines within a Waste Heat Recovery (WHR) system. Studies have shown over 10% improvement on vehicle efficiency is possible.



ORC can be explained by considering your kettle at home; heat is applied to the water that changes state to steam, and this steam could then be used to drive a turbine generator to produce electrical energy.

In engine WHR, the high speed electrical machine is used as a generator to recover engine waste-heat via an Organic Rankine Cycle (ORC). ORC can be explained by considering your kettle at home; heat is applied to the water that changes state to steam, and this steam could then be used to drive a turbine generator to produce electrical energy. Modern ORC systems are based on this principle but tend not to use water.

There are many different arrangements for recovering waste heat. Figure 1 pictures a Cummins ISX with an ORC integrated onto the entire engine that drives a turbine. For this application the objective was to feed this recovered energy back to the crankshaft on the engine. To enable this Power Electronics is used to take the Electrical Energy from the turbine generator and push the energy into the crankshaft of the engine via a flywheel mounted electrical machine. Figure 2 shows a smaller turbine generator that was used to recover less power in order that the recovered electrical energy could be fed directly into the vehicles electrical system.

This article provides just two examples of how we at Cummins Generator Technologies can help develop technologies that will help save the planet.
More to follow in future editions.

Figure 1 - Cummins ISX Engine fitted with an ORC

Figure 2 - Example of a 5kW 120krpm Turbine Generator used with a small ORC system