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Transport: New train of thought helps improve energy efficiency

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It might seem odd to associate the huge trains that carry iron ore across Western Australia's outback with concern for the environment. But Richard Cohen, general manager of the 1,300km of railways operated by Rio Tinto, one of the biggest miners, in the Pilbara region, would love to take improvements in the environmental performance of its diesel-electric locomotives a stage further.

At present, when each train's three locomotives apply the brakes to a 33,000-tonne, 230-wagon laden train, the electric motors on its six axles turn into generators, producing electricity. The energy is dissipated by heating up banks of electrical resistors. If some of the electricity could be stored and used to restart the train, the saving in fuel and carbon-dioxide emissions could be substantial.

The iron ore trains are an excellent illustration of the challenges all transport modes face in trying to improve their energy efficiency.

All boil down to basic physics. Environmental performance improves when the most efficient use is made of the fuel that accelerates a vehicle; when the vehicle becomes easier to accelerate; when the friction that dissipates momentum is reduced; and when the energy generated slowing the vehicle is stored and reused.

The US's General Electric, builder of the Evolution locomotives that form much of Rio Tinto's fleet, has already taken one key step by overhauling its engine design. Further design improvements, such as a better turbocharger and higher pressure pistons, have allowed GE to replace its 16-cylinder engine with a 12-cylinder model producing the same power. Fuel consumption has fallen by at least 3 per cent.

The improvement echoes steps taken in both the car industry and aviation, where computer-assisted design of pistons and turbine blades, and electronic control of fuel injection, have substantially improved the forward momentum extracted from each millilitre of fuel. Modern marine engines consume far less fuel than even relatively recent predecessors, while some ships now recover and use the heat in engines' exhaust gases.

Lorenzo Simonelli, chief executive of GE Transportation, the locomotive-building division, says the company is investing to create the locomotives that will be needed to keep rail competitive over the next 10 to 20 years.

"People have to get more on to rail," he says. "It's the right thing to do – and it's the mode of transport that's most efficient."

Some energy-saving techniques are inappropriate for heavy-haul freight locomotives. Because they need to transfer enough effort to the rails to start 33,000 tonne trains, Rio Tinto's diesels carry added weight to prevent their wheels from slipping. In transport modes where the main weight is the vehicle itself, a reduction in weight can be one of the most effective means of saving energy.

The Boeing 787 Dreamliner is lighter – and more fuel-efficient – than older airliners because it uses composite materials far lighter than traditional aluminium fuselages.

Japan's Shinkansen trains consume less energy than other high-speed trains because they need less strong bodies and are consequently far lighter.

Air friction is also a negligible problem for a train moving as relatively slowly as one of Rio Tinto's iron ore trains, but reducing drag from the surroundings can have a marked impact in other transport modes. Germany's Siemens claims the redesigned nose of its Velaro-D high-speed train will cut energy consumption by 10 per cent compared with previous versions.

The hulls of the E-Class ships of Denmark's Maersk Line – the world's largest container ships – are covered in a non-toxic paint that stops build-up of barnacles and other sea creatures from increasing the water drag on the ships' hulls.

Yet the biggest potential saving for trains such as Rio Tinto's – the harnessing and reuse of the power from braking – has been unrealised until now because of the technology's complexity. There has been an attempt on electrified railways in recent years to use more such energy by feeding currents generated during braking back into the overhead wire or third rail for another, accelerating train to use.

The main problem is that, when no other train is accelerating, rheostatic braking – as the banks of resistors are known – is still required.

For non-electrified transport modes, the challenge is far greater – to produce a battery robust enough to survive repeated cycles of charging and discharging but light enough not to waste the energy savings in the effort of dragging the battery around.

While such technology is already widely used in hybrid cars, it is far more difficult to handle the huge electrical loads generated when slowing down trains such as Rio Tinto's. But Mr Simonelli says new investments should ensure GE can produce effective hybrid diesel and battery-electric locomotives. "We're investing $150m in sodium battery technology that allows the hybrid to become a reality," he says.

Henry Posner, a US railway investor, says that, even with Evolution locomotives' fuel-saving levels, the small Iowa Interstate Railroad which he controls was surprised to be able to justify buying new locomotives because the fuel savings would fund them.

It is hardly surprising, then, that Mr Cohen, running far heavier, more energy-intensive trains says he is keeping in close contact with GE about trying out the far more revolutionary hybrid technology when it is sufficiently developed.

"It's something very interesting on our horizon," he says.

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