SUPPLY CHAIN & LOGISTICS ASSOCIATION OF AUSTRALIA

Fact sheet no.6
Glossary

The technology and concepts associated with energy efficiency mean that there can be a lot of jargon or unfamiliar terminology.

This fact sheet describes and defines concepts and terms covered in the other project materials.

It is one of six fact sheets and other resource material developed by the Supply Chain and Logistics Association of Australia (SCLAA) and project partners to help SMEs in the supply chain and logistics sector with energy efficiency improvements and energy cost reductions.

The full suite of resources is available from http://energy-efficiency.sclaa.com.au

➤ Road Transport Fleet Opportunities

New engine/drivetrain technologies. Modern engines use a range of technologies to reduce fuel consumption, and different types of engines (e.g. diesel, petrol) may use different systems. When buying a new truck, buyers will have an idea of the size (or power output) of the engine they need, but few have a good understanding of the kind of systems used to improve efficiency. Most of these are either fitted or not (i.e. they are not options). Examples that can indicate a more efficient engine include:

- **Smaller size engine (downsizing).** Engine size typically refers to the swept displacement of the pistons in their cylinders – for example, a 3.0 litre engine for a passenger car, or a 12-litre engine in a truck. Modern engine controls and fuel systems (e.g. direct injection) allow more torque and power to be produced across a wider range of engine speeds. More power means that a smaller engine might be used than has been the case in the past. This is particularly true when downsizing is combined with modern turbochargers or superchargers.
- **Turbocharging or supercharging.** These two techniques essentially do the same thing: force more air into the engine than can be sucked in at normal atmospheric pressure. More air allows more fuel to be supplied (and therefore more power produced) while still maintaining the right air/fuel ratio for combustion. Turbocharging and supercharging allow a smaller engine to produce as much peak torque and power as a non-turbo engine that is 20-40% larger. In real conditions, the extra power of the turbocharger is not required all the time and so the engine can

operate as the smaller engine that it is (using less fuel). Superchargers are driven directly by the engine's crankshaft (normally via a belt) while turbochargers are driven by the flow of exhaust gases through a turbine.

- **Turbo compound.** Multiple stages of turbocharging which allow extra energy to be recovered from the exhaust gases.
- **Variable displacement or cylinder deactivation.** Different manufacturers call these systems by different names: for example, GM-Holden's Active Fuel Management; Honda's Variable Cylinder Management; Mercedes' Active Cylinder Control. Essentially they all take the same approach by de-activating or turning cylinders "off" (at least the fuel supply) during times of low power demand such as coasting. Such systems are most effective on large multi-cylinder engines.
- **Variable air compressor, oil pump or water pump.** The vehicle's demand for compressed air (for truck braking systems), oil (for engine lubrication) and water (for cooling of engine and/or gearbox) varies with the operating conditions. Most traditional compressors or pumps for these systems operated all the time, using up small amounts of engine power regardless of what the demand load was. Newer systems allow the pump to be switched off or its speed to be varied depending on the demand.
- **Smart (electric) ancillary equipment.** Similar to oil and water pumps, other ancillary equipment such as power steering, air conditioning, and refrigeration equipment also draw power from the engine. Making these systems intelligent (responsive to demand) or electrically powered, can reduce parasitic power consumption and thereby reduce fuel consumption.
- **Intelligent transmission.** These are either traditional or newer gearbox designs which use advanced controls for gear shifting and the timing of shifts. The best systems use data from the truck itself (engine, body, load, brakes) as well as the topography ahead (from sensors or GPS data) to determine the most suitable gear for the conditions. Fuel efficiency is achieved by specific fuel-saving shift modes in the software that select the most appropriate gear for power/torque requirements. Most systems are one of three types:

1. Traditional automatic with lock-up torque converter or clutches in several gears to reduce "slip" and improve efficiency
2. Automated manual transmissions (AMT) essentially operate as a two-pedal manual gearbox: smart electronics, servos and robotics take care of the clutch function.
3. Dual-clutch gearbox: essentially an AMT with two drive shafts and two clutches, so one gear is active and another pre-selected. Extra efficiency above an AMT is achieved by eliminating shift time between gears.

- **Stop-start systems** reduce engine idling by turning the engine off when the vehicle stops – for example, at traffic lights. They are designed to restart the engine the instant the driver attempts to move off, and require good integration with the rest of the engine/transmission, so can't be fitted as an after-market kit. These are more common on light commercial vehicles than large trucks at this stage.
- **Battery-electric hybrids** combine two power sources – usually a regular internal combustion engine and an electric motor. Energy is recovered and stored in batteries during braking, to be re-used in acceleration. The level of assistance from the battery/electric motor depends on system size and design, with some allowing small distances to be covered on battery power alone.
- **Predictive cruise control.** All cruise systems allow a set speed to be maintained, but the best systems adjust speed to be compatible with surrounding traffic using radar or other sensors to monitor vehicle movements and driver behaviour, and topography and corners on the road ahead.
- **Acceleration/speed control.** Drivers often use more acceleration than is actually required, or exceed the speed limit to gain time. In some cases, acceleration can be limited by settings in the engine computer. Vehicle speed can also be limited by a company policy, real-time monitoring, a buzzer or alarm, and after-market speed governors. Make sure systems are allowable by law in your area.
- **Driver information systems.** Many drivers just don't know the most fuel-efficient way of operating a vehicle's engine, transmission and other systems. Driver information systems such as gear shifting lights, engine "green zones", and real-time messaging can save fuel by informing the driver when they need to act.

Fuel efficient equipment. Apart from purchasing new, more efficient trucks, fleet operators have some options to improve their existing fleet by adding equipment or modifying vehicles. A basic overview of these measures is provided below.

- **Auxiliary power systems.** For trucks that have major energy requirements for on-board equipment (or power during engine-off periods), an auxiliary power source can reduce fuel use by allowing the main truck motor to be turned off and a smaller (more efficient) motor more appropriate for equipment requirements to be used. A common example is stand-alone air conditioning system to keep the cabin cool when a driver takes rest breaks (so the main truck engine can be turned off).
- **Low rolling resistance tyres,** often called eco-tyres or green tyres. Rolling resistance can account for up to 30% of the energy a truck uses at highway speeds; so any reduction in rolling resistance has a corresponding benefit in fuel efficiency. At least two manufacturers produce low rolling resistance tyres, with each taking a different approach (one improving the structure of the tyre carcass and sidewall, the other producing a special tyre rubber compound).
- **Automatic tyre inflation/monitoring.** Under-inflated or over-inflated tyres can increase fuel use and tyre wear, and affect ride/handling characteristics. Tyre pressure monitoring systems can warn the driver when tyre pressure drops, including when a puncture occurs (possibly preventing a costly and dangerous blowout). Central tyre inflation systems can maintain or adjust tyre pressure, but are mainly used off-road where frequent pressure changes are required.
- **Aerodynamic devices.** At medium and high speeds, more than 30% of engine power (and up to half, depending on body configuration) is consumed to overcome aerodynamic drag. Drag can be reduced by making the truck more streamlined, removing protrusions, and reducing air gaps. Various devices are available including roof spoilers, cab skirts, trailer skirts, wheel covers, trailer 'boat tails', and other equipment. Combining different devices can provide substantial savings.
- **Light-weighting.** The literature suggests a basic rule of thumb is that a specific percentage weight reduction can produce up to half that percentage in fuel savings (so 10% weight reduction saves up to 5% fuel). Note that this assumes the rest of the vehicle (engine, transmission, brakes, etc) is optimised for the lower weight. Similarly, many operators will simply increase payload up to the regulated mass limit. So actual fuel savings are likely to be less impressive; however, fuel use per unit of freight will improve. Lightweight materials include aluminium, magnesium and composites, but weight reduction can also be achieved through good design. Common parts/systems that are available in lightweight versions include wheels, bullbars, drive shafts, truck bodies, entire trailers, mudflaps; as well as packaging and pallets for products. Don't forget weight can be removed by taking out unnecessary equipment like racks/shelving, towbars, driver options/accessories, and other equipment; and by regular cleaning to remove dirt and mud.

Behaviour change and freight practices. Besides the physical equipment fitted to the truck, how the fleet is maintained and managed can also improve fuel efficiency. Opportunities here include:

- **Eco-driving (or environmental driver training)** refers to a system of driving techniques intended to minimise fuel consumption by reducing wasted energy. Basic techniques include smooth acceleration and braking, anticipating changes in traffic by looking far ahead rather than just the vehicle in front, reduced engine idling, shifting gears to match the engine's torque characteristics and load, and maintaining momentum in hilly terrain. Many of the techniques not only save fuel but also improve road safety, providing a double-dividend for the business. There are many providers of eco-driving training that can work with your business.
- **Idle reduction.** Engine idling in a large truck can consume up to 4 litres of diesel every hour, often with little or no benefit to the company. The fleet manager can set policies and implement basic monitoring to discourage drivers from excessive idling. Idle cut-off devices can also be purchased and fitted to vehicles.
- **Load consolidation.** Holding back deliveries that are not time-critical, so that different consignments can be aggregated into a single load, can reduce the total number of trips required in a day or week, and therefore reduce fuel usage. Sharing loads with non-competing businesses can also reduce wasted trips.
- **Off-peak and night time freight.** Driving in peak traffic periods results in high levels of wasted energy as the truck must be frequently accelerated and decelerated can spend a lot of time idling on congested roads. Negotiating delivery times outside the morning and afternoon peak periods can help to reduce fuel consumption, trip times, wear and tear, and accident risks.
- **Preventive maintenance.** Keeping equipment in good condition reduces energy consumption by reducing friction, wear and breakdowns. Regular and scheduled maintenance as specified by the manufacturer keeps equipment running as it was designed to.
- **Good tyre maintenance.** Wheel balance and alignment have a significant impact on rolling resistance. The lower the rolling resistance the less energy is required to overcome it. Regular balancing and alignment can therefore improve fuel efficiency and extend tyre life, as well as reducing the risk of tyre failure.

- **Optimised routing and scheduling.** In the same way that consolidating loads can reduce the number of trips required, the order of deliveries can reduce the total distance travelled. Modern software systems can help optimise the order of deliveries to reduce time spent on the road and in traffic, as well as the optimum combination of consignments to maximise load capacity.
- **Reduce top speed.** Because aerodynamic drag is such a major factor in energy consumed on the highway (30-50%), reducing the cruising speed by even 5 or 10 km/h can make a measurable difference. Some fleets have successfully used policies or equipment that prevents drivers exceeding an agreed speed (e.g. 90km/h). Other factors also need to be considered such as safety and disruption to other road users, but a safe option could be to use the maximum open road speed limit.
- **Streamlining.** This opportunity applies primarily to light vehicles whose original shape may have been affected by fitting roof racks, bull bars, towbars, large aerials or other equipment that protrudes into the air stream. Unless it's essential for most work, remove them or find more aerodynamic alternatives.

➤ Warehouse Opportunities

Insulation. For a warehouse with a HVAC system in place, adding insulation is the simplest way to improve the thermal performance of a building, as it significantly reduces the amount of artificial heating and cooling required.

For those warehouses without a HVAC system in place, insulation can still provide benefits in the form of increased comfort levels for staff, and reduced loads on cold storage areas.

Insulation is graded by its R-value, a measure of thermal resistance it provides - the higher the R value, the more effective the insulation.

Insulation is much cheaper to include at the initial construction phase of a warehouse, but can be retrofitted later on. If you are retrofitting insulation, consider doing it in tandem with other renovations or maintenance to reduce costs.

The effectiveness of insulation is impacted by a variety of factors – insulation age, height of your roof, building shell material, orientation, spacing, gaps, air leakage etc. It can be applied to the roof, walls and floor, both internally and externally. For guidance on the suitability of insulation for your warehouse, speak further with a reputable insulation supplier or an accredited energy auditor.

Refrigerated stores. Poor sealing and insulation, resulting in heat gain or the loss of cold air, is a major burden on refrigeration systems.

Fixing cold air leaks in refrigerated stores can save you 10% at little cost, and it is a good place to start because it reduces avoidable energy losses at the downstream end (once the work has already been done in cooling).

Similarly, leakage of refrigerant fluid is common and good maintenance and repairs can often result in up to 10% energy savings.

Compressors use the most energy in commercial refrigeration, followed by fan motors and then other equipment (lighting, heaters, etc.).

Optimising compressor operation or replacing compressors with high efficiency units can therefore save up to 10-12% of energy use compared to a conventional unit.

Simple measures like improving defrosting, regular maintenance, and keeping the door closed are all easily implemented.

Motors. Electric motors are used in a range of plant and equipment throughout the supply chain and logistics sector – including fans, pumps, compressors, conveyors and cranes, as examples. Motors operate at their highest efficiency between about 60% and 100% of their full-rated load, dropping off sharply in efficiency below 50% loading.

Variable speed drives help ensure that power generated matches the power required. In some circumstances this power optimisation can save you more than 10% related to that component, with a payback period around 4 years.

High efficiency motors incur a 10–15% price premium on standard motors, but the payback can be as little as 6 months (typically up to 2 years depending on application).

Lighting. Lighting can account for 50-80% of energy consumed in a warehouse. Install skylights for natural light (use perspex as roofing material instead of tin) and replace all gas discharge lighting to save another 10%.

For optimum efficiency, LED lights can provide the required luminosity for a typical warehouse. While these incur higher upfront costs, they save money in the long run: firstly, via reduced electricity use; secondly, through replacement costs (they last ten years or more); and thirdly, in lower maintenance costs (e.g. less need to hire scissor lifts). Compact fluorescents are a cheaper alternative to LEDs, but produce fewer savings.

Heating, ventilation and cooling (HVAC). The biggest opportunities for energy reductions in warehouse HVAC depend on whether an air conditioner is fitted, and whether it is a stand-alone unit or a central unit. Air conditioners use a lot of energy when operating, so the control system is crucial to ensure they only work when they have to: a flexible control system and

responsive air conditioning system can save more than 3% of total warehouse energy use.

The biggest savings can be locked in at the design stage:

- The use of natural cooling through vents and doors to control air movement can reduce the need for cooling systems on hot days. Where this can't be achieved, fan systems can be used to circulate air to prevent the use of air conditioning
- Good insulation can reduce heat loss in colder areas on hot days
- For central plant air conditioning systems, economy cycles that exchange ambient air to help control indoor temperature can not only reduce energy use but can also help improve indoor air quality

Routine maintenance on HVAC systems is a low-cost action that can save another 1% or more or total warehouse energy. Similarly, high efficiency motors on the air conditioner compressor or variable speed drives and controls for fans can save 1-2% by matching ventilation and temperature to only what is required.

Conveyors. If you have an old conveyor system on the site, consider upgrading individual components or sub-systems to newer designs. Examples of modern conveyor types include:

- narrow belt
- electro-adhesion
- vertical carousels or lift modules.

If conducting a major upgrade, automated storage and retrieval systems (AS/RS) reduce labour costs by using unmanned guided forklifts to store or retrieve products. The cost of such systems can be high, but they also produce compounding savings by reducing the need for lighting, ventilation, and safety incidents.

Forklifts. Switching fuels may not save much energy (or it could be hard to quantify), but it can help save costs. Some operators are swapping their LPG forklifts for natural gas, while others are switching to hybrid or battery-electric models. Some models of excavator, front-end loader and other construction-based equipment are now available with energy-recovery (or hybrid) systems that can reduce diesel use by more than 20%.

Again, simple things can also provide meaningful savings: turning the engine off on forklifts, tractors, loaders, and cranes (rather than idling) is an example. Large pieces of equipment can use over 4 litres of diesel simply idling for an hour.

Warehouse Management System (WMS). A good WMS can save energy by streamlining, integrating and optimising operations within the warehouse. Efficiency can be achieved with a WMS via:

- inter-leaving tasks (multi-tasking) for mobile equipment like forklifts, so they can do other tasks in between loading/unloading
- enabling cross-docking, whereby freight is unloaded from one truck and loaded directly into another at the dock without being stored in the warehouse
- optimising storage locations to reduce handling time and distance within the warehouse – for example, by co-locating fast-moving stock near receive/despatch areas
- allow integration of energy management systems, such as switching lights on/off only in areas being used at the time
- enabling flexible fulfilment so items can be picked by zone, order or item and integrating with other management systems for labour, freight carriers, stock control, etc.
- vertical carousels or lift modules

Even though these examples show that a WMS can have impacts on many areas of the business, a good system and supplier should be able to commission a new system within six weeks in most SME applications.

Learn more on how to make your business more energy efficient at **sclaa.com.au**

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