

Commercial Vehicles Mega Trend INDIA 2013

Fuel economy improvement potential from commercial vehicles

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- ❑ **First Oil Crisis is reported way back in 1973.**
- ❑ **Improving fuel economy is a vital way to save oil and cut CO₂ emissions. A DRIVE against Global Warming Fight.**
- ❑ **As a consequence, Fuel economy came into focus as a performance parameter**
- ❑ **Fuel economy measures at several fronts could cut the fuel use by upto 50 % in addition to considerable reduction in emissions**
- ❑ **Fuel Economy is more or less a primary and undisputed performance parameter to the Vehicle users across the globe, irrespective of the end application .**

What is fuel economy ?

Quantity of fuel energy needed to drive a certain distance
(liter / 100 km)

or

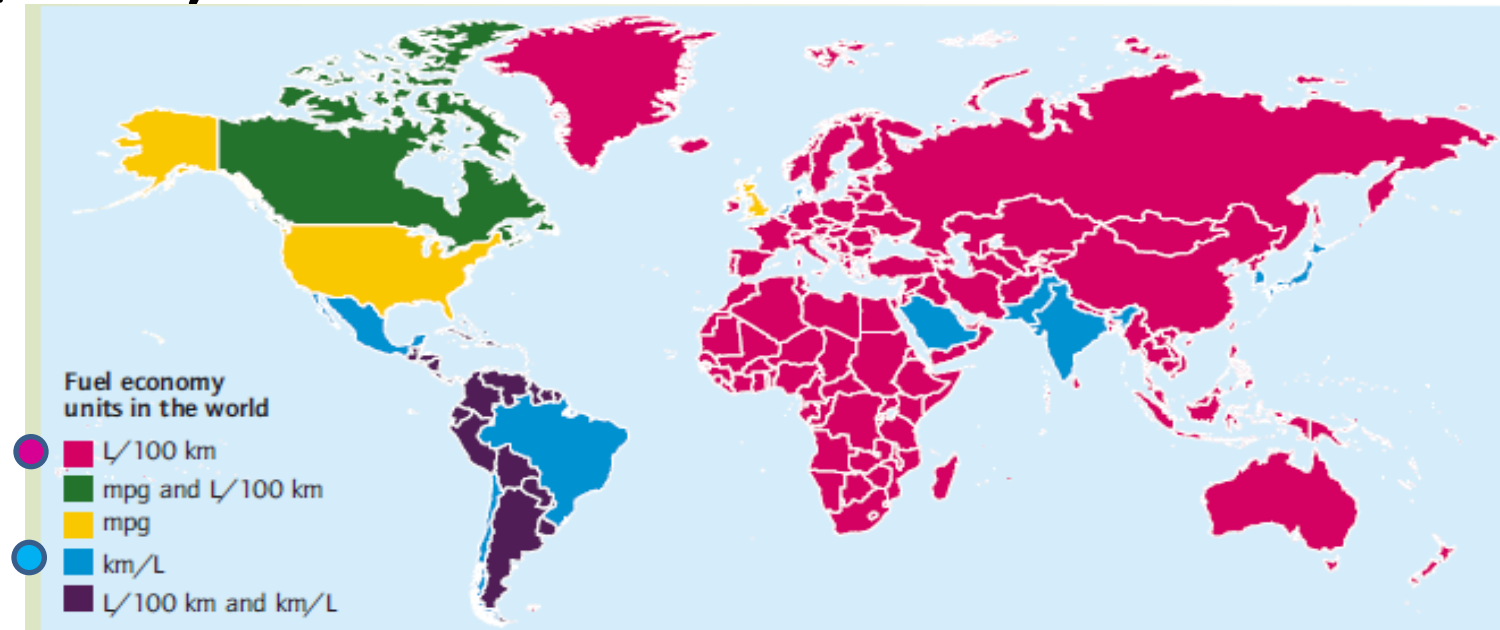
Distance covered with a given quantity of fuel energy.
(Km / liter)

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Lower the Fuel Consumption

Higher the Fuel Economy

Lower the CO₂ Emission

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Average Vehicle FUEL Economy (liter / 100 km) : Global Scene

	2005	2010	2020	2030
Passenger LDVs	8.1	7.6	5.4	4.1
Light/medium trucks	13.7	13.4	10.7	9.5
Heavy trucks and buses	39.1	35.9	31.8	27.1
Two-wheelers	2.8	2.9	2.6	2.3

Source : Technology Road map

	2005	2010	2020	2030	
Heavy trucks and buses	39.1	35.9	31.8	27.1	L/100 km

In the United States, the representative truck averages about 40 L/100 km, with around 75% average load capacity. US trucks use higher average power and manual transmission.

In EU, similar trucks average around 35 L/100km, but with a lower average load factor of around 50%. Most of the trucks are equipped with an automated manual transmission.

Presently in India, average fuel economy of a loaded truck comes to 40L/100 km, whereas for a inter-city bus this figure averages 32L/100 km. Average power is low and vehicle is equipped with Manual Transmission.

Vehicle Power Requirement

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The power required to maintain a given road speed depends on the sum of the following forces:




- Aerodynamic Drag
- Grade Resistance
- Tire Rolling Resistance
- Engine Accessory
- Drivetrain losses

Vehicle Power Requirement

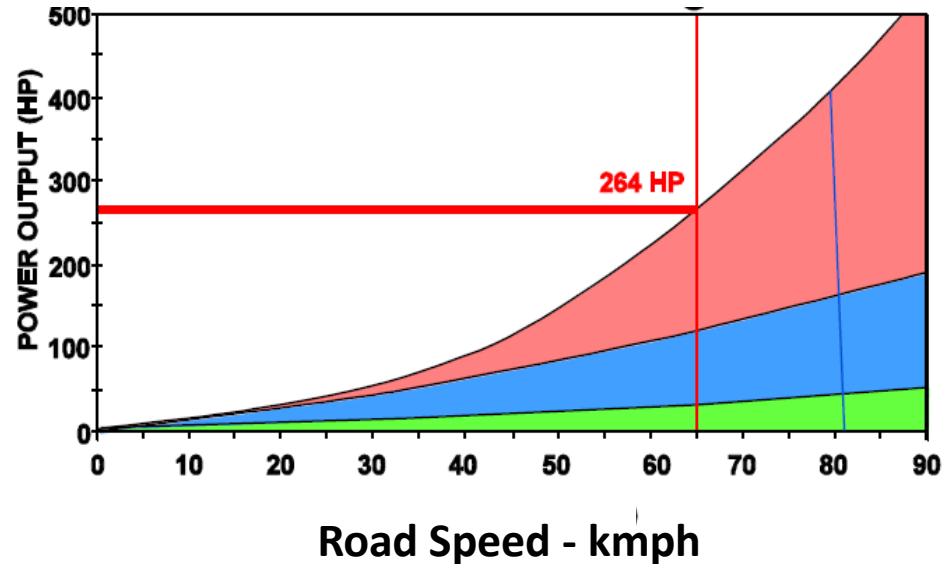
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Level Road Power Requirement at vehicle speed of 65 kmph	
	Aerodynamic Drag - 145 hp
	Tyre resistance - 87 hp
	Miscellaneous - 32 hp

264 hp	

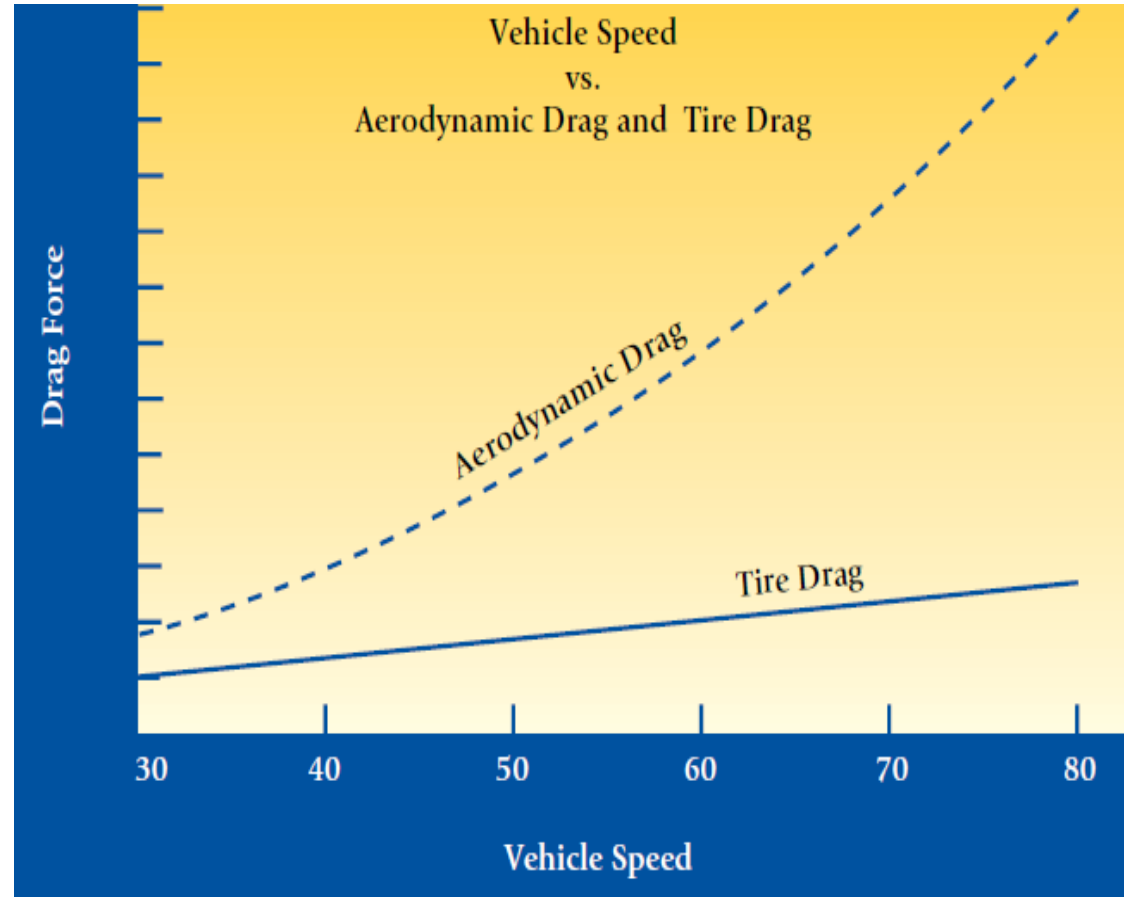


EXAMPLE

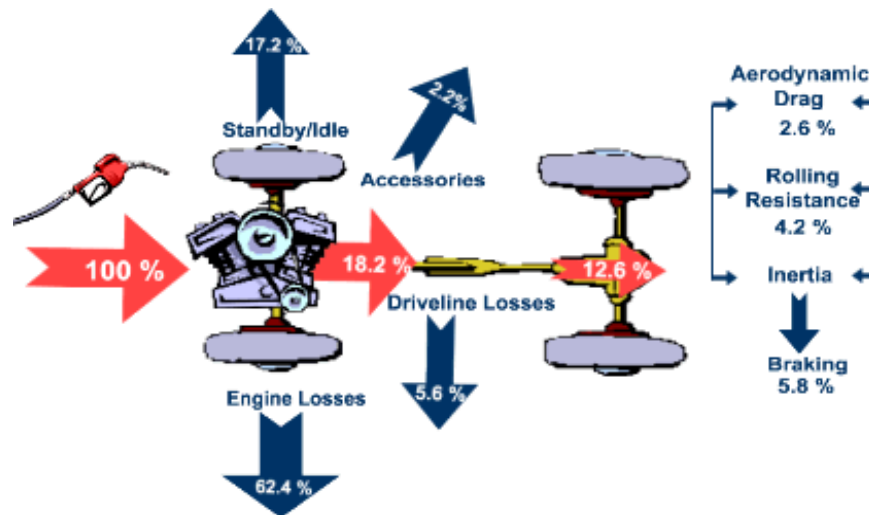
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- **Grade Resistance**
- **Tire Rolling Resistance**
- **Engine Accessory**
- **Drivetrain losses**



- Depending on the **drive cycle**, only about 14%–26% of the energy from the fuel put in by the fuel is used to move a vehicle down the road.
- The rest of the energy is lost to engine and driveline inefficiencies or used to power accessories.
- Therefore, the potential to improve fuel efficiency with advanced technologies is enormous.



City Driving (Stop & Go)

Engine losses 74-75%
 Parasitic losses 6-7%
 Power to wheels 14-16%
 Drivetrain losses 4-5%
 Idle losses 6%

Highway driving

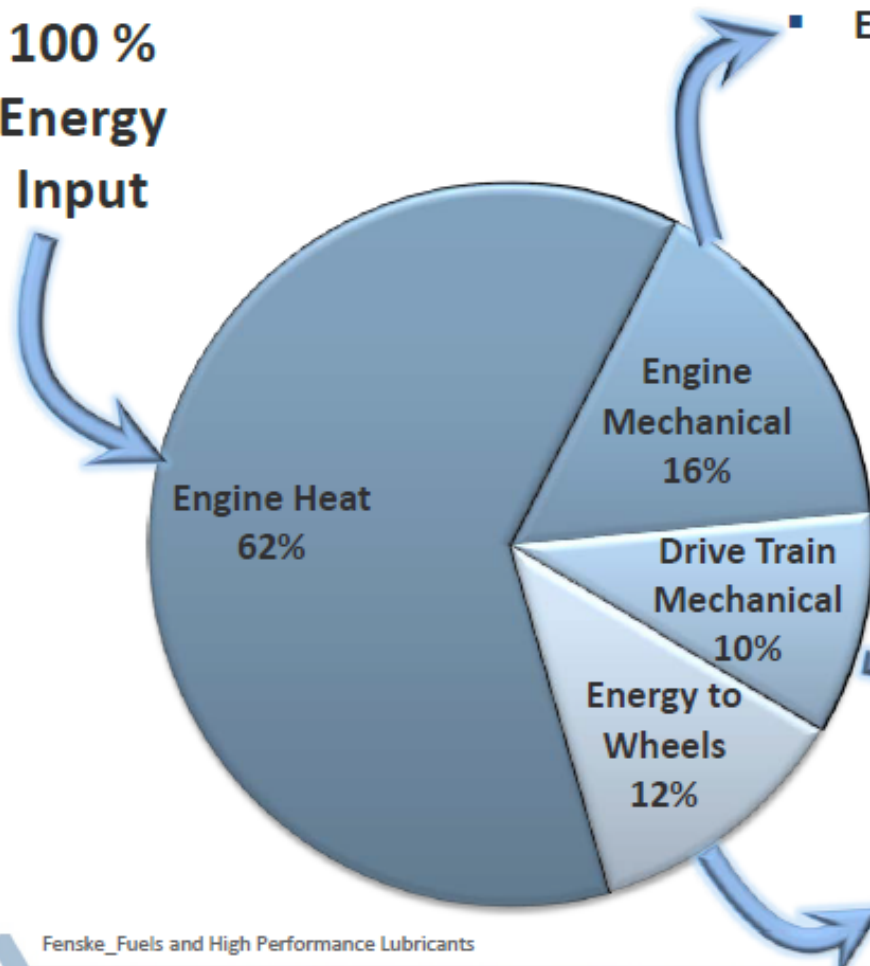
Engine losses 65-69%
 Parasitic losses 3-4%
 Power to wheels 20-26%
 Drivetrain losses 5-7%
 Idle losses- NIL
 (highway driving no idling)

Combined City/Highway driving

Energy 55% city and 45% highway driving.
 Engine losses 70-72%
 Parasitic losses 5-6%
 Power to wheels 17-21%
 Drivetrain losses 5-6%
 Idle losses 3%

How Much is Lost to Friction ? - More Energy is lost to Friction than is Delivered to the Wheels - Approximately 10% in Engine and 5% in the Drivetrain (1.1-1.7 MBBL/day)

100 %
Energy
Input



Engine Mechanical Losses

- Pumping Work
- Overcoming Friction
 - Rings and piston skirt
 - Valvetrain
 - Bearings & Seals
- Accessories

Drive Train Mechanical Losses

- Overcoming friction
 - Transmission
 - Differential
 - Bearings & Seals
- Coasting and Idle Work
- Braking Work

Energy at Wheels

- Inertia, Rolling Resistance, Air Resistance, Gravity (grades)

Fenske_Fuels and High Performance Lubricants

Heavy-duty vehicles

Fuel savings and the impacts of technologies are highly dependent on whether

- the truck is mainly used for urban driving (such as delivery trucks)
- long-haul (mainly highway) shipments

Technological measures to improve fuel efficiency for heavy duty vehicles can be split into four categories:

Engine:

including auxiliary aggregates such as cooling, power steering and the braking system;

Drive-train:

transmission, including any hybridisation system;

Vehicle:

chassis, bodywork (including fairings and other aerodynamic devices), trailer and tyres; And

ITS/ICT:

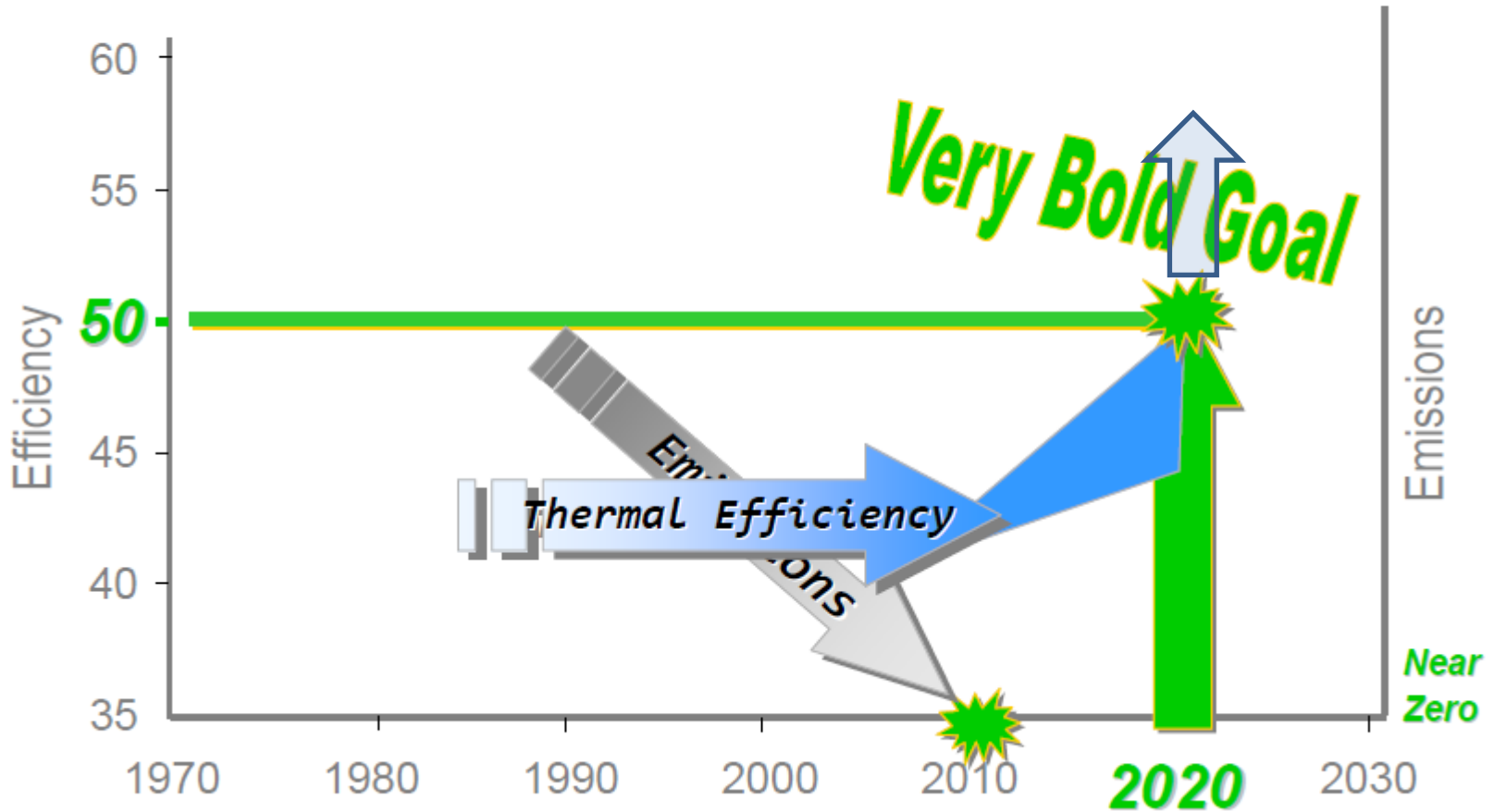
intelligent transport systems and information/communication technologies to help drivers optimise in-use fuel economy.

Engine Technologies

In a vehicle layout, engine is the largest user of energy.

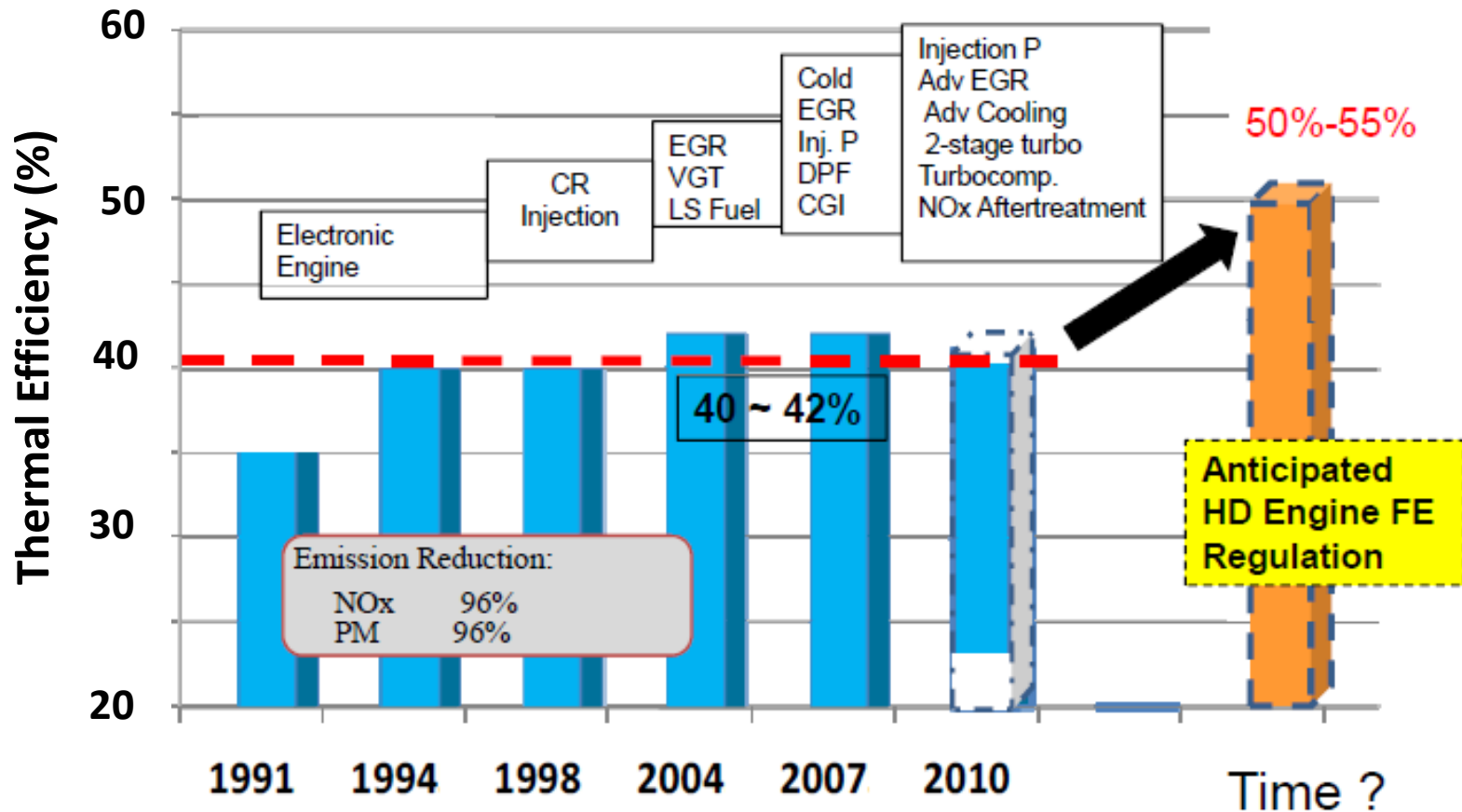
Therefore, engine becomes the focal point to employ FUEL SAVING TECHNOLOGIES to achieve a large sum of benefits.

Efficiency and Emissions Progress- Diesel Engines



Caterpillar: Non-Confidential

DIESEL ENGINE THERMAL EFFICIENCY TARGETS



Diesel Engine Technology Options for fuel economy & Emissions

The diesel engine technologies identified for potential fuel consumption reduction :

- Turbocharging, including turbo-compounding**
- Variable valve actuation**
- Electric-driven accessories**
- Engine friction reduction**
- Low temperature combustion**
- Improved DPF and SCR systems**
- Thermal insulation of ports and manifolds**
- Electronic controller calibration management**
- Waste Heat Recovery**
- Cooling and thermal management**
- Transmission match**
- hybridization**

Diesel Engine Technology Options for fuel economy & Emissions

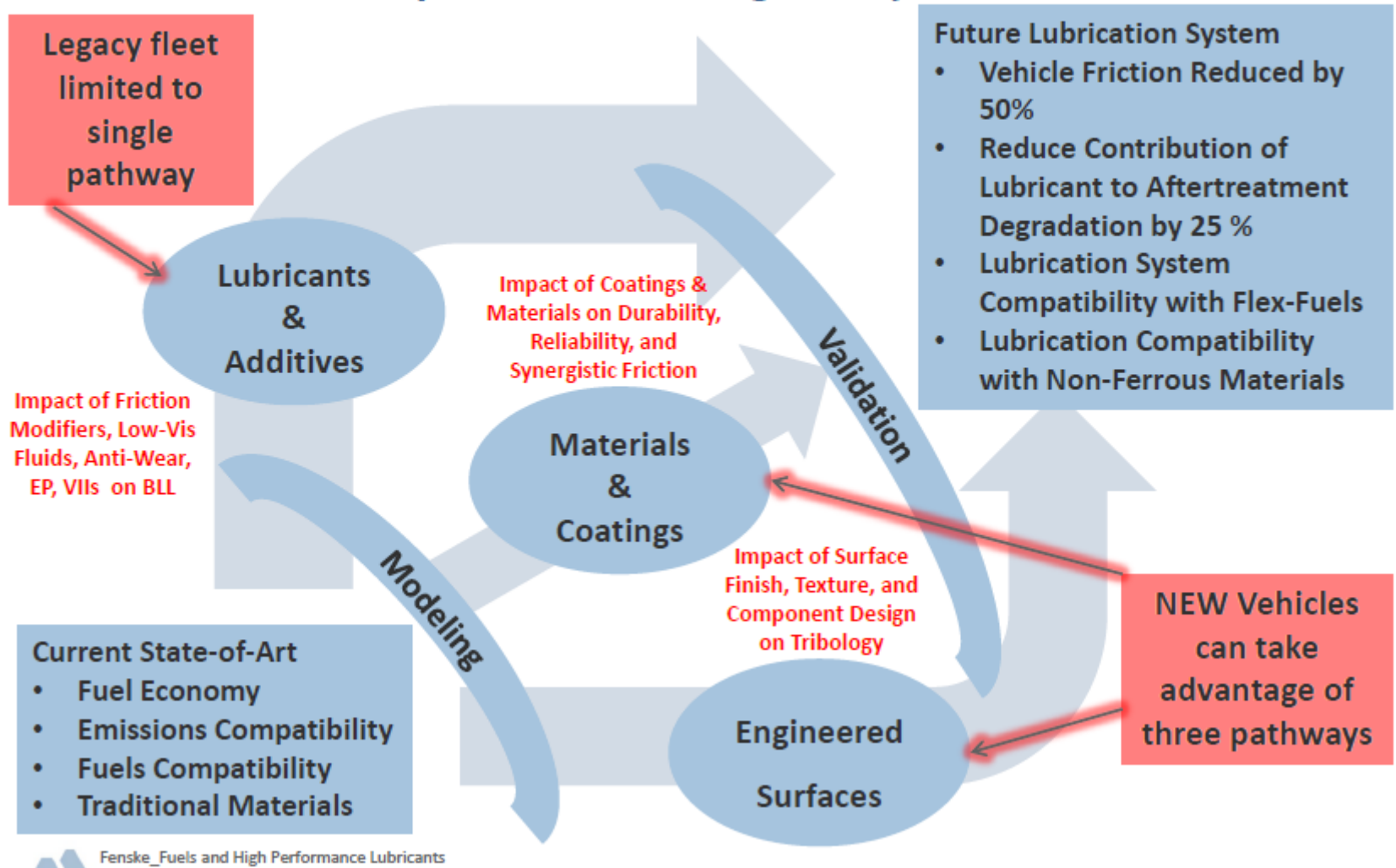
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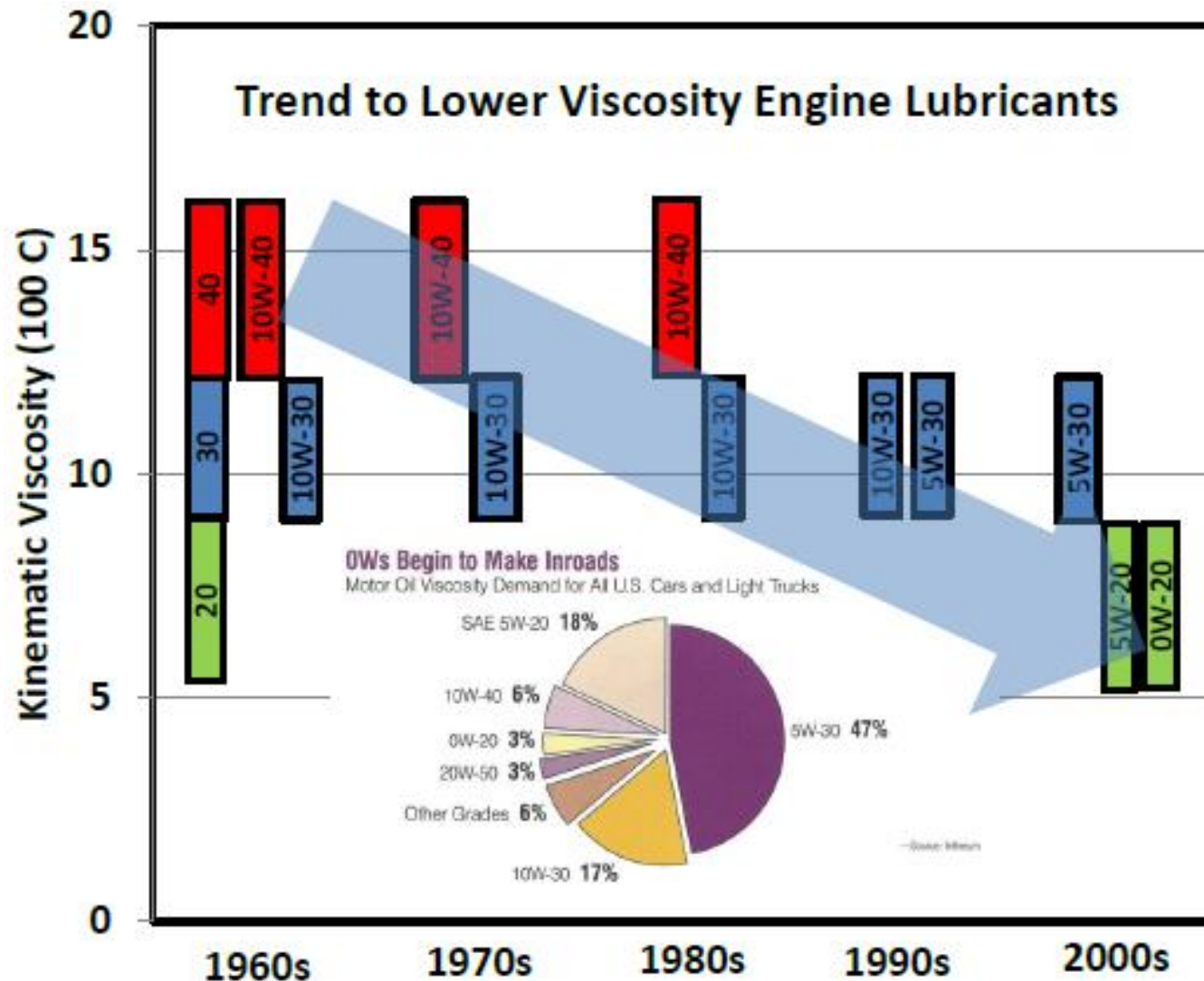
**Integrated
Solution**

**COST
QUALITY
RELIABILITY**

Multiple Pathways to Improve Fuel Efficiency with Improved Tribological Systems



Moving towards Lower viscosity Lubricants



Drive-train: automation

Automated manual transmission (AMT) has gained market share since the 1980s in Western Europe.

Automated manual transmission combines advantages of a manual gear shift, such as high efficiency, with those of automatic transmissions, such as the ability to change gears at the best point and provide comfort to the driver. With differently skilled drivers, fuel consumption can be reduced by up to 10% *(Hill et al., 2011)*.

Category	Technology	Fuel improvement potential
Engine	Variable valve actuation	1% to 2%
Engine	Sequential turbo/downsizing	Up to 5%
Engine	Speed control (injection)	Up to 5%
Engine	Oil and water pump with variable speed	1% to 4%
Engine	Controllable air compressor	3.5%
Engine	Smart alternator, battery sensor electric accessory drive	2% to 10%
Engine	Start/stop automatic	5% to 10%
Engine	Dual fuel systems	10% to 20%
Engine	Pneumatic booster: air hybrid	Up to 4%
Engine	Turbocompound (mechanical/electric)	4%/7%
Engine	Bottoming cycles/waste heat recovery (e.g. organic Rankine)	1.5% to 10%

Category	Technology	Fuel improvement potential
Drive train	Eco roll freewheel function	1%
Drive train	Automated manual transmission	4% to 6%
Drive train	Full hybrid	15% to 30% urban 4% to 10% long haul
Drive train	Flywheel hybrid	15% to 22% urban 5% to 15% long haul
Drive train	Hydraulic hybrid	12% to 25% urban Avg 12% long haul
Vehicle	Low rolling resistance tyres	5%
Vehicle	Aerodynamic fairings	0.5% to 5%
Vehicle	Aerodynamic trailer/boat tail	12% to 15%
Vehicle	Single wide tyres	5% to 10%
Vehicle	Light-weight materials	2% to 5%
Vehicle	Active aerodynamics	Up to 5%
ITS/ICT	Predictive cruise control	2% to 5%
ITS/ICT	Driver support system	5% to 10%
ITS/ICT	Acceleration control	Up to 6%
ITS/ICT	Vehicle platooning	Up to 20%

Non-engine Technologies

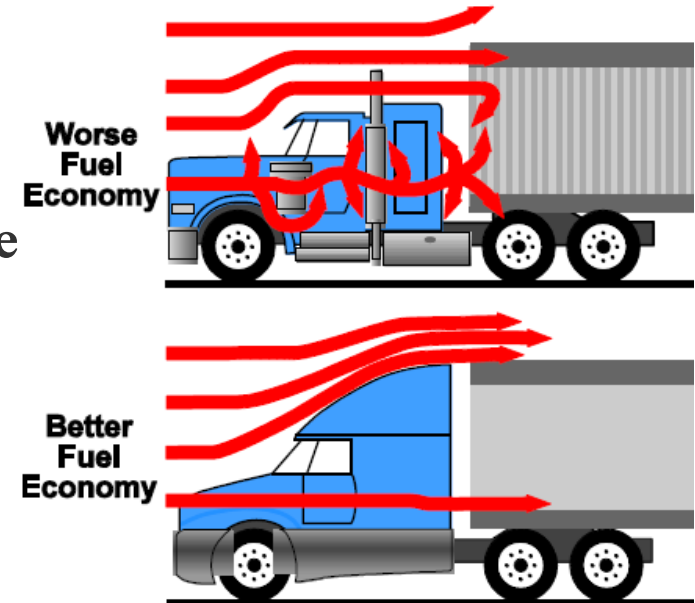
Apart from engines and drive-train systems, a range of important vehicle technologies could help improve vehicle efficiency by lowering the energy demands on the drive train

Aerodynamic Drag

As vehicle moves down the road, gravity and wind resistance work in opposition. This is known as drag.

Aerodynamic drag grows exponentially with increased vehicle speed. Drag shows greatest effect on long-haul applications where trucks are traveling at higher speeds over a longer period of time.

The reduction of aerodynamic drag for on-highway vehicles is even more important, as it greatly decreases the energy output required of the engine, resulting in improved fuel economy.



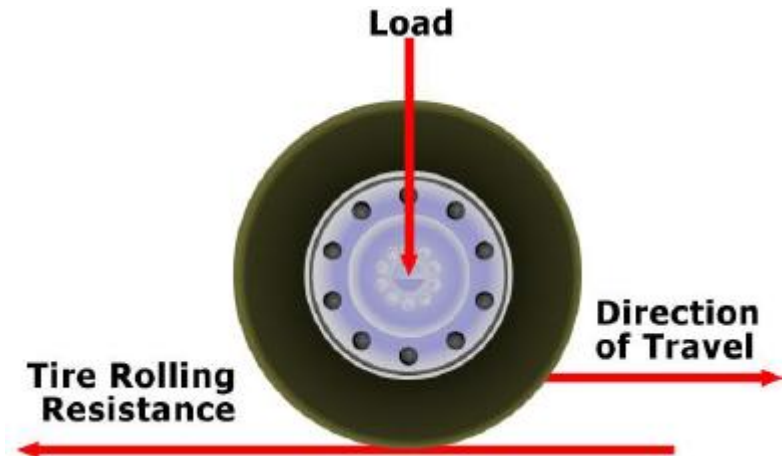
Tyres

- Tyre rolling resistance (RR) relates to flattening and friction of the tyre as it rolls. Higher inflation results in less flattening.

Tires flex more at higher speeds.

Leads to more friction, higher tire temperatures and reduced fuel economy.

- Tyre pressure monitoring system maintain tyre inflation and aids to achieve fuel economy goals
- Taking these items together, a 5% fuel economy improvement potential is estimated for tyres.



Head lamps

Most vehicles are equipped with halogen headlamps, but these are relatively inefficient. Light-emitting diode (LED) and xenon lamps are far more efficient.

Xenon lights can match halogen performance with less than half the energy use

For use as daytime running lights, LEDs offer significant energy savings at modest cost.

Air conditioning systems

wherever air conditioning is used a significant percentage of the time, improved air conditioning systems could save 3 to 4% of vehicle fuel.

Material substitution

**Stronger, lighter steels have been developed that can play an important role in reducing weight. A significant share of high-strength steel could reduce vehicle weight by up to 10%
(Ref : Lotus Engineering, 2010).**

Aluminium has significant lightweight potential and are being used in some larger, luxury vehicles. Aluminium could cut vehicle weights by 10% at reasonable cost and up to 25% when used in all suitable components.

Composite materials consisting of a glass- or carbon fibre-reinforced polymer could reduce vehicle weight by up to 40% but at higher cost. So they are a long-term option.

FE improvement potential

Aerodynamic drag reduction	3%
Tyres	3% to 5%
Head lamps (halogen, xenon, LEDs)	0.2% to 0.5%
Air conditioning systems	2% to 4% (more in hot regions)
Material substitution and lightweighting	10% weight reduction at little cost premium

Roadmap vision: fuel economy improvement and impacts on energy use and CO₂

Other Factors affecting in-use fuel economy

The difference between tested and in-use fuel economy is due to attributes of the vehicle, the driver and the road.

Apart from engine and vehicle technologies, other measures that can provide significant fuel savings include :

- encouraging fuel-efficient driving behaviour
- improving traffic flow - reducing congestion, better traffic light management
- general road conditions.

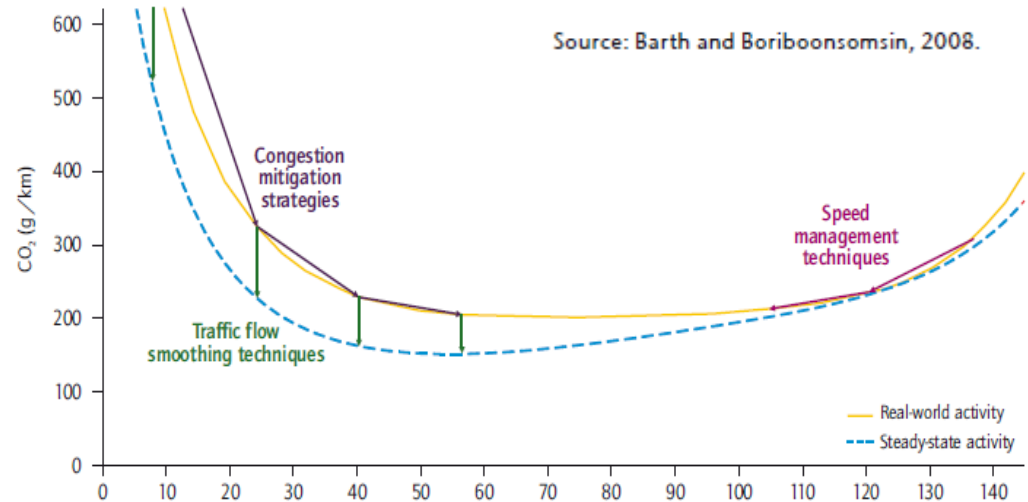
Road and traffic conditions

Smoother road surfaces and better traffic flow can improve fuel economy by reducing rolling resistance and stops and starts.

Average speed and fluctuations in speed in urban driving conditions have a significant influence on in-use fuel economy

Techniques that adjust vehicle speeds can improve fuel economy:

- congestion mitigation,
- traffic flow
- smoothing
- speed management



Traffic Operation Strategies to improve fuel economy

Road and traffic conditions

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Studies in Sweden, the Netherlands and the United States have shown that smoother roads could improve fuel economy by 5%

Driving behaviour

The way a person drives a vehicle – whether a car or a truck – can have a major effect on in-use fuel economy. Many tips can help drivers improve their driving style to save fuel.

On the road

- Start driving as soon as the engine is started (no need to warm up modern engines except in very cold conditions).
- Avoid unnecessary idling.
- Don't speed (above 90 km/h, fuel economy can decrease rapidly).
- Use overdrive gears and cruise control when appropriate.
- Minimise the need to brake by anticipating traffic conditions.
- Avoid jackrabbit starts and stops.
- Use air conditioner only when absolutely necessary (although at high speeds, air conditioning may reduce fuel economy less than opening windows).
- Combine errands into fewer car trips.
- Remove excess weight (*e.g.* remove ski and cycle racks when not in use).
- Avoid packing items on the roof of the car.

At the garage

- Keep the engine tuned.
- Keep the tyres properly inflated and aligned.
- Change oil regularly.

Driving behaviour

- Improving fuel efficiency by changing driver behaviour is mostly a matter of education and Training.
- Technologies are being introduced that can help drivers track fuel economy, often in real time, such as gear-shift indicators, tyre pressure monitor sensors and eco- and/or fuel economy displays.
- Fuel economy can be improved by up to 10% when adopting eco-driving measures

CLOSING REMARKS

How to Get Greater Fuel Economy !

Controllable Factors

- ❑ Driver
- ❑ Gearing
- ❑ Aerodynamics
- ❑ Maintenance
- ❑ Powertrain Spec

Uncontrollable Factors

- ❑ Weather
- ❑ Environment

Fuel economy from the commercial vehicles can be realised through working on :

- **Engine factors**
- **Vehicle factors and specifications**
- **Environmental factors**
- **Traffic management and infrastructure**
- **Driver technique and operating practices**

Energy Efficient Technologies

Transmission Technology	Average Efficiency Increase
<p>Continuously Variable Transmissions (CVTs) have an infinite number of "gears", providing seamless acceleration and improved fuel economy.</p>	6%
<p>Automated Manual Transmissions (AMTs) combine the efficiency of manual transmissions with the convenience of automatics (gears shift automatically).</p>	7%
Engine Technology	Average Efficiency Increase
<p>Variable Valve Timing & Lift improve engine efficiency by optimizing the flow of fuel & air into the engine for various engine speeds.</p>	5%
<p>Cylinder Deactivation saves fuel by deactivating cylinders when they are not needed.</p>	7.5%
<p>Turbochargers & Superchargers increase engine power, allowing manufacturers to downsize engines without sacrificing performance or to increase performance without lowering fuel economy.</p>	7.5%
<p>Integrated Starter/Generator (ISG) Systems automatically turn the engine on/off when the vehicle is stopped to reduce fuel consumed during idling.</p>	8%
<p>Direct Fuel Injection (w/ turbocharging or supercharging) delivers higher performance with lower fuel consumption.</p>	11-13%

Top Tips for Fuel Economy

- ❑ Slow down
- ❑ Keep RPMs low
- ❑ Anticipate hills and traffic
- ❑ Reduce stops
- ❑ Avoid idling
- ❑ Minimize accessory loads
- ❑ Reduce trailer gap
- ❑ Use progressive shifting
- ❑ Stay in top gear
- ❑ Use cruise control

Important MANTRA to be followed

Important MANTRA

**GOOD SPEC
+ GOOD DRIVING**

= GREAT FUEL ECONOMY

Thank you...

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