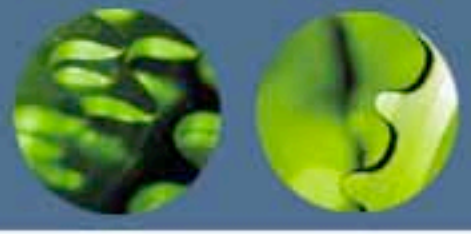
2007 Technical and Maintenance Conference

FUEL EFFICIENCY SESSION

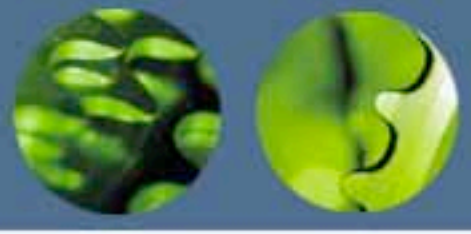
Colin White
Product Development Manager
Isuzu Australia Ltd.



FUEL EFFICIENCY SESSION

SPEAKERS

- Peter Hart – Hartwood Consulting
- Colin White – Isuzu Australia Ltd.
- Mark Agnew – DECA Training
- Phil Burnard - Bridgestone



FUEL EFFICIENCY SESSION

- Where the Fuel Goes?
  - The truck factors that use power.
- Speccing for Fuel Efficiency
  - How to minimise the effect of those factors
- Drivers and Fuel Efficiency
  - The Driver factor

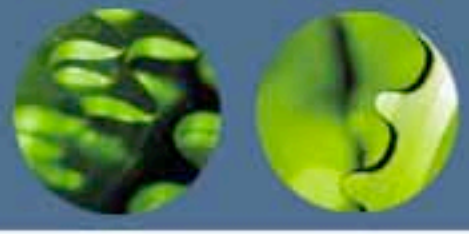
FUEL EFFICIENCY SESSION

Where the Fuel Goes

Dr. Peter M. Hart
Director
Hartwood Consulting Pty. Ltd

Where Did My Fuel Go ?

Energy Content of Fuels:		1 litre	
Diesel		45 MJ/l	100%
Biodiesel		41 MJ/l	91%
Petrol	Octane 98	39 MJ/l	87%
Compressed LNG		37 MJ/l	82%
Petrol	Octane 95	36 MJ/l	80%
Petrol	Octane 98	33 MJ/l	73%
LPG		26 MJ/l	58%
Ethanol		24 MJ/l	53%
Lead Acid Battery	145 kJ/kg	or 0.27MJ/l	0.6%
Hydrogen	140 MJ/kg		



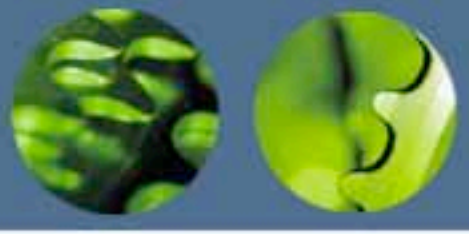
Where Did My Fuel Go ?

Thermodynamics

Fundamental Limit - Heat into Work

$\eta < (T_{max} - T_{min}) / T_{max}$

Large diesel engine: $\eta \sim 40\%$



Where Did My Fuel Go ?

- **Aerodynamics**

  Theory: Power ~ C_d x speed^3

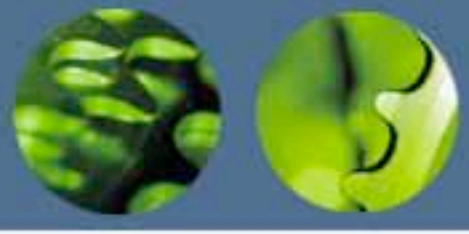
  In practice not that simple

- **Tyre Losses** ~ Weight x speed$^{1.5}$

  Assumed to be proportional to weight carried.

  In practice varies with speed.

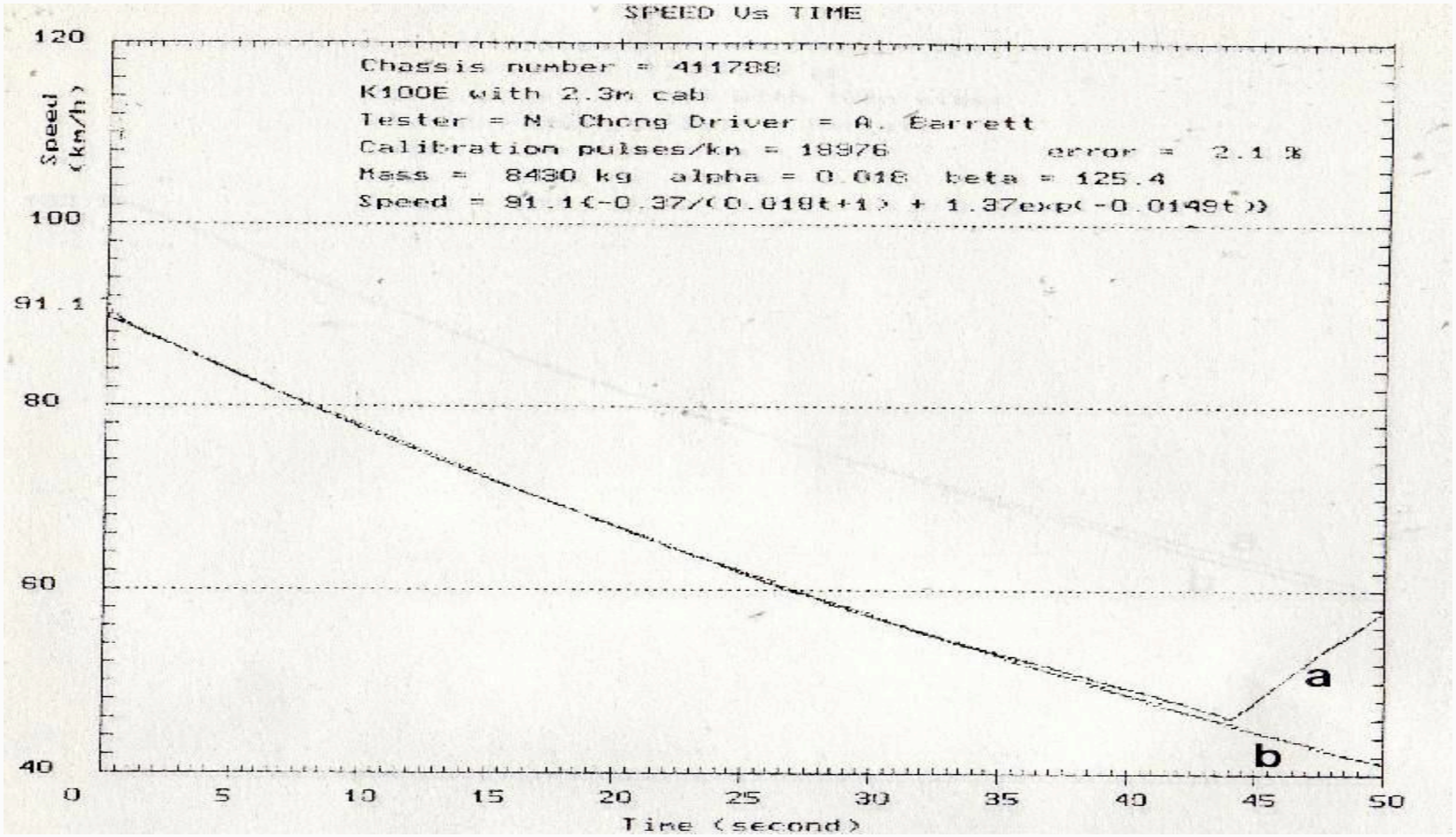
- **Drivetrain Losses** Slight increase with speed

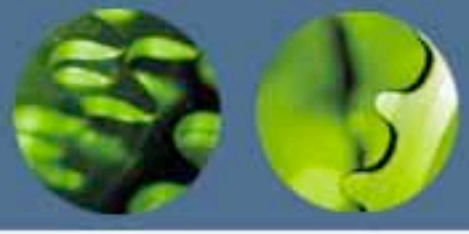


Where Did My Fuel Go ?

- **Exhaust** 55%
- **Supercharging / Turbocharging**
  Can't defeat the thermodynamics rule!.
- **Engine Auxiliaries** 3% - 5% P_{max}
  Alternator, AC, Compressor, Oil pump..
  Around 3-5% of max power
- **Engine & Transmission Losses** 2% - 3% P_{max}
  RPM dependent
  Around 3% of max power

Where Did My Fuel Go?



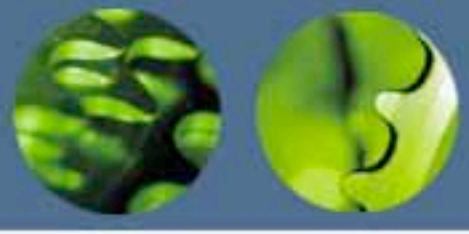


Where Did My Fuel Go ?

Fuel Economy of Trucks

450Hp+	7 – 9 MPG	(34l /100km)
300Hp	11 – 15 MPG	(21l /100km)
200Hp	15 – 20 MPG	(15l /100km)

? Your experience

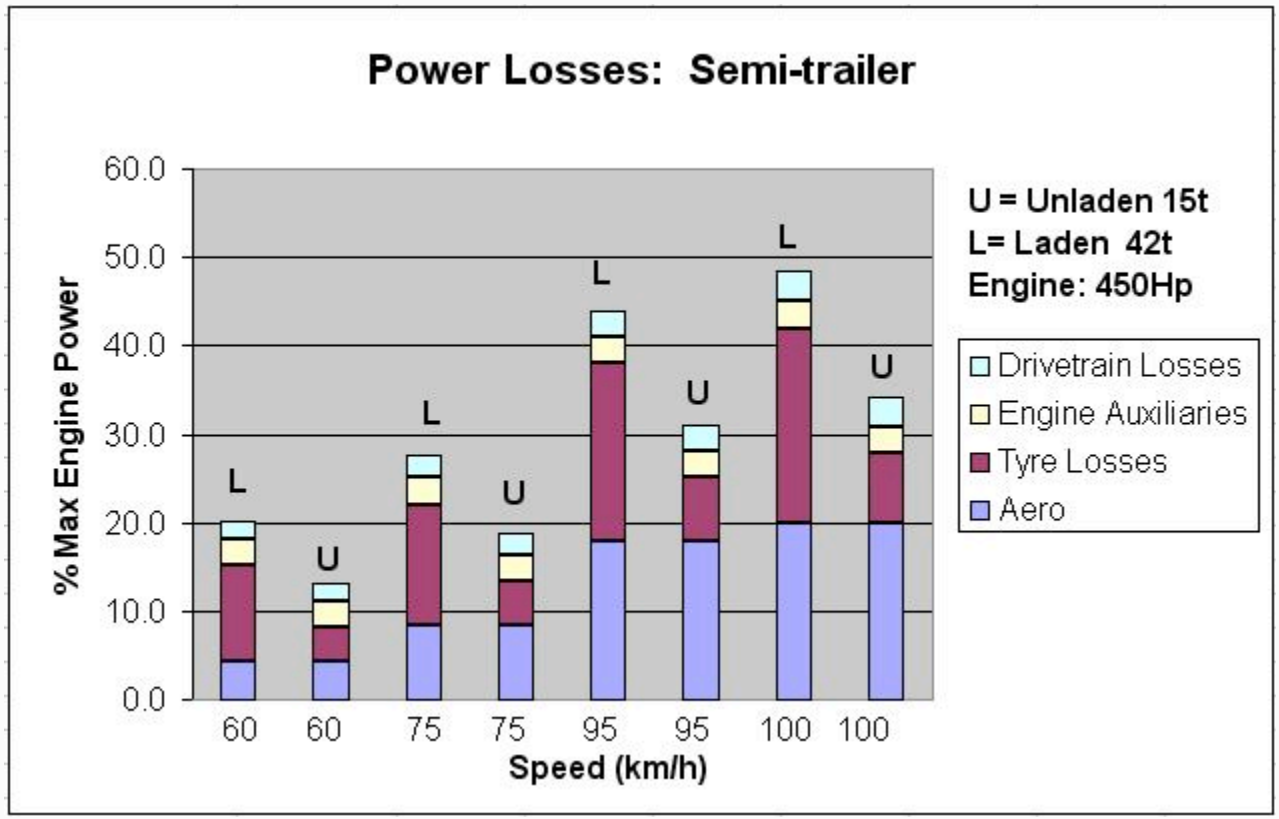


Where Did My Fuel Go ?

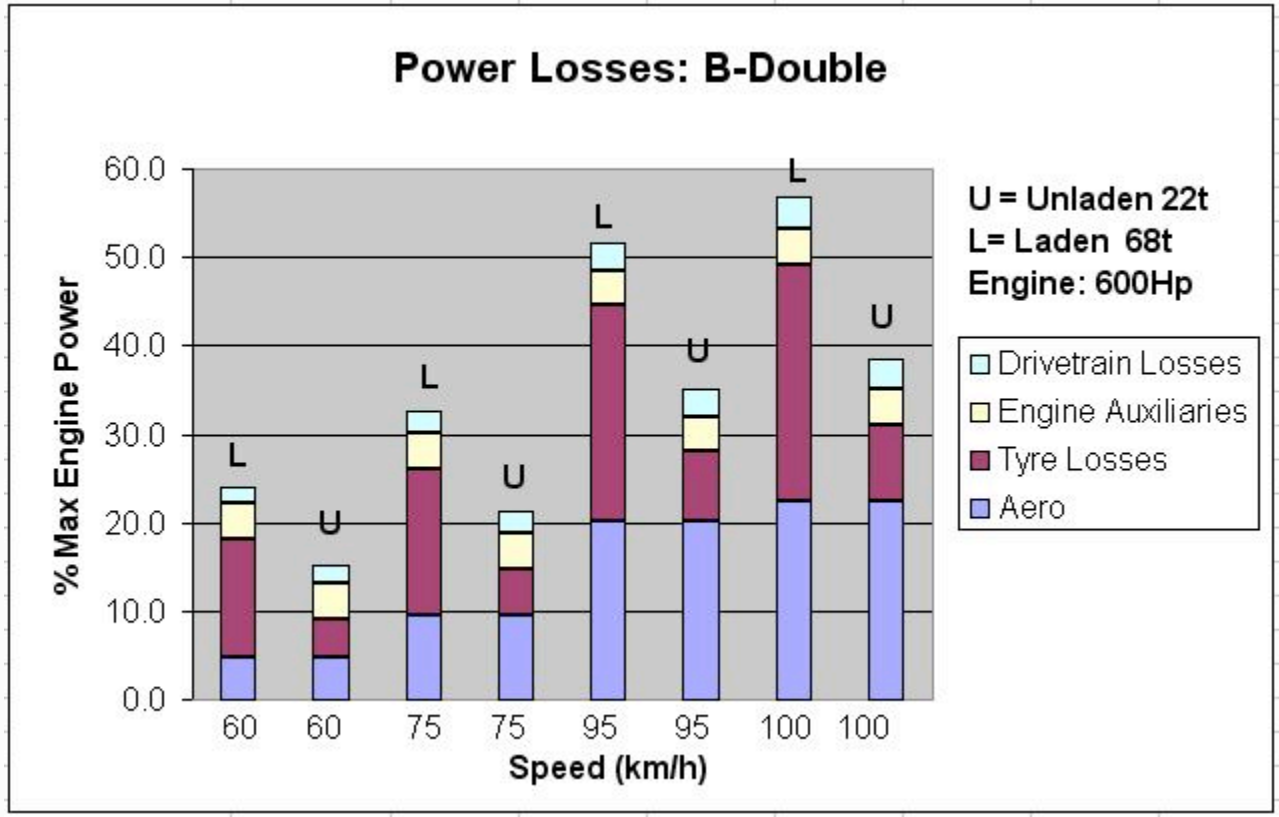
Relevant considerations are:

- Truck Efficiency
  - Engine inc. Auxiliaries
  - Aerodynamics
  - Tyres
  - Drivetrain losses
- Road Conditions — Traffic flow Surface Slope Straightness
- Driving Practices — Acceleration Anticipation Speed
- Maintenance Practices — Injectors Bearings Wheel alignment Tyre pressures

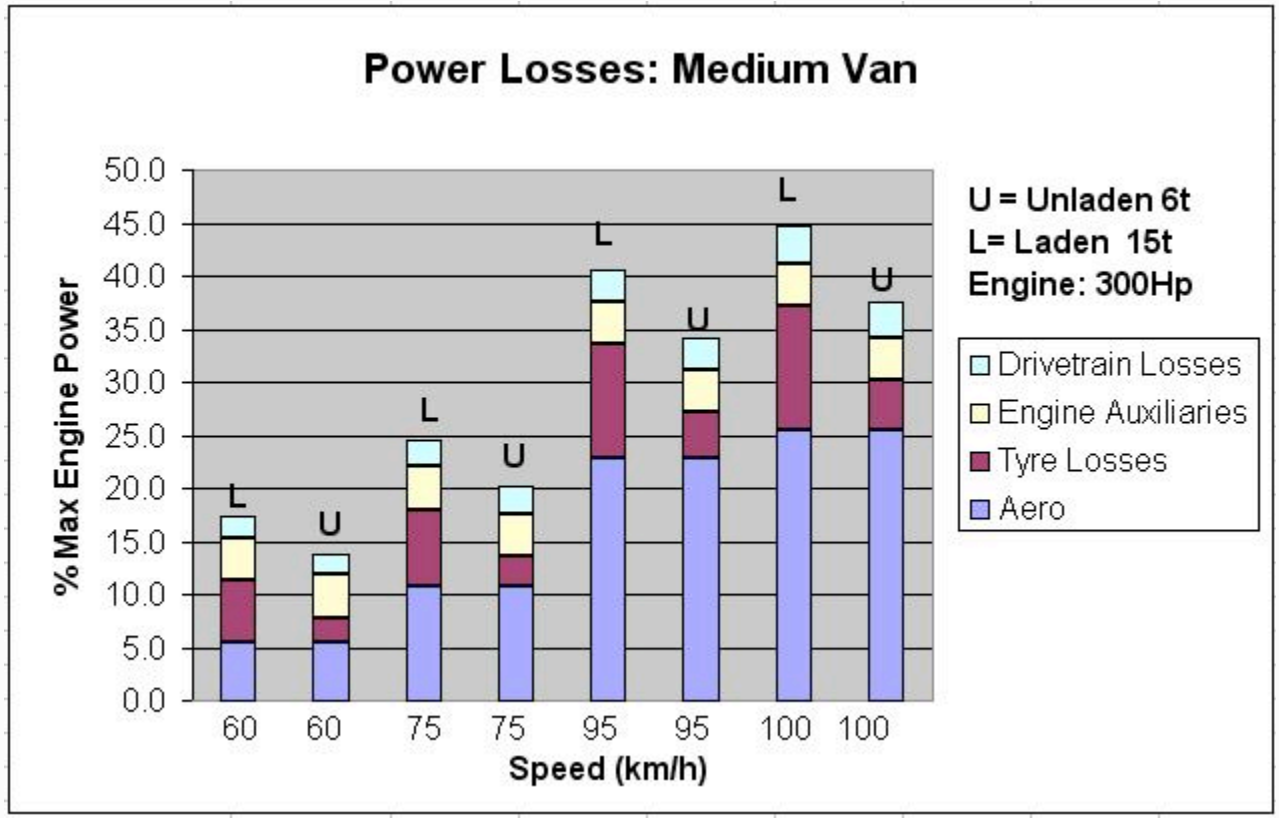
Where Does My Fuel Go ?



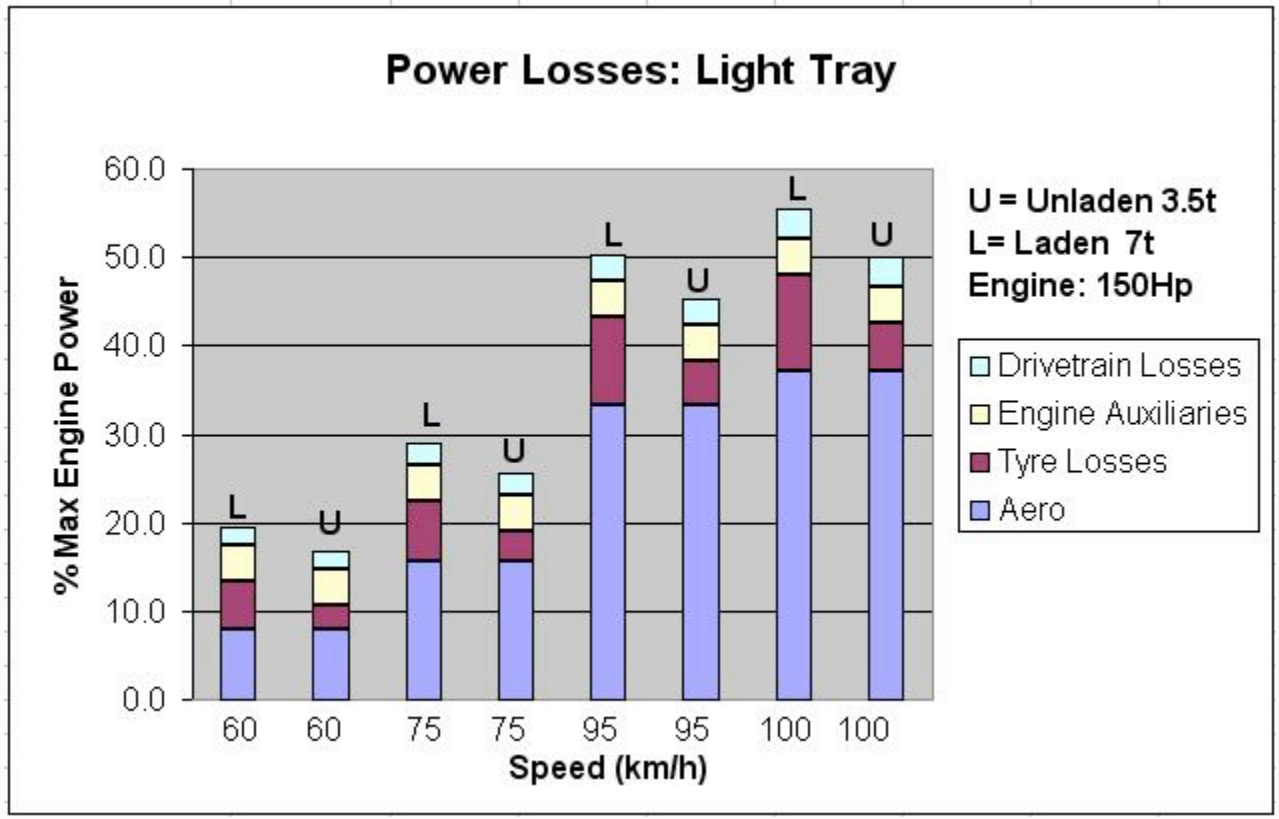
Where Does My Fuel Go ?

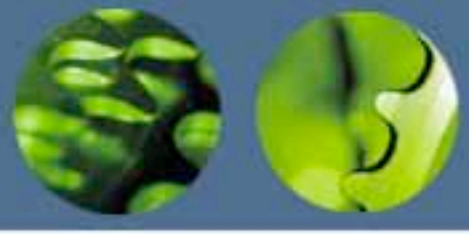


Where Does My Fuel Go ?



Where Does My Fuel Go ?

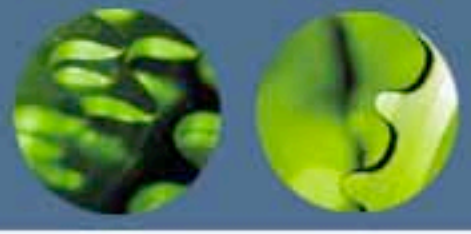




Fuel Economy Improvement

To Reduce Mechanical Resistance:

- Gear fast, run slow.
- Check that the desired cruise speed corresponds with the engine “sweat spot”
- Use synethic oils
- Don’t use higher viscosity oils than actually needed
- Changing to small diameter drive tyres increases engine RPM and may disturb fuel economy



Fuel Economy Improvement

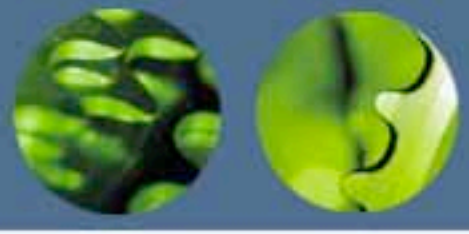
To Reduce Tyres Losses:

- Higher capacity tyres have greater losses.
- Low profile tyres are preferable.
- Reduce weight of rotating parts. Wide base single tyres are preferable
- . Aluminium wheels are preferable
- Use all position tyres on the rear. Same tread as on steer-axle

Fuel Economy Improvement

To Reduce Tyres Losses:

- Rolling resistance decreases as tread depth reduces.
- A tyre with 50% tread depth has a 6% reduction I rolling resistance.
- Use of low loss tyres on trailers is particularly effective
- Keep tyre inflation to specification.
- Don’t go out in the wet!
- Rough asphalt increases tyre losses by ~ 7% compared to smooth asphalt



Fuel Economy Improvement

WalMart USA Goal (2006)

Double truck fuel economy 2006 - 2015

7.8 to 15.6 miles / Imperial gallon

(36 l/100km to 18 l/100km)

Fuel Economy Improvement

Wal-Mart Plan:

- Trailer side skirts
- Super single tyres to replace duals
- Aerodynamic treatment of trucks
- Reduce truck – trailer spacing
- Greater use of tag axles (ie 6x2)
- Use of auxiliary power units to reduce engine usage.
- Reduced idling time at docks

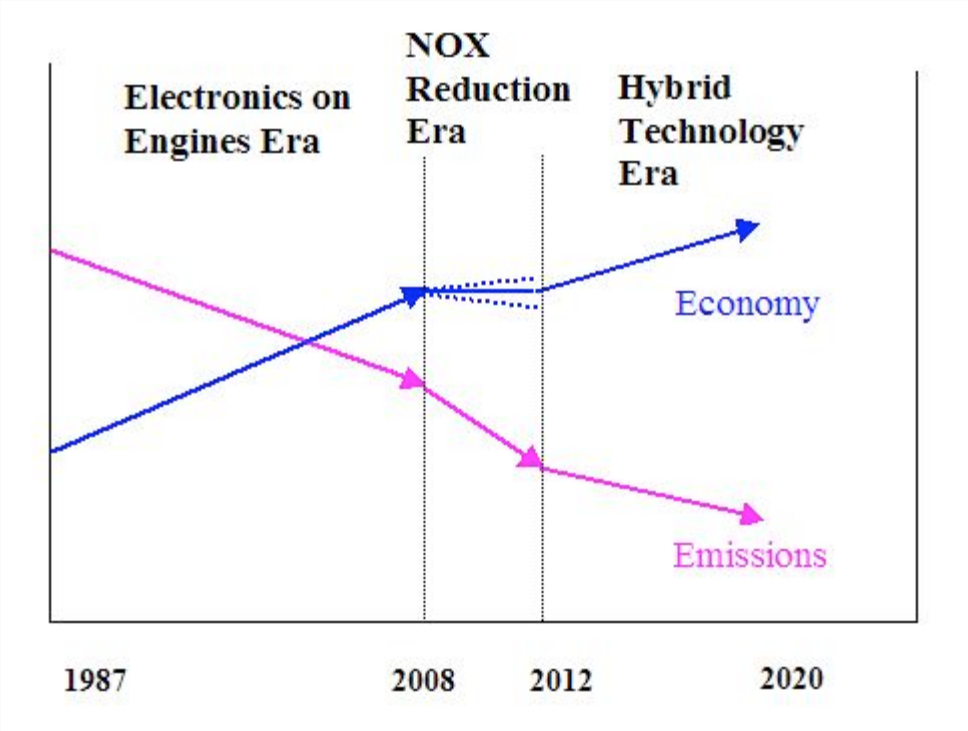
Fuel Economy Improvement

SmartWay Project –
US EPA & Freight Industry

- Technical advice, sharing of experiences
- Grants for specific modifications
- No cost independent measurement of performance
- Low interest loans for refurbishing older vehicles.

New Technologies

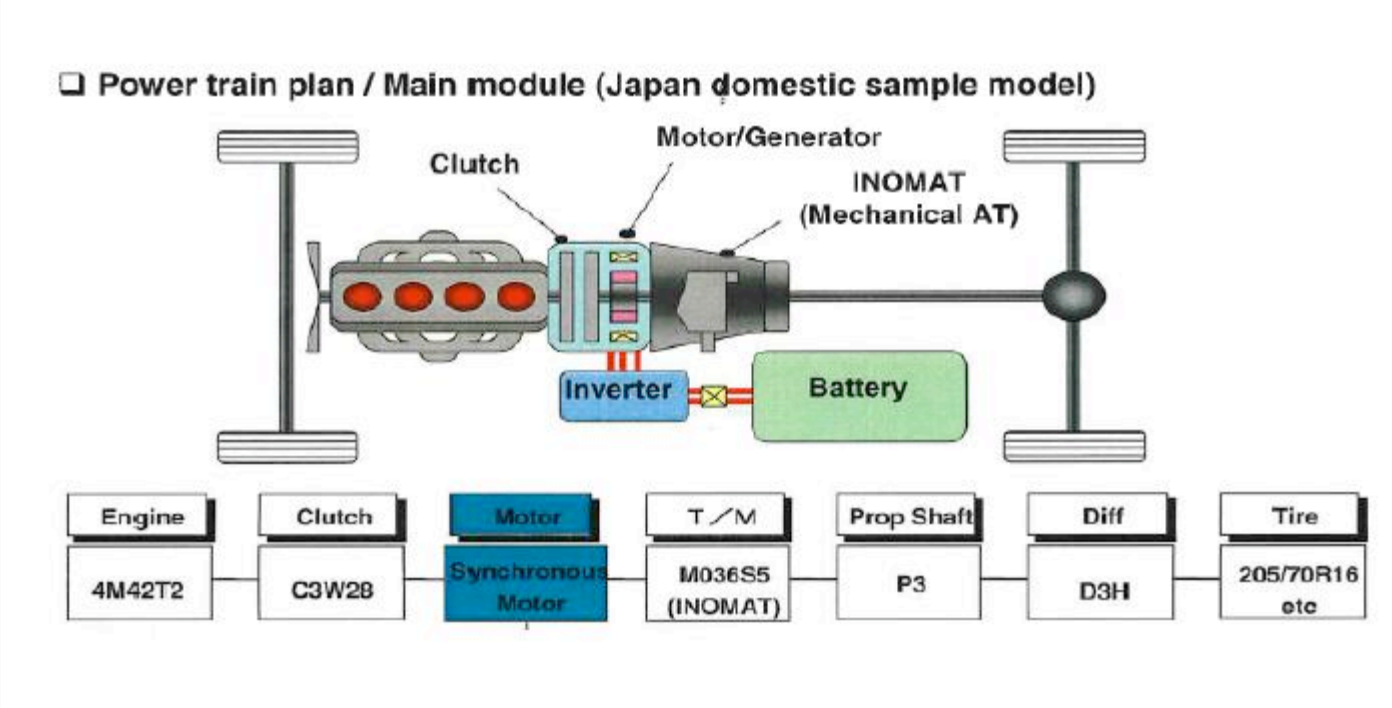
At the end of the 30 year long period of win-win for emissions / fuel economy improvements.



Current Level Engine Technology

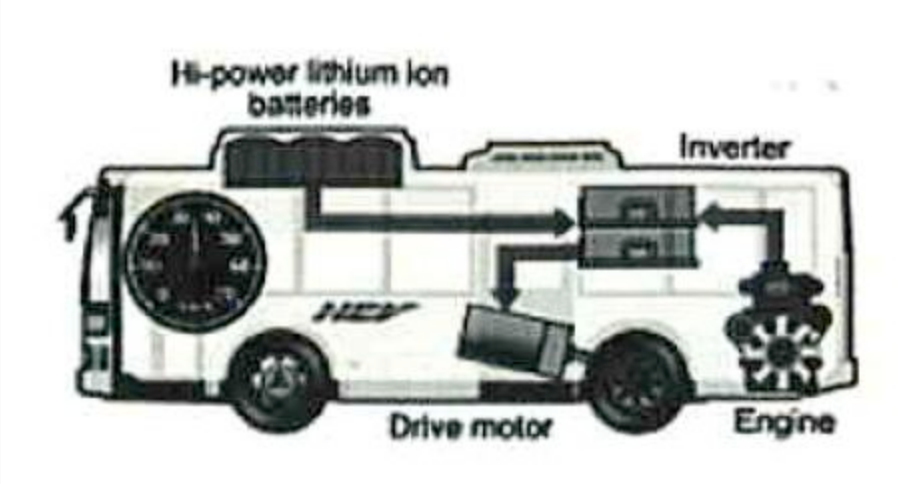
Hybrid Technology –

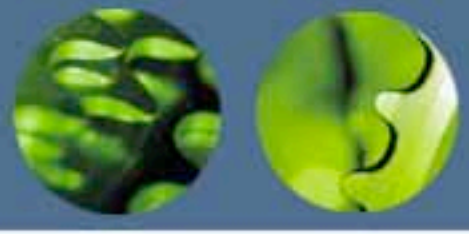
Diesel engine + Regenerative Electric Motor



Hybrid Technology

Hino Bus





Hybrid Technology

Some Predictions about Hybrids:

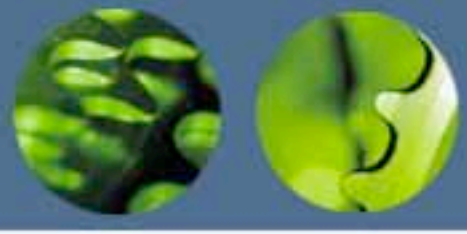
- Add-on drive-train retarder / motor will become available.
- New types of standard batteries will be used.
- Some engine auxiliaries will be moved onto the
- electrical system.
- Diesel engines will be downsized.
- Exhaust brakes will disappear.

Finis

FUEL EFFICIENCY SESSION

Speccing for Efficiency

ColinWhite
Product Development Manager
Isuzu Australia Ltd

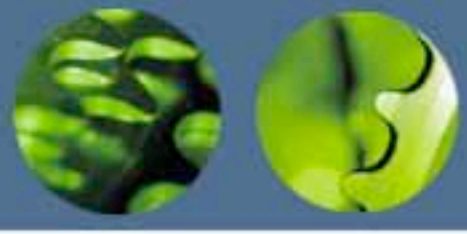


Speccing for Efficiency

- What can the operator not control
  - Regulatory impacts
  - How manufacturers solutions to regulations can impact on you.
- What the operator can control

Speccing for Efficiency

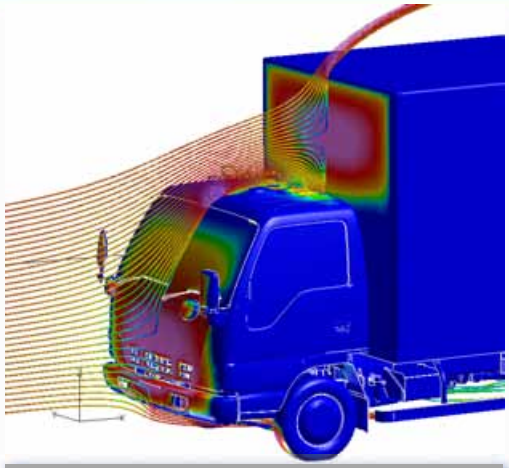
- Regulations Impacting Fuel Economy
  - ADR80/01,02 Diesel Engine Emissions
    - Some ADR80/02 engines will have reduced fuel economy – up to 5%
    - Higher Heat Rejection increases cooling fan power and ‘Fan On’ time.
  - ADR83/00 External Noise
    - Extra sound shielding can effect cooling airflow and also increase fan power and ‘Fan On’ time.



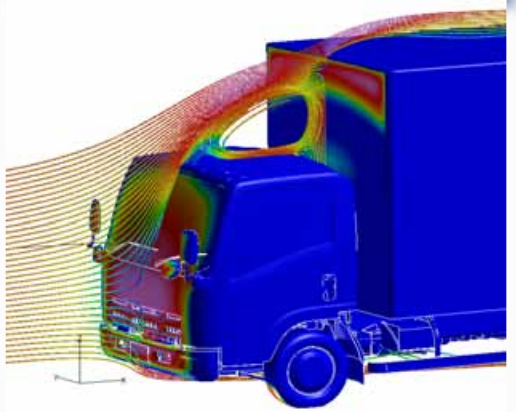
Speccing for Efficiency

- Regulations Impacting Fuel Economy
  - Engine manufacturers strive to limit fuel economy impacts for each engine emission change
  - Manufacturers, with each model, improve truck aerodynamics
  - Manufacturers are continually improving cooling systems and airflows

Speccing for Efficiency



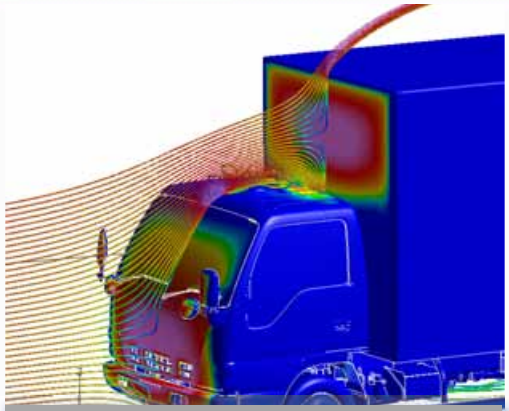
Old model



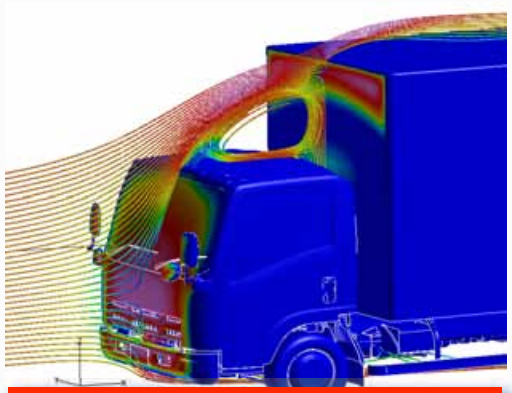
New model

- New cabin shape improves fuel consumption by reducing drag co-efficient.

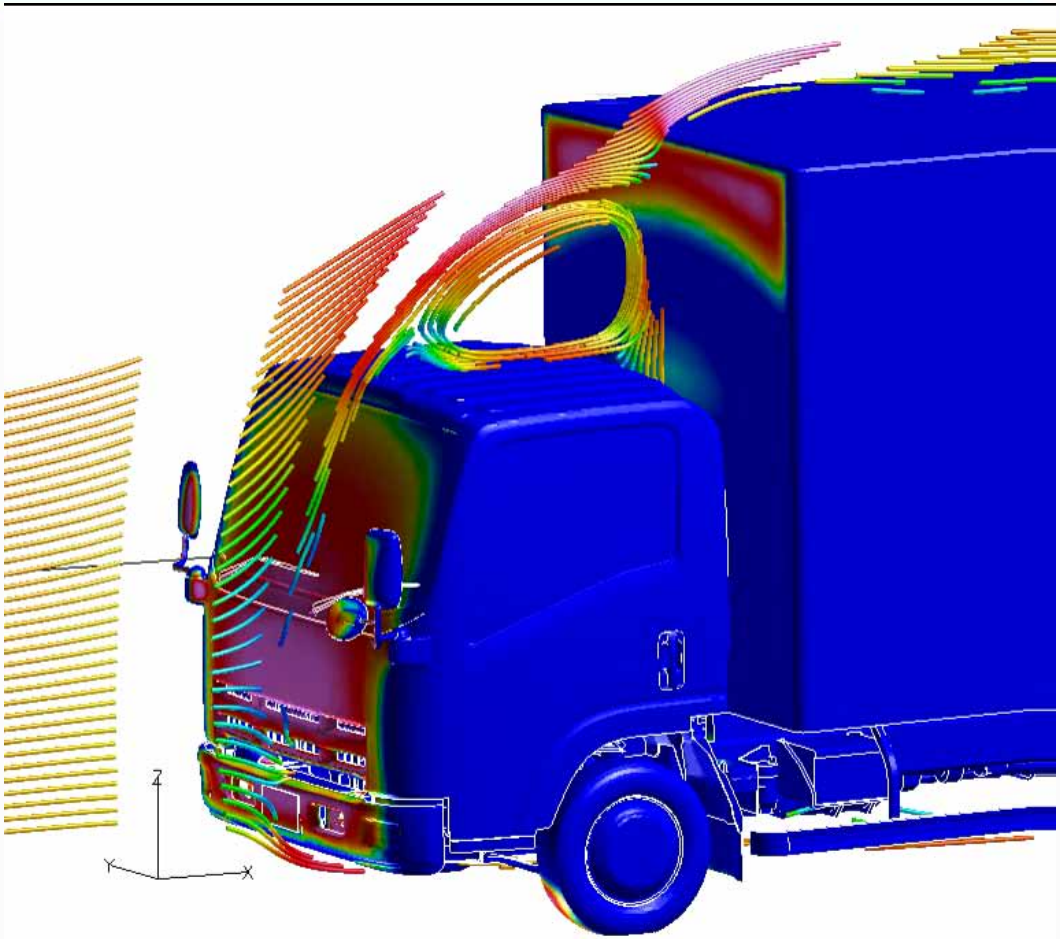
Speccing for Efficiency



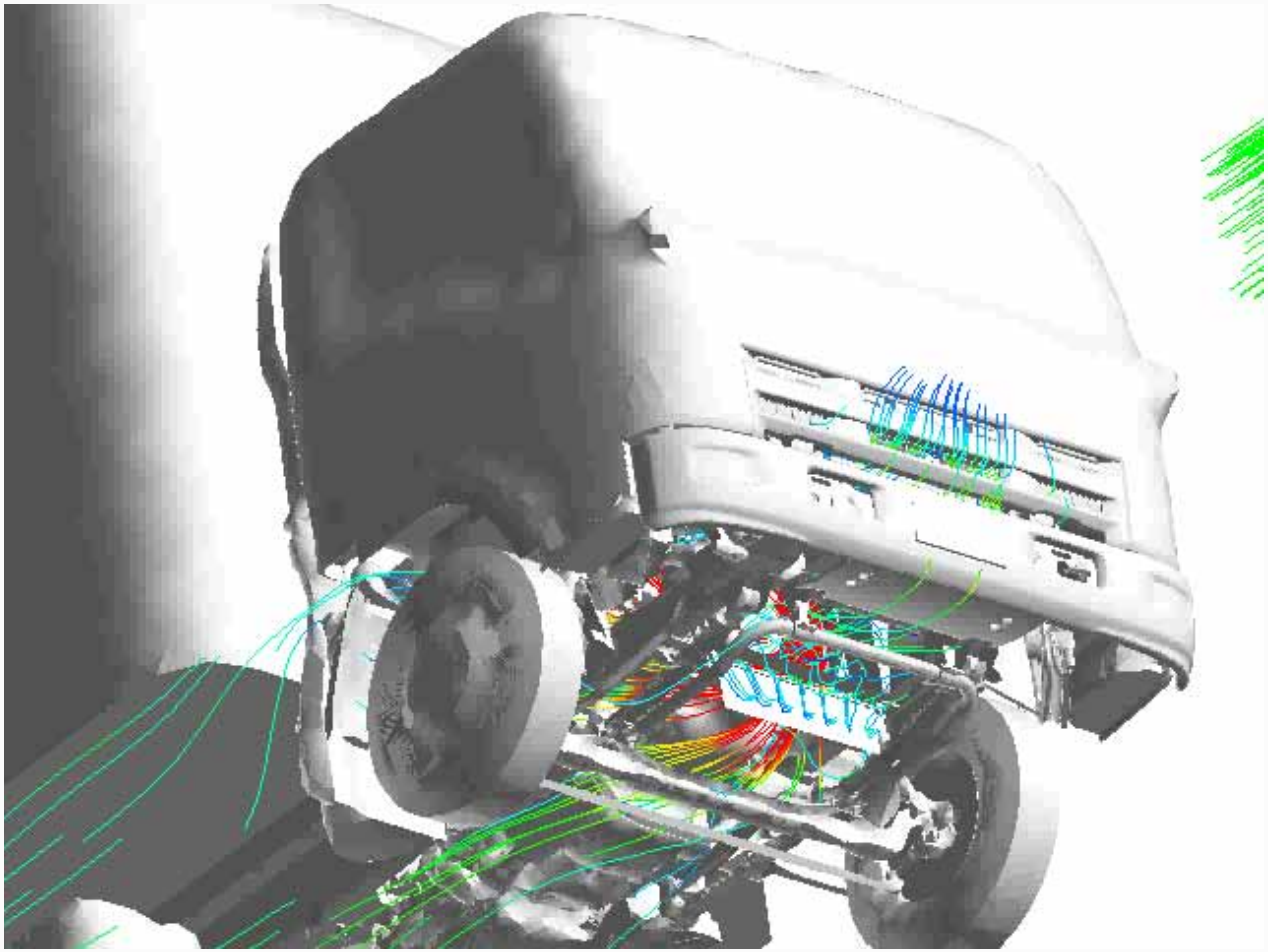
Current model



New model

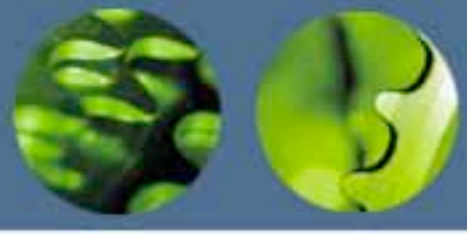


Speccing for Efficiency



Speccing for Efficiency

- Aftermarket Add-ons
  - Bullbars
  - Winches
  - Hi Rail equipment
- Disrupt cooling airflows
  - Increase fan power consumption and fan ‘on’ time
  - May lead to overheating
- Consult your Truck Dealer or Manufacturer

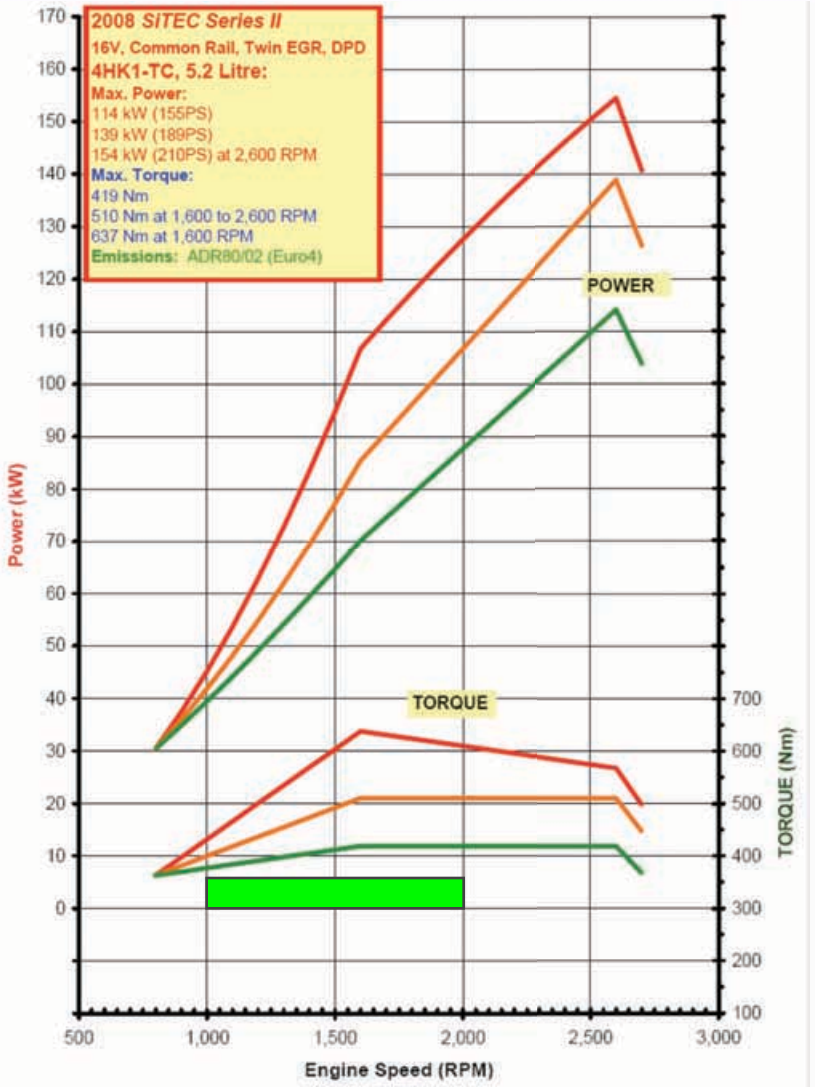


Speccing for Efficiency

- What can the operator control?
  - Truck driveline specification
  - Body Type and Size
  - Operating speeds
  - Aerodynamic configuration
  - Rolling resistance – tyre selection

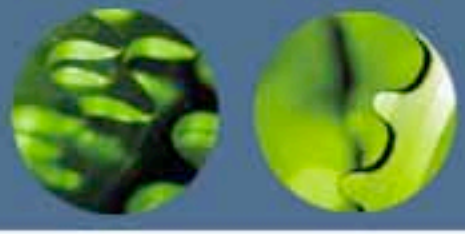
Speccing for Efficiency

- Truck driveline specification
  - Choose the spec to encourage operation in the ‘Green Zone’
  - Choose Rear Axle Ratio to cruise in the Green



Speccing for Efficiency

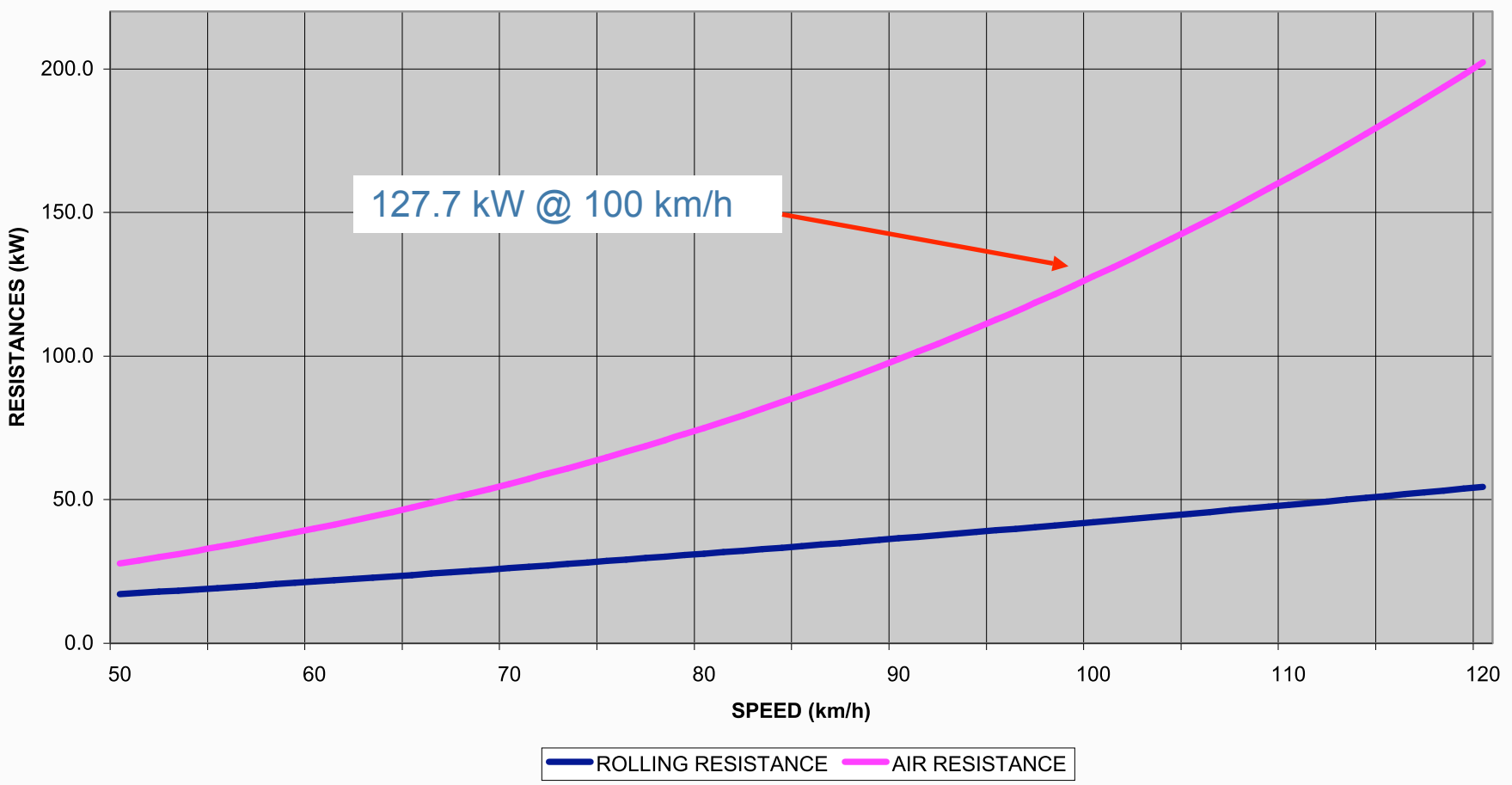
- Truck driveline specification
  - Choose the most efficient driveline.
    - Can you use a 4x2 or 6x2 configuration instead of a 6x4?
    - Improves Driveline efficiency by 5 – 8%
    - Improves Fuel consumption by 2 – 4%
  - Choose Enough Power
    - Too much power, particularly in distribution vocations encourages the driver to use the power available unwisely.



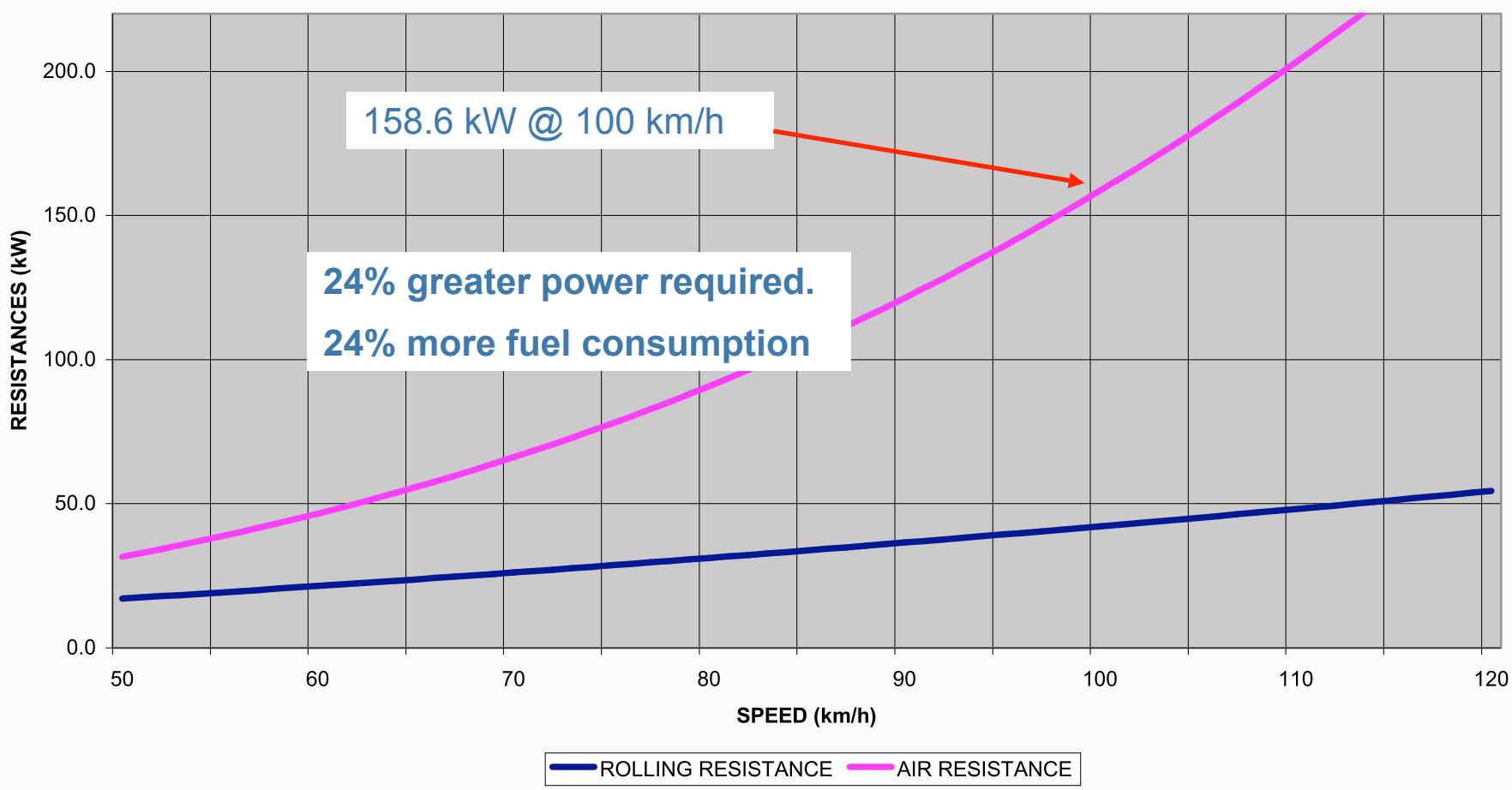
Speccing for Efficiency

- Body Type and Location
  - What size body do you need?
  - Frontal Area has direct first order relationship to fuel consumption
- Example of same spec truck with 33% greater frontal area:

Speccing for Efficiency



Speccing for Efficiency

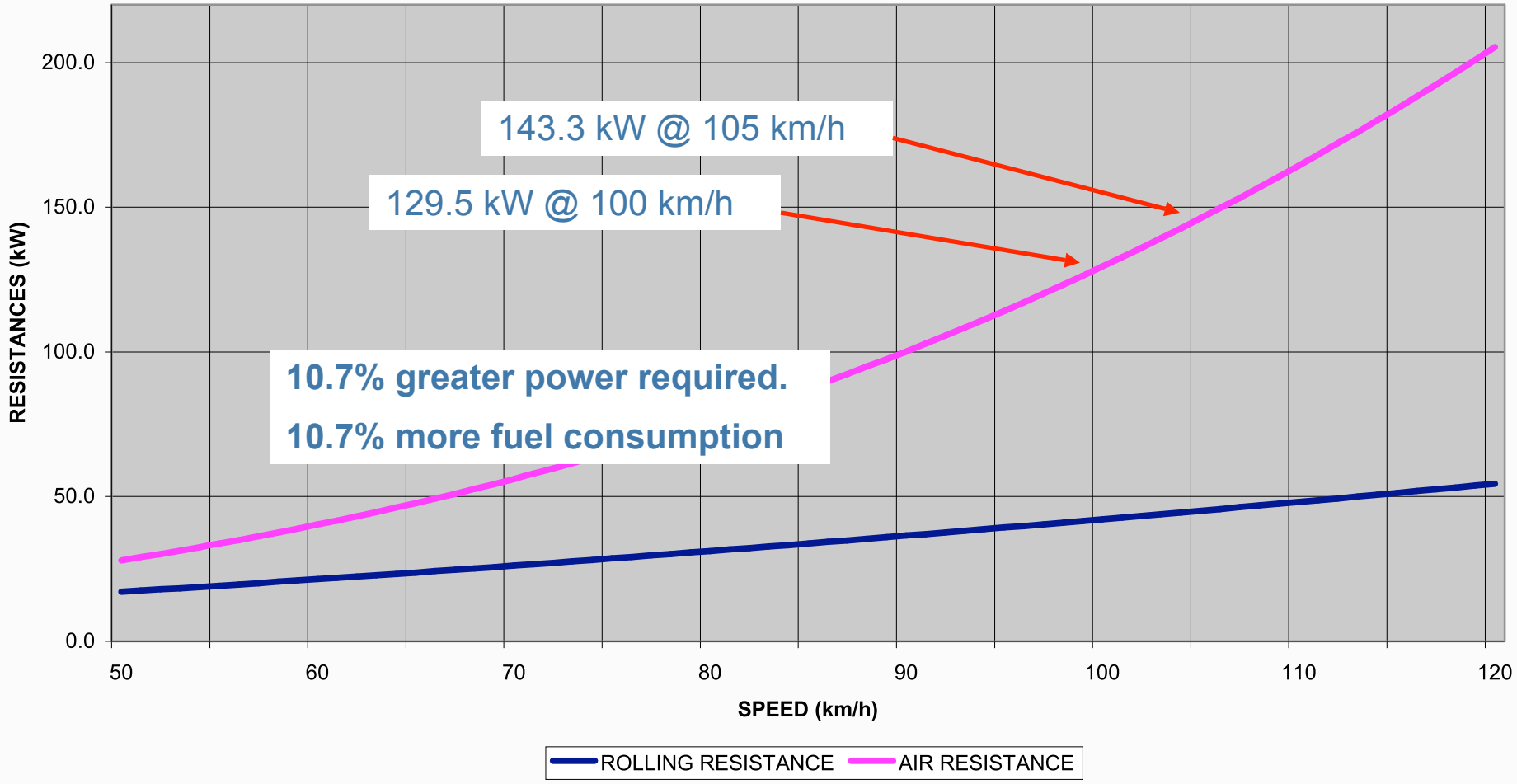


Speccing for Efficiency

- Body Type and Location
  - What size body do you need?
  - Frontal Area has direct first order relationship to fuel consumption
- Example of same spec truck with 33% greater frontal area:
- 24% greater fuel consumption
- Make sure the body is no bigger than you need.

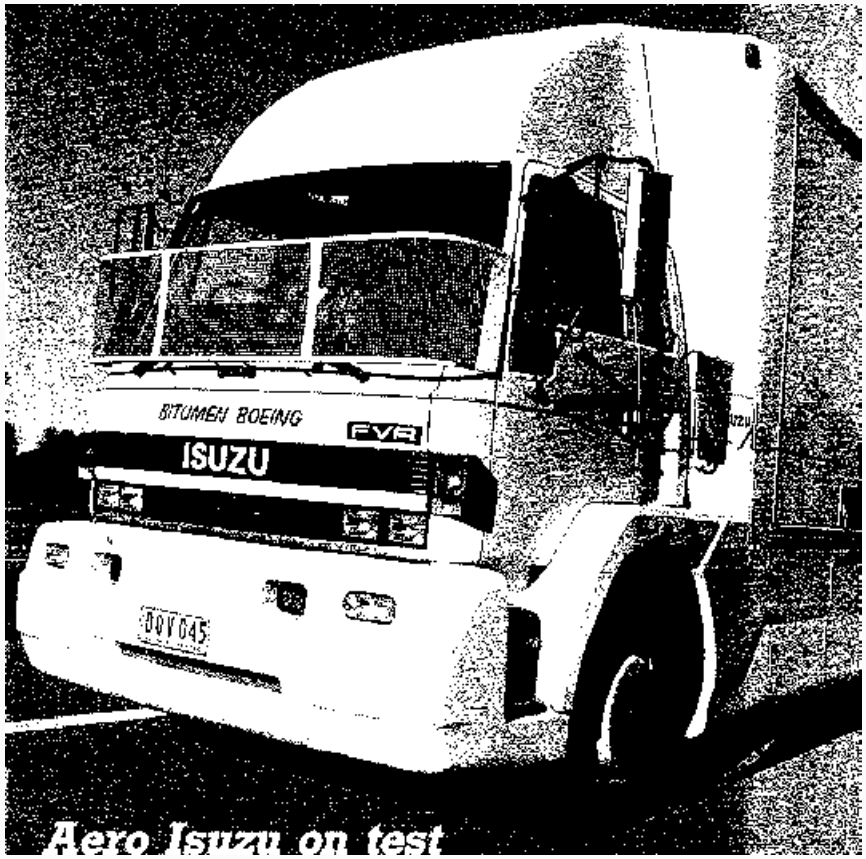
Speccing for Efficiency

Rigid Truck 22.5 t - 2.5m x 4.0m High



Speccing for Efficiency

- Aerodynamic Configuration

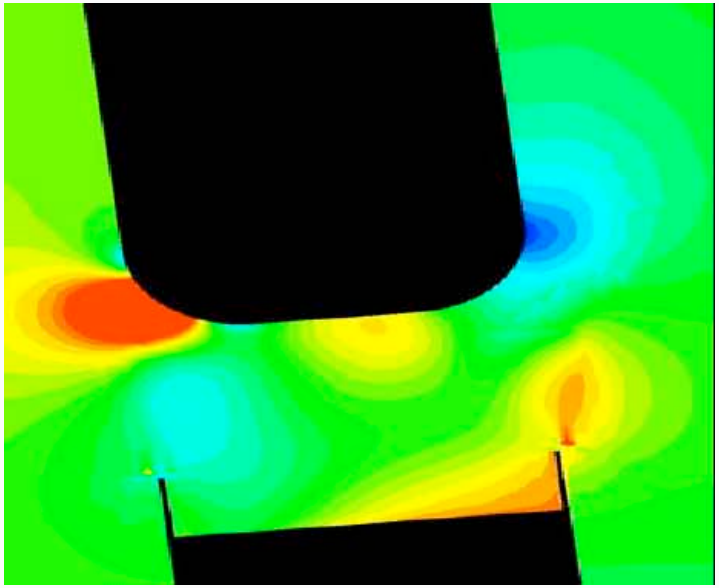


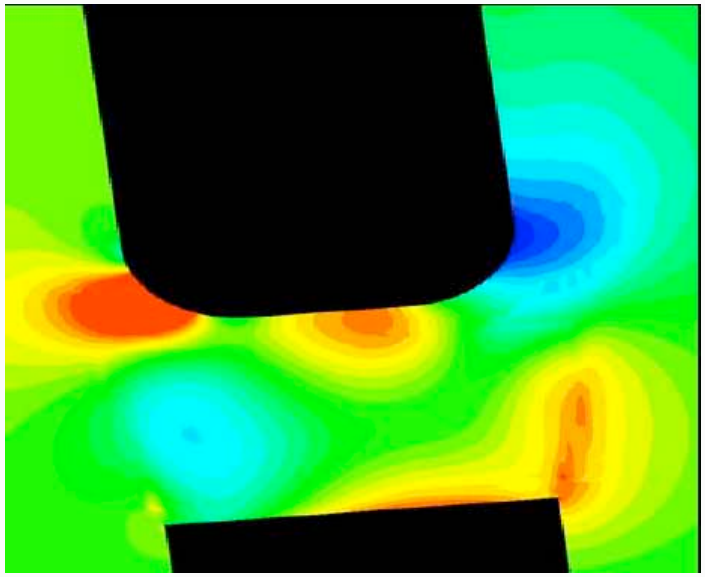
Speccing for Efficiency

- Aerodynamic Configuration
- Roof Fairing and side Extenders
  - 10 - 15% Drag Reduction

Speccing for Efficiency

- Additional Aerodynamic Devices
  - Cab Side Extenders or Gap Seals
  - Improve Cd by up to 0.03





Speccing for Efficiency

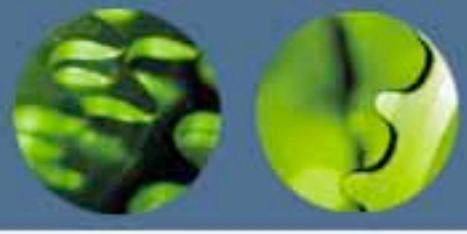
- Body Location

Current ADR 80/00 with Vertical Exhaust

New ADR80/02 with Horizontal Exhaust

Speccing for Efficiency

- Additional Aerodynamic Devices
  - Trailer or Body Skirts
  - Improve Cd by up to 0.05

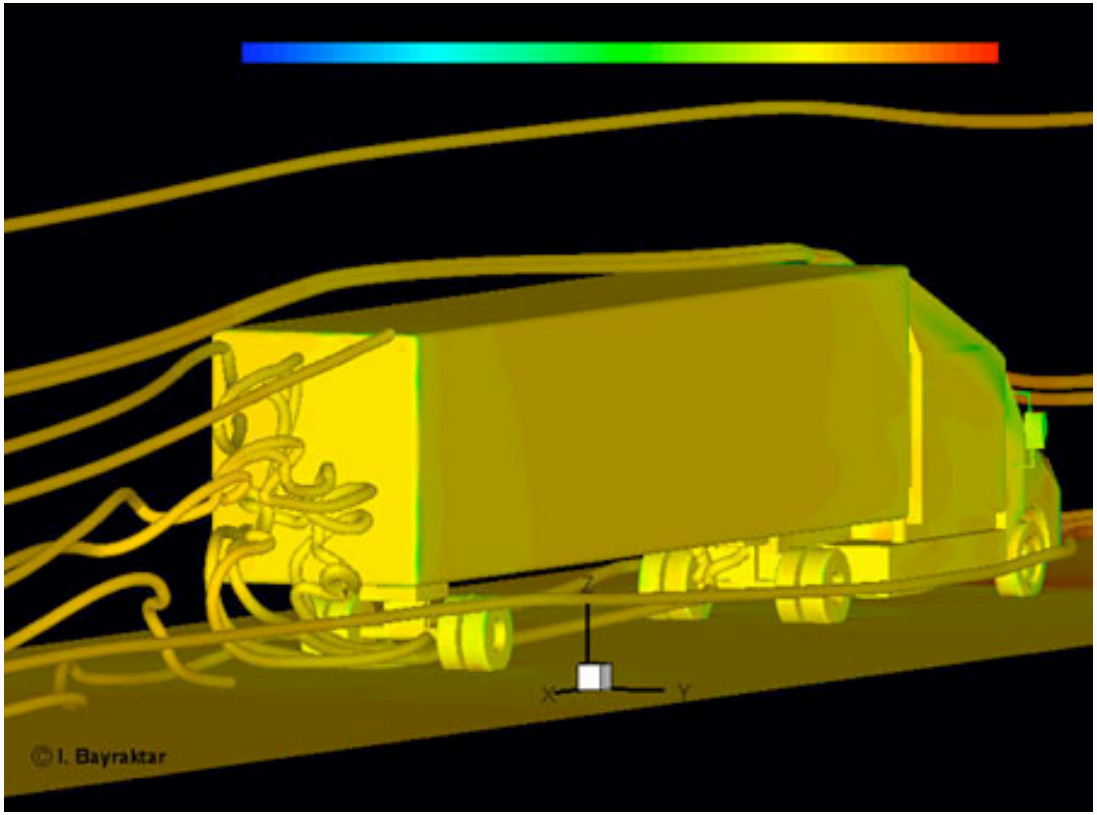


Speccing for Efficiency

- Additional Aerodynamic Devices
  - Truck Cd is around 0.6 to 0.65
  - Cd improvements of by up to 0.05 + 0.03 improves Cd by 13%
  - Implies fuel consumption improvements of up to 6 – 9%

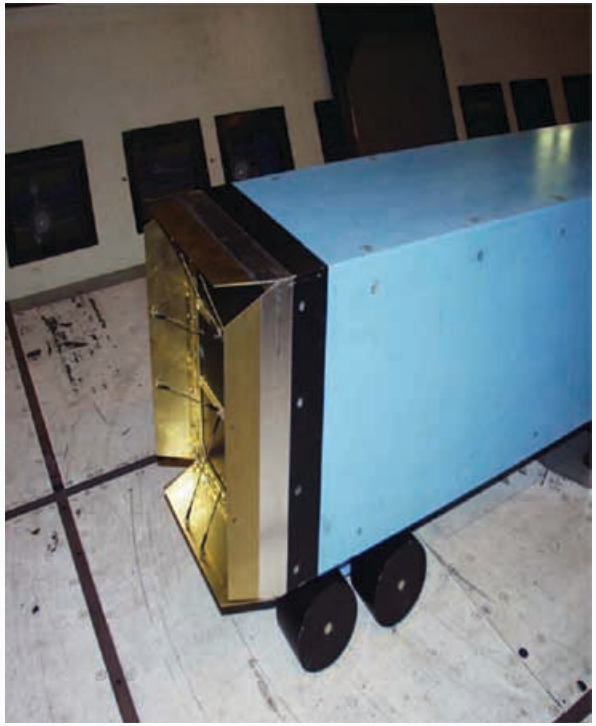
Speccing for Efficiency

- Future Aerodynamic Devices
  - Rear of trailer or body is the major source of pressure drag



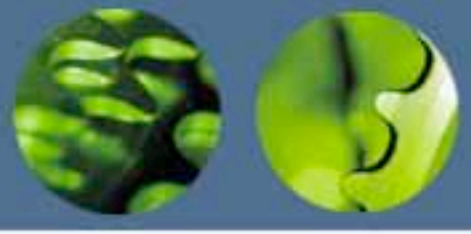
Speccing for Efficiency

- Future Aerodynamic Devices
  - Research is being conducted on rear of trailer devices



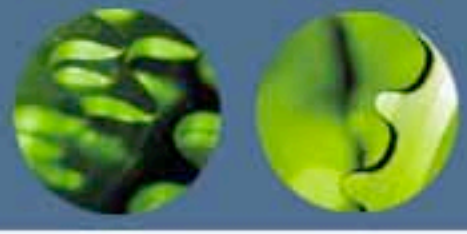
Speccing for Efficiency

- Future Aerodynamic Devices
  - Research is being conducted on rear of trailer devices



Speccing for Efficiency

- Future Aerodynamic Devices
  - Rear of trailer devices
  - Promise Cd improvements up to 0.08 or another 6 to 9% fuel consumption reduction
- These devices would not be legal in Australia
  - Rear Overhang limits
  - Overall Length limits
- Time to get the NTC involved?



Speccing for Efficiency

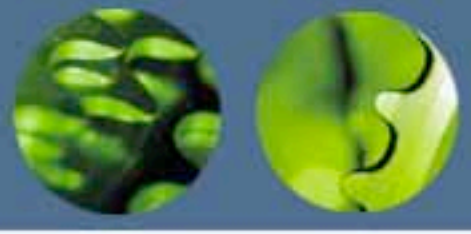
- Rolling resistance – Tyres Major Contributior
  - Tyre Selection
  - Tyre Maintenance
- Tyre Selection
  - Deep Tread Tyres give Greater Rolling Resistance.
  - Tyres Suppliers can advise
- Tyre Maintenance

FUEL EFFICIENCY SESSION

Drivers and fuel efficiency

Mark Agnew
Sales and Marketing Manager
DECA Training

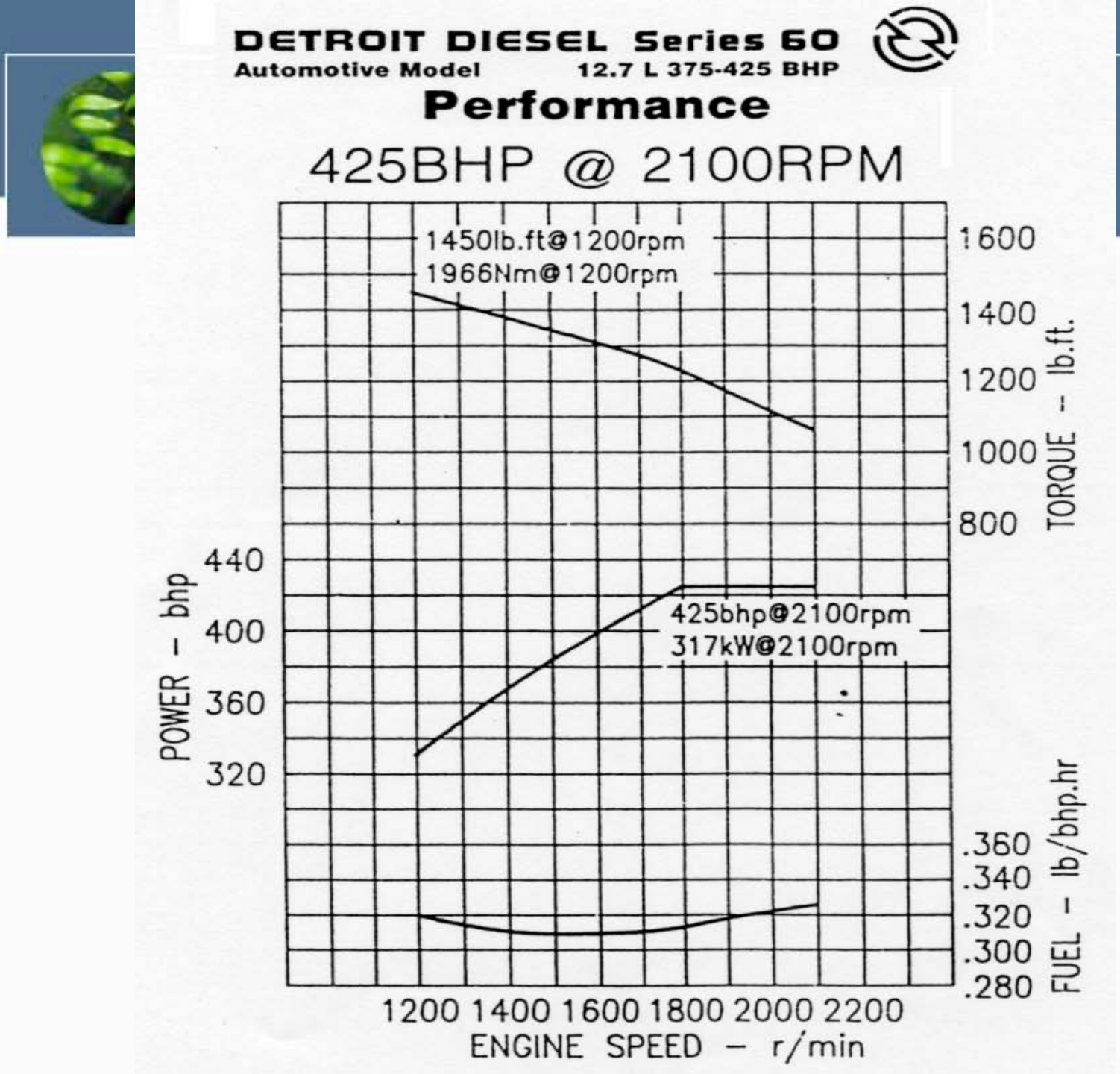
Drivers and fuel efficiency

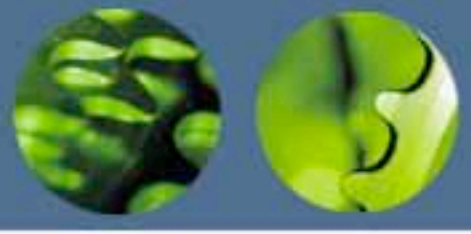


Drivers and Fuel Efficiency

Causes of inefficiency

- Over – revving
- Excessive gear changes
- Using gears to slow, instead of brakes
- Poor traffic management


DETROIT DIESEL Series 60
Automotive Model 12.7 L 375-425 BHP
Performance
425BHP @ 2100RPM
1450lb.ft@1200rpm
1966Nm@1200rpm
425bhp@2100rpm
317kW@2100rpm
POWER - bhp
440
400
360
320
TORQUE - lb.ft.
1600
1400
1200
1000
800
FUEL - lb/bhp.hr
.360
.340
.320
.300
.280
1200 1400 1600 1800 2000 2200
ENGINE SPEED - r/min

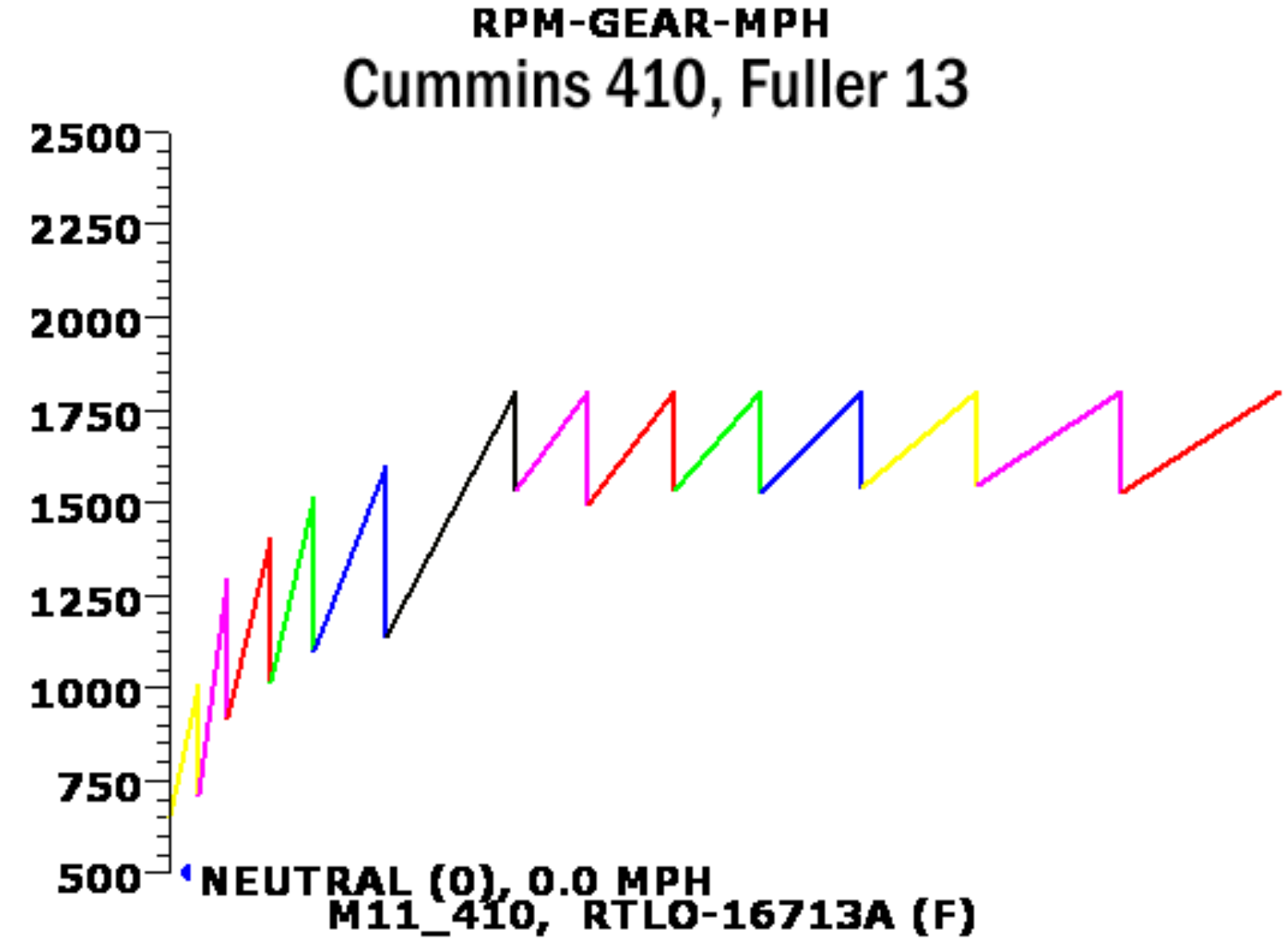


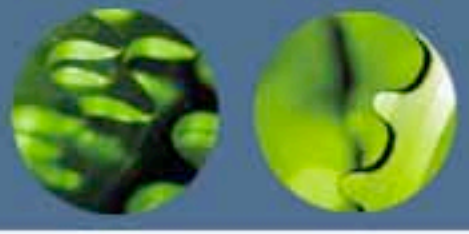
Drivers and Fuel Efficiency

Techniques for fuel efficiency:

- Progressive gear shifting
  - Low gears shifted at low revs – max torque
  - Higher gears at higher revs – max power
  - Uses torque where it is needed

Drivers and Fuel Efficiency

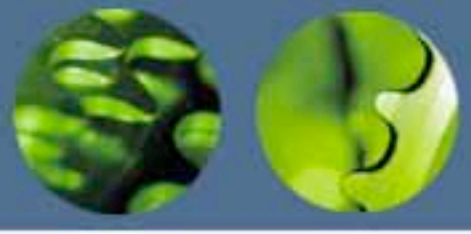




Drivers and Fuel Efficiency

Techniques for fuel efficiency:

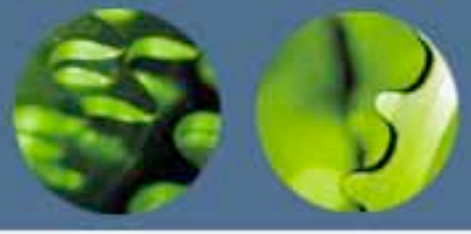
- Skip Shifting
  - Used on flat or downhill
  - Eliminates unnecessary gear changes
  - Use brakes to slow



Drivers and Fuel Efficiency

Techniques for fuel efficiency:

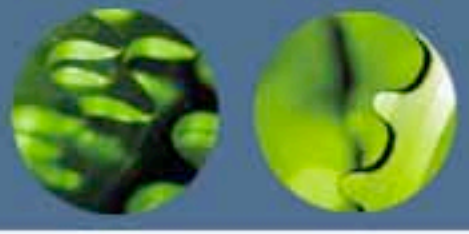
- Traffic Management
  - Observation and planning
  - Anticipation
  - System of vehicle control



Drivers and Fuel Efficiency

Training

- Knowledge of engine specifications
- Skills
  - Traffic management
  - Progressive shifting
  - Skip shifting
- Motivation



Drivers and Fuel Efficiency

Benefits

- Fuel savings – up to 10%
- Reduced maintenance and repairs
- Improved Safety

2007 Technical and Maintenance Conference

FUEL EFFICIENCY SESSION

Questions?