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# Engine Expo 2008

## Light Vehicle Powertrains – Production and Technology for Global Markets

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Knibb, Gormezano and Partners
Stuttgart, 6 May 2008

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# Global Sales and Production Trends

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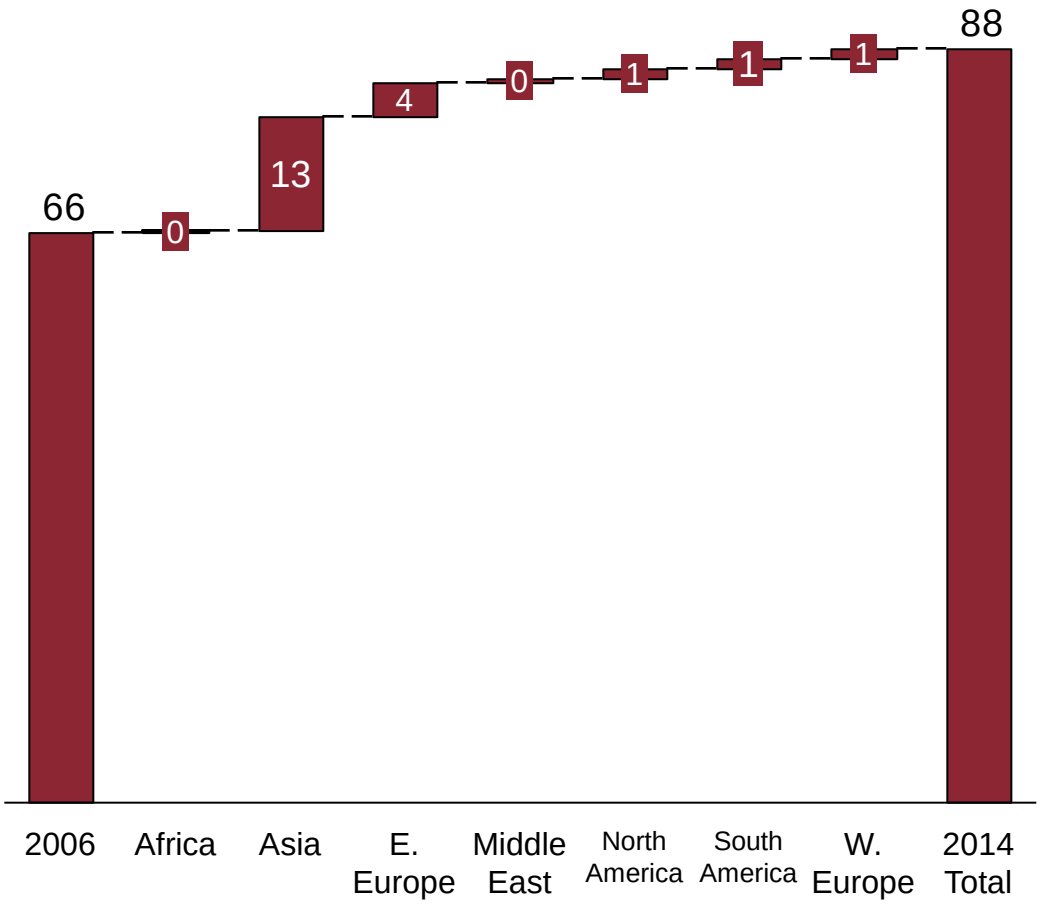
Global Light Vehicle Production (Millions 2006-2014)




- Asia and Central and Eastern Europe account for most growth between 2006 and 2014
- Credit crunch, recession and fuel prices have downward impact on forecast

Source: J. D. Power Automotive Forecasting

# Global Emissions



- Major driver for development over past 10 years
- Standards focused around US, European and Japanese levels;
  - US most stringent, with Japan and Europe catching up;
  - Varies between diesel and gasoline;
  - Drives up fuel consumption and cost;
  - Most gasoline will continue with three-way catalyst (TWC), diesels with mix of DeNOx catalyst, DPF and SCR on larger vehicles

# Global Emissions Compliance

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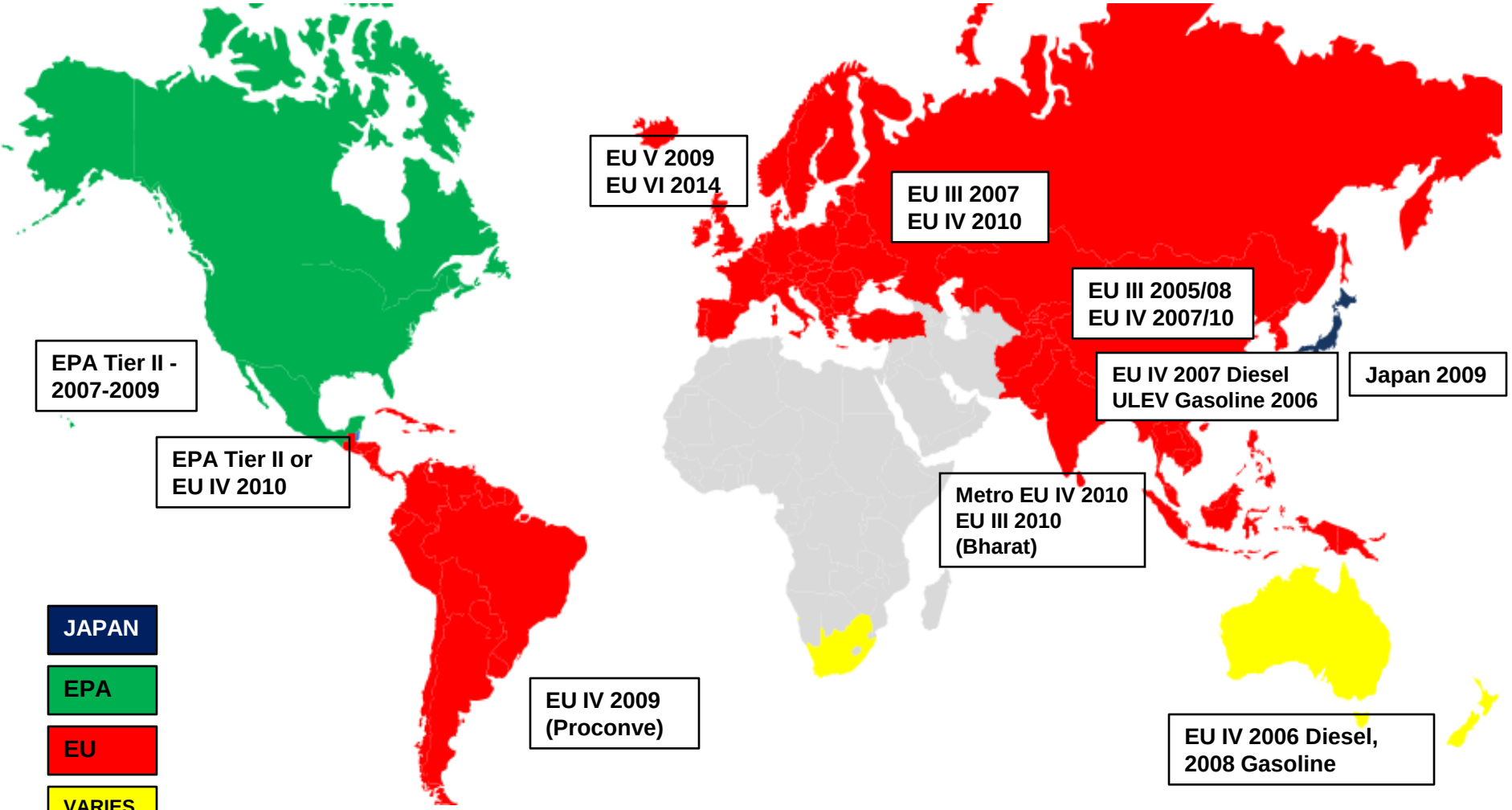
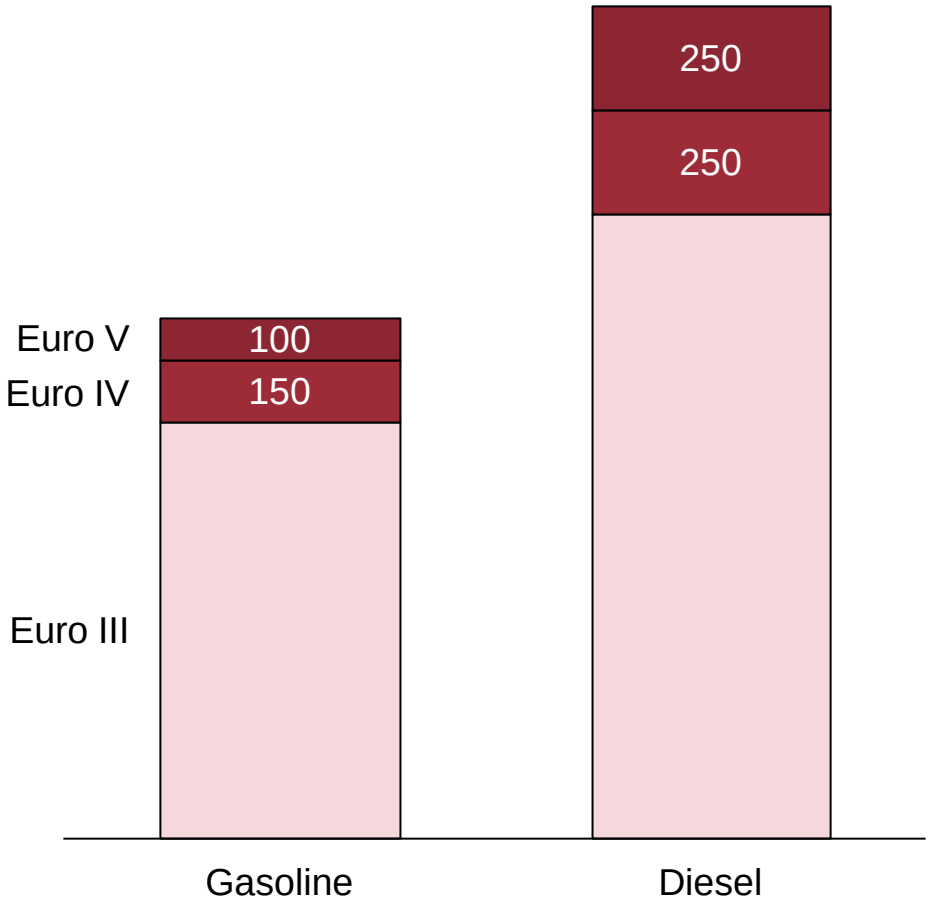
KGP




**EPA Durability 190,000km, Euro V 100/160,000km,*
*(NB Some variation between diesel and gasoline legislation with phase in periods)*

# Production Cost Increments – Noxious Emissions

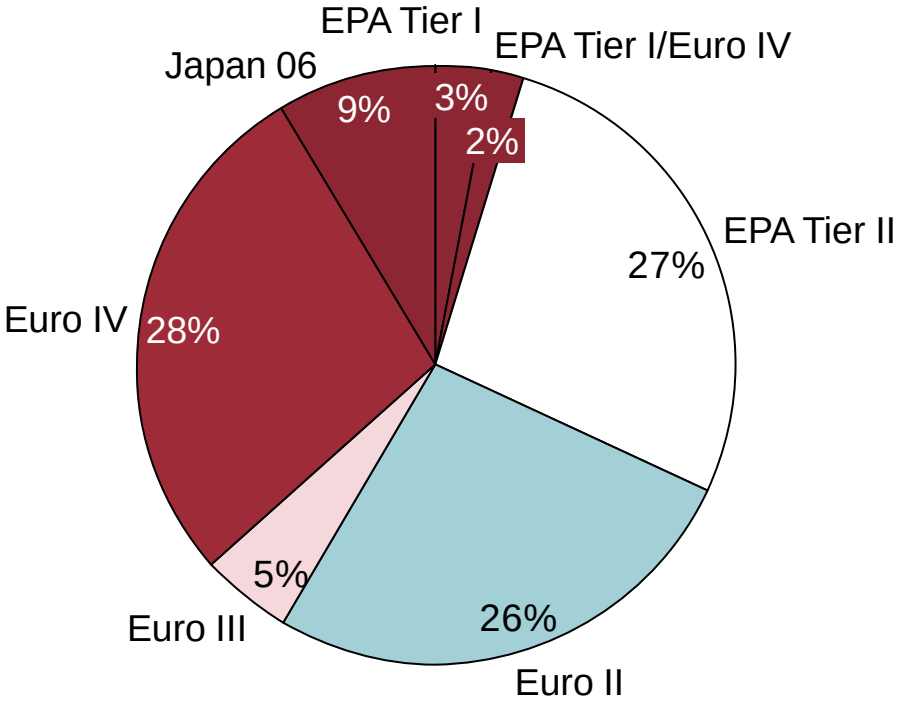



Incremental costs to meet emissions legislation

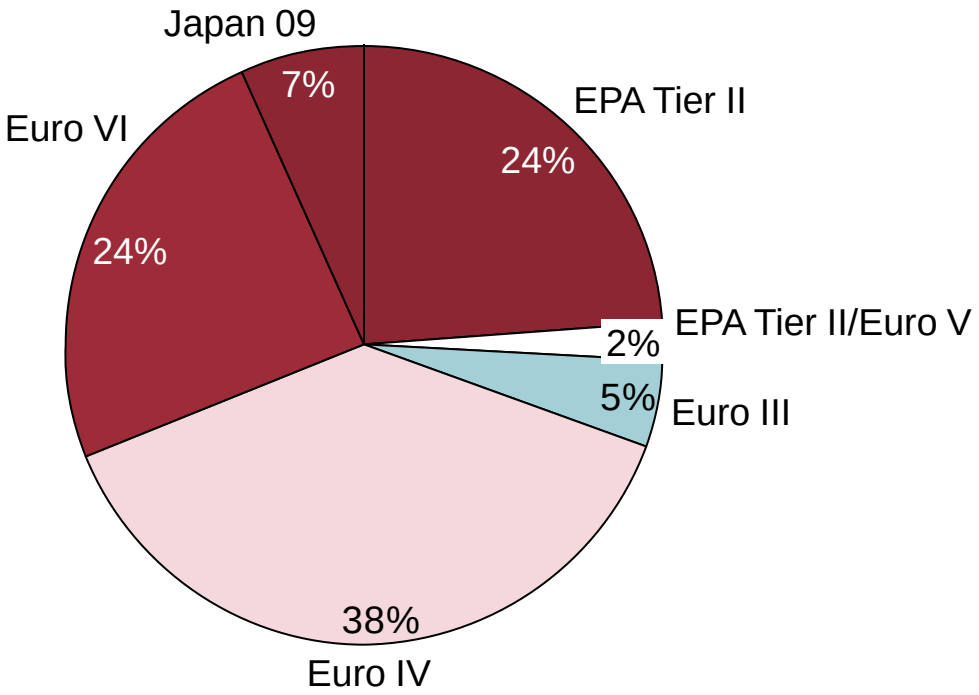
- Gasoline EU V vs EU III $250
- Diesel EU V vs Gasoline EU V $750

*Source: KGP Global Light Vehicle Engine Production 2006*

# Global Emissions Compliance Shares




2007

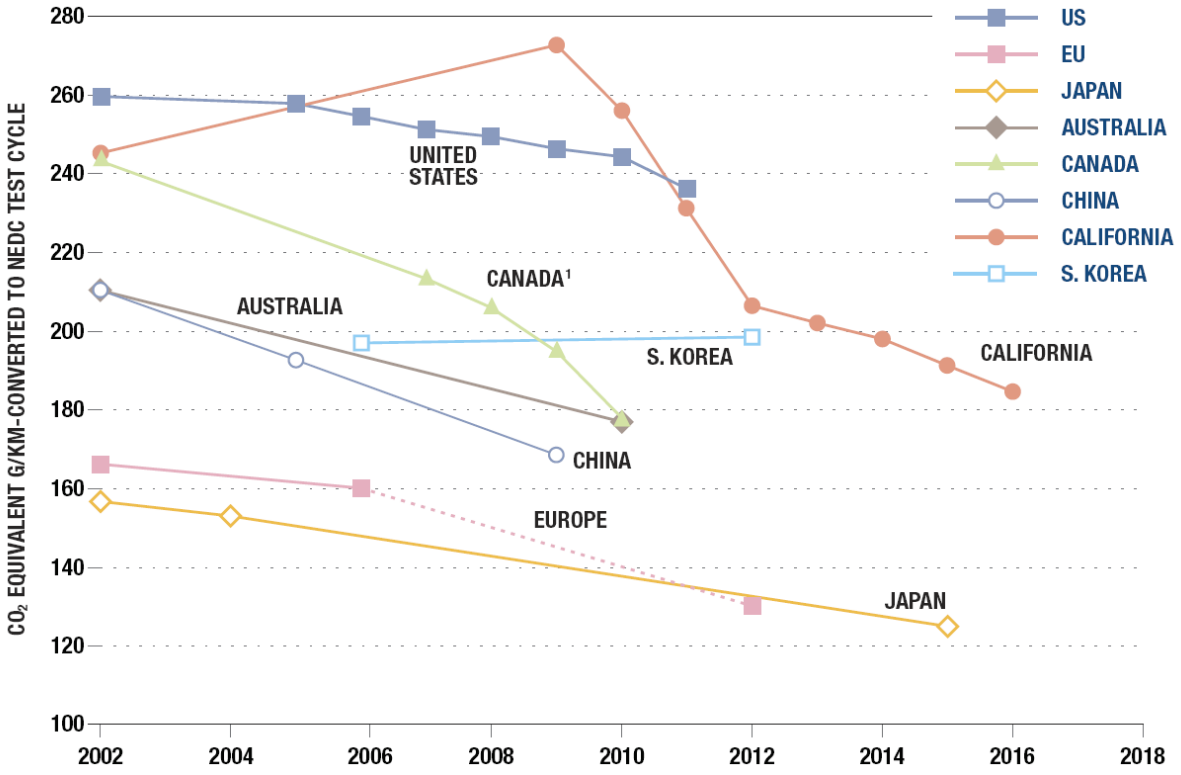



2015

*NB Shares are only approximations*
*Euro II is Euro II or less*

# $CO_2$ and Fuel Economy Standards

- Most markets that are regulated have fuel economy standards;
- Difficult to compare across test cycles;
- Most sources differ in conversion rates




*Source: International Council on Clean Transportation 2007*

# $CO_2$ Emissions from the new fleet

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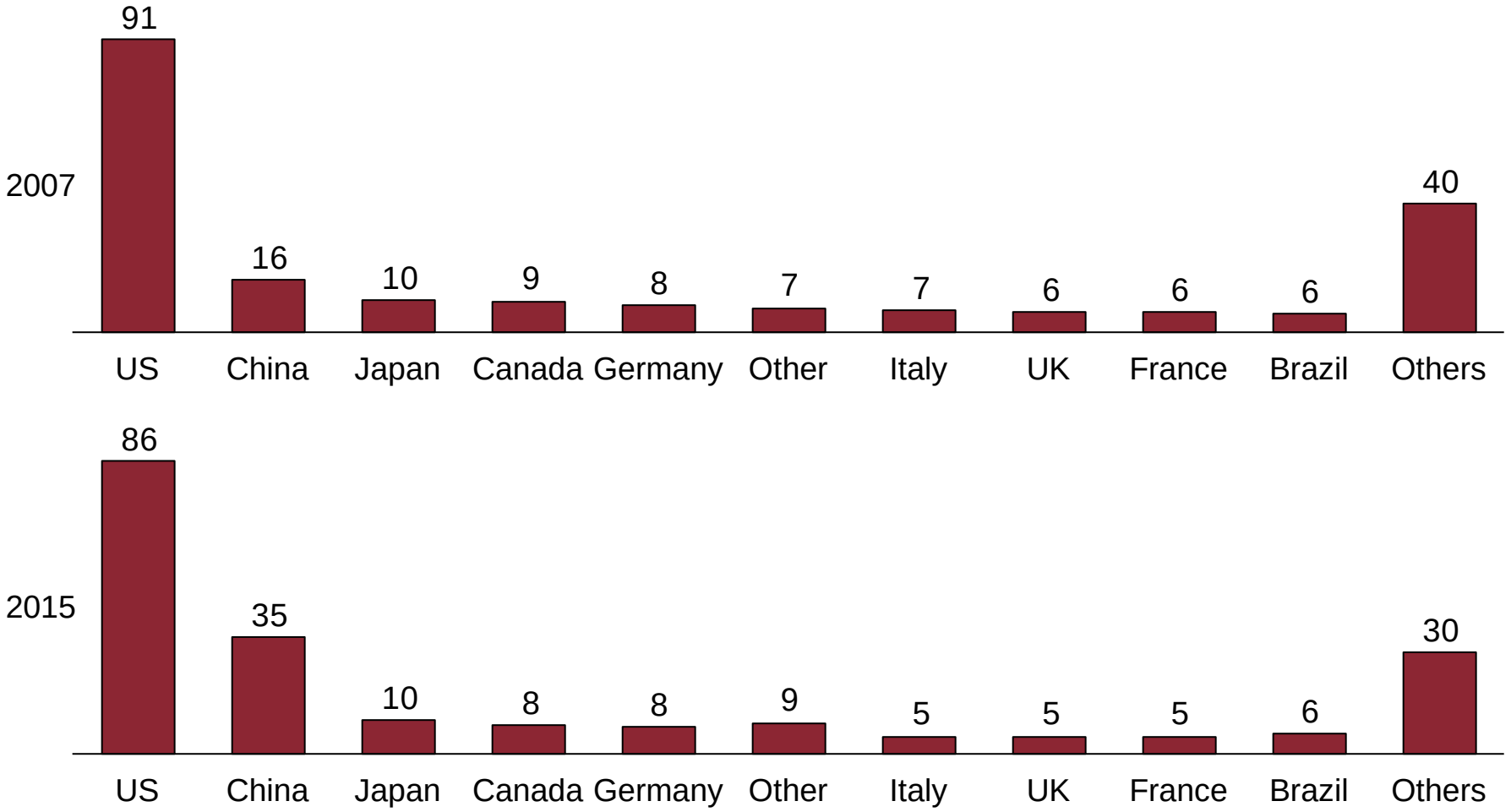
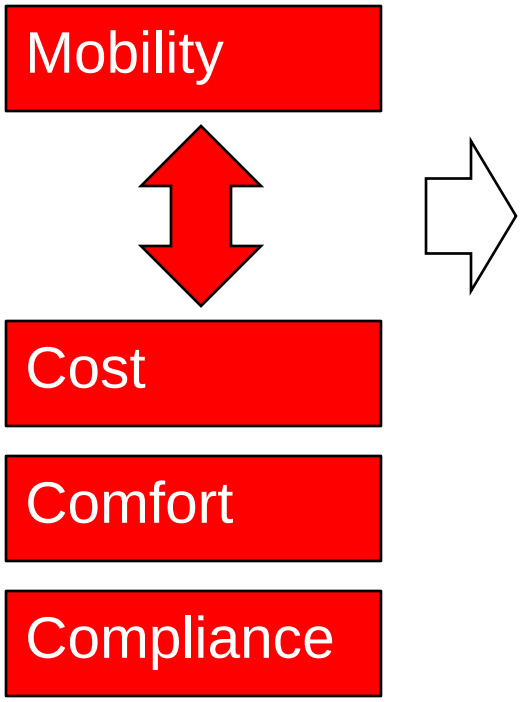
- Looking at the impact of CO2 km x sales and distances travelled (Billions g);
- Assumes static distances travelled




*NB Shares are only approximations*

# Market Drivers






| *Developed Markets* | *Developing Markets* |
|---|---|
| Comfort | Purchase Price |
| Purchase Price | Fuel Economy |
| Features | Ease of Maintenance |
| Performance | Durability |
| Reliability | Reliability |
| Fuel Economy | Features |
| Image | Performance |
| Service Cost | Comfort |

# Dieselisation

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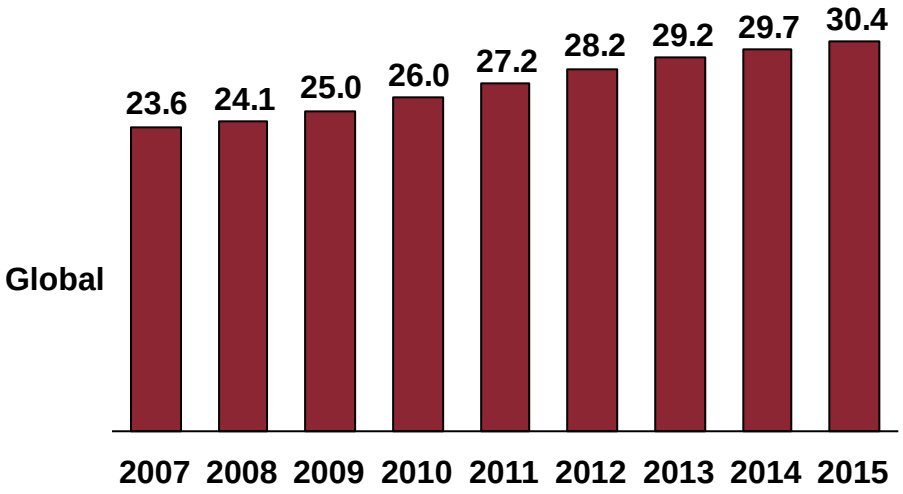
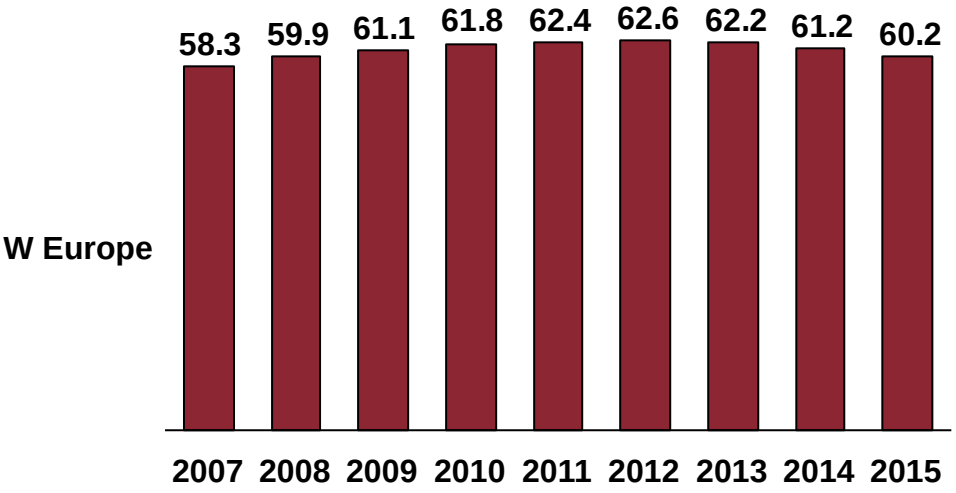
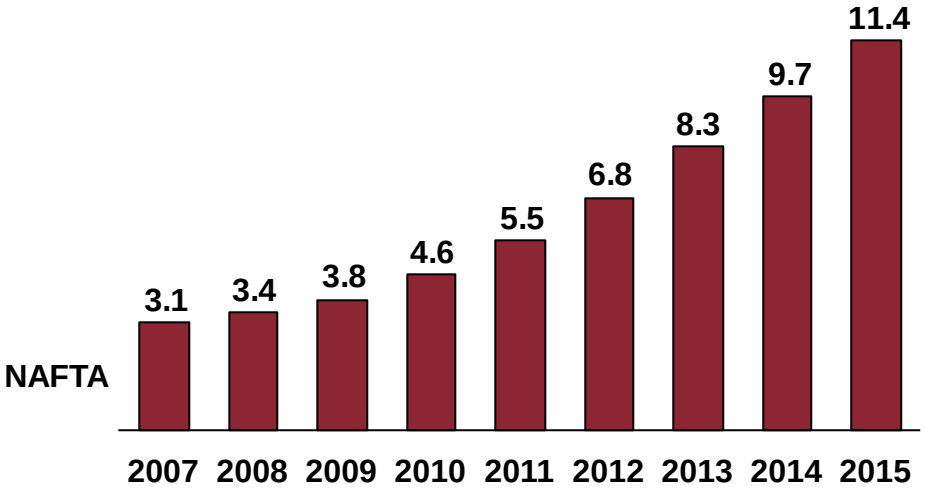
## Diesel share of light vehicle sales (%)




- Diesel share likely to increase globally
- Forecast sensitive to diesel vs gasoline differential and long-term fuel prices
- Hybrids in comparison accounted for 0.5% of light vehicles globally in 2007 and 2% in the US



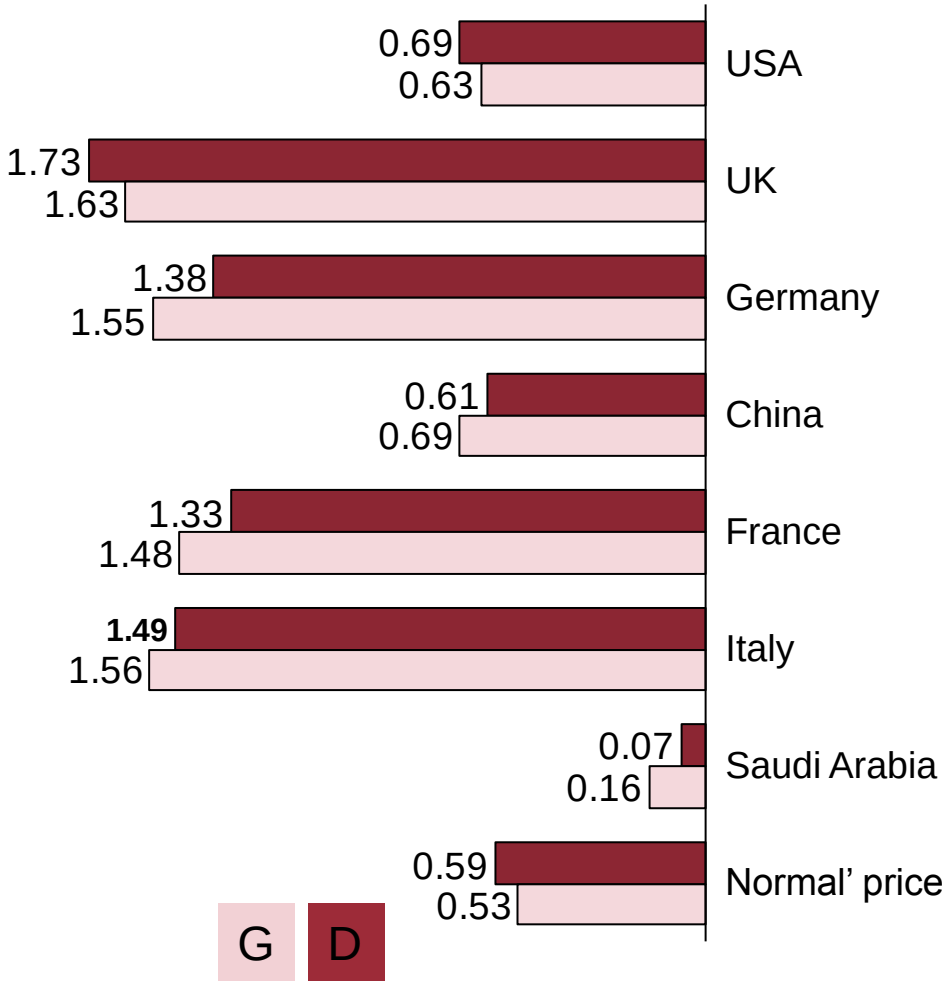



# Fuel Prices

- Fuel price is a key driver
- Long term forecast uncertain – other than upwards
- China only major market to subsidise fuel prices
- Diesel share forecast sensitive to diesel price, particularly in North America, where a significant gap has opened
  - US gasoline $0.96, diesel $1.12
  - Current prices UK gasoline $2.2, diesel $2.4 per litre

November 2006 Fuel Prices ($ litres)

Source: GTZ




68% of US voters polled said gas prices were there top concern.

# Alternative Fuels

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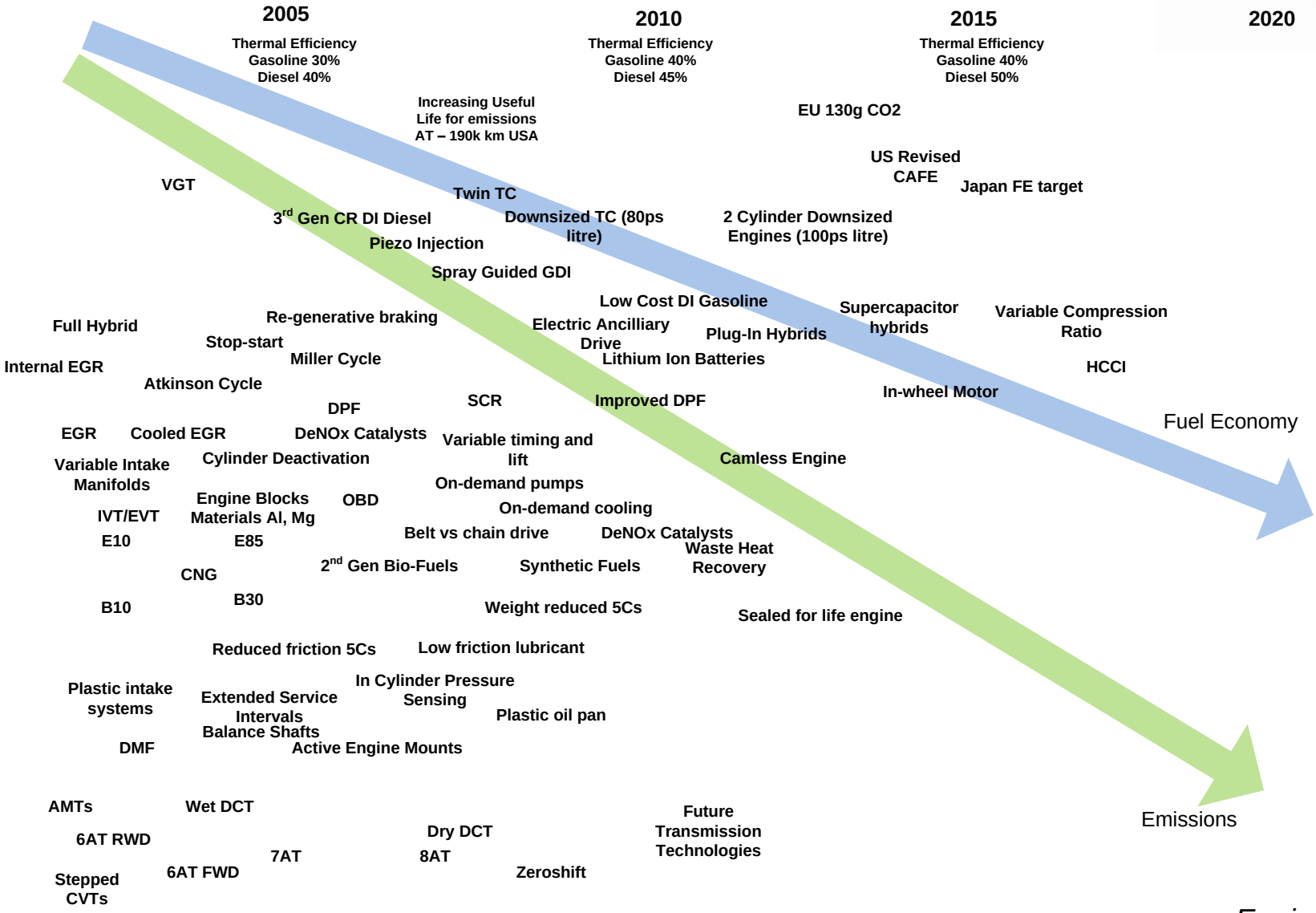
- Likely to become more economically feasible as fossil fuel prices increase;
- Need to move away from food-source based 1st generation fuels to prevent increased food prices;
- Uncertainty over global requirements, particularly in relation to EU Bio-Fuels mandate;
- Brazil and US are major markets for alternate fuels;
- CNG adoption mixed – particularly attractive in Middle East and adopted in India;

# Technology Roadmaps – Developed Markets

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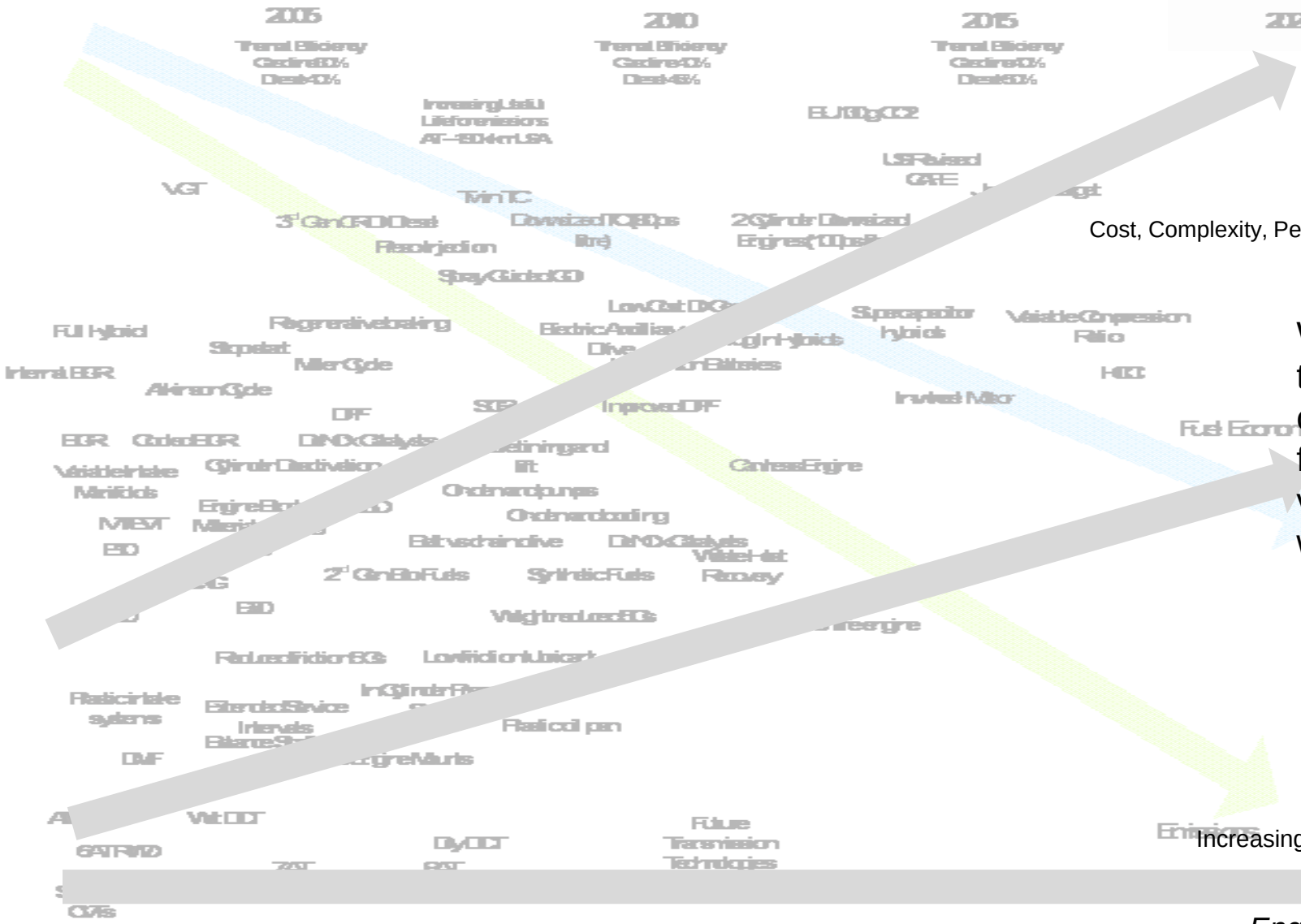
# Technology Roadmaps – Developed Markets

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# Sulphur

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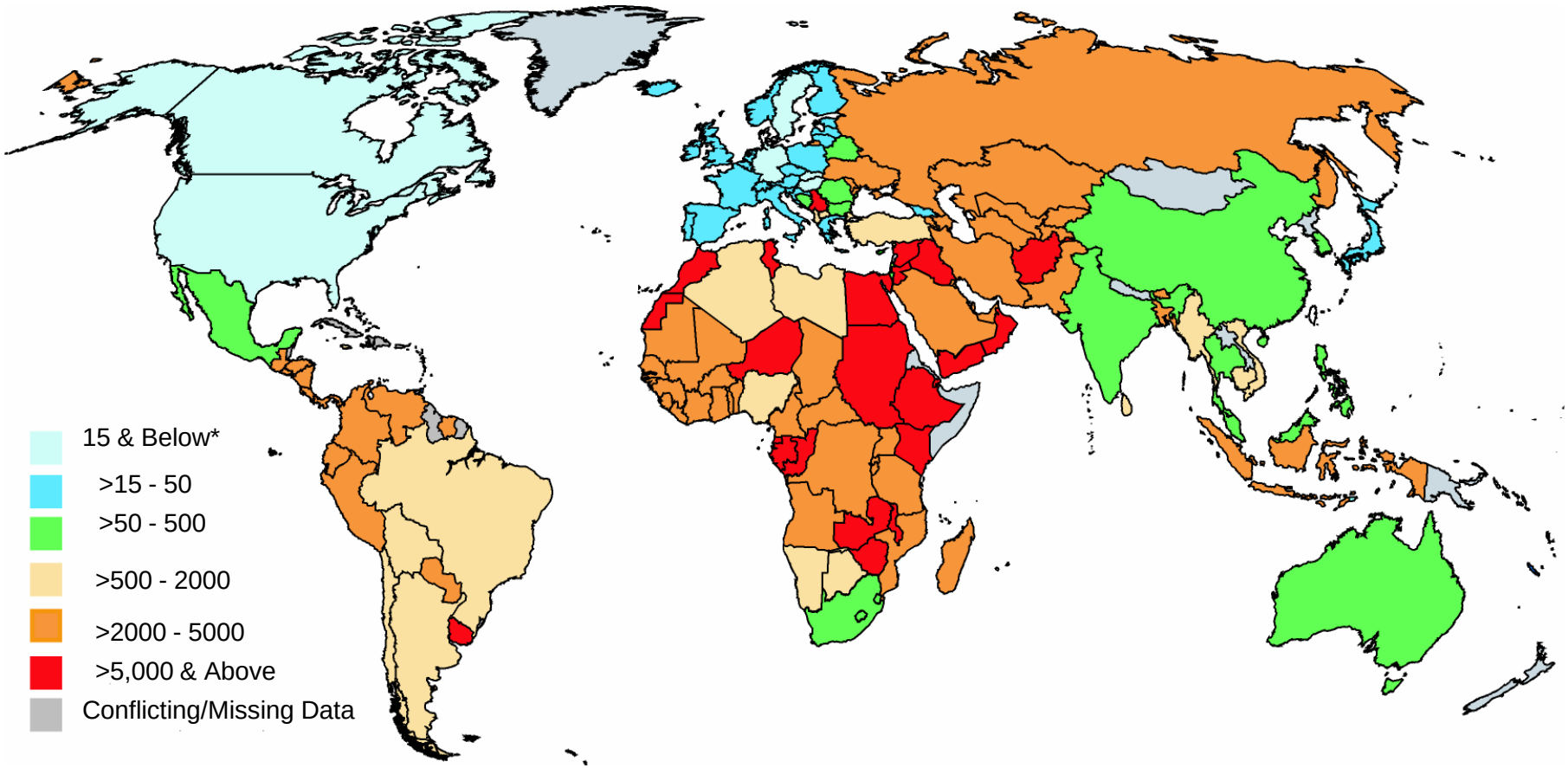


* Information in parts per million (ppm)
Sulphur levels are maximum allowable as of September 2007. Source: UNEP

# North America

- Fuel economy currently a very hot topic;
- Major market for hybrids;
- Considerable investment in diesels;
- High automatic share;
- Increasing transplant share;
- Opportunity for downsizing with GDI and TC;
- Low sulphur diesel introduced for 2007 HD standards
- Switch back from trucks to cars also required, along with other measures – weight reduction etc.

| Key Market Characteristics | |
|---|---|
| Average Displacement | 3600cc |
| Diesel Production Share | 5.5% in 2007 |
| Automatic Share | >90% |
| Fuel Economy Std | CAFE proposed 25mpg combined by 2020 (24.8 in 2007) |
| Key Technologies | DISI TC, Stop-start, 6AT, DCT |
| Emissions Standards | Tier II |
| Average Power | 240ps |

*Based on production volumes

# Western Europe

- High diesel share; reaching saturation?
- Focus on $CO_2$ reduction, not clear on how fleet average will be applied;
- Uncertainty over bio-fuels directive;
- Shift to central European production – vehicles, increasingly engines;
- Widespread taxation incentives (disincentives) based on displacement and fuel type;
- Slowly growing hybrid share;
- Rapid uptake of stop start technology;
- Suitability of powertrain technology for global markets?
- Focus on engine downsizing and stop-start, with other vehicle measures including weight reduction

| Key Market Characteristics | |
|---|---|
| Average Displacement | 1865cc |
| Diesel share | 51% in 2007 |
| Automatic Share | 20% |
| Fuel Economy Std | 130g $CO_2$ by 2012 |
| Key Technologies | DISI TC, Stop-start, DCT |
| Emissions Standards | Euro IV |
| Average Power | 128ps |

*Based on production volumes

# Japan

- Most stringent fuel economy target;
- Little diesel penetration;
- Hybrid's appear too expensive;
- Significant penetration of smaller (Kei) cars;
- High automatic share;
- FE target being tightened;
- Globalisation of manufacturing and engine plants;
- Potential for stop start with automatic?
- Next round of emissions legislation in 2009;
- High export volume;

| Key Market Characteristics | |
|---|---|
| Average Displacement | 1944cc |
| Diesel share | 7% in 2007 |
| Automatic Share | 75% |
| Fuel Economy Std | Weight based fuel economy target for 2015 |
| Key Technologies | DI gasoline, stop-start |
| Emissions Standards | Japanese standard |
| Average Power | 136ps |

*Based on production volumes

# Brazil

- High share of multi-fuel vehicles;
- Limited exports outside region and no domestic manufacturers;
- Very low automatic share.

| Key Market Characteristics | |
|---|---|
| Average Displacement | 1410cc |
| Diesel share | 3.7% in 2007 |
| Automatic Share | <2% |
| Fuel Economy Std | None |
| Key Technologies | Multi-Fuel FIE |
| Emissions Standards | Euro III |
| Average Power | 90ps |

*Based on production volumes

# Russia

- Significant growth in sales forecast;
- Large share of imported vehicles, as domestic manufacturers slow to respond to products;
- Investment needed in modern engines and transmissions;
- Low automatic share;
- Low diesel share;
- No fuel economy standards;

| Key Market Characteristics | |
|---|---|
| Average Displacement | 1780cc |
| Diesel share | 9.5% in 2007 |
| Automatic Share | <5% |
| Domestic Mfrs | <50% of sales |
| Fuel Economy Std | None |
| Key Technologies | SMPI,TWC, CR DI |
| Emissions Standards | Euro III |
| Average Power | 94ps |

*Based on production volumes

# India

- High share of domestic manufacturers
- Increasing JV share
- Low automatic
- Low cost market
- Increasing diesel share
- Low automatic share, increasing

| Key Market Characteristics | |
|---|---|
| Average Displacement | 1450cc |
| Diesel share | 9.5% in 2007 |
| Automatic Share | 10% |
| Fuel Economy Std | None |
| Key Technologies | SMPI,TWC, CR DI |
| Emissions Standards | Euro II/III |
| Average Power | 66ps |

*Based on production volumes

# China

- Massively increased production;
- Domestic and JV manufacturers growing strongly;
- Investment in new engine models required for many manufacturers;
- Divergent needs of small car market and mid-sized/premium segments;
- Size based fuel economy standard introduced;
- Increasing automatic share
- Low diesel share

| Key Market Characteristics | |
|---|---|
| Average Displacement | 1875cc |
| Diesel share | 9.5% in 2007 |
| Automatic Share | 30% |
| Fuel Economy Std | Weight based fuel economy standard introduced |
| Key Technologies | SMPI,TWC, CR DI 6ATs, DCTs |
| Emissions Standards | Euro III/IV |
| Average Power | 106ps |

*Based on production volumes

# Conclusions

- ‘No size fits all’
- Complex future technology roadmap for all markets
- Low cost, durable requirements for developing and developed markets

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## Acknowledgements


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