Advances in Engine Technology

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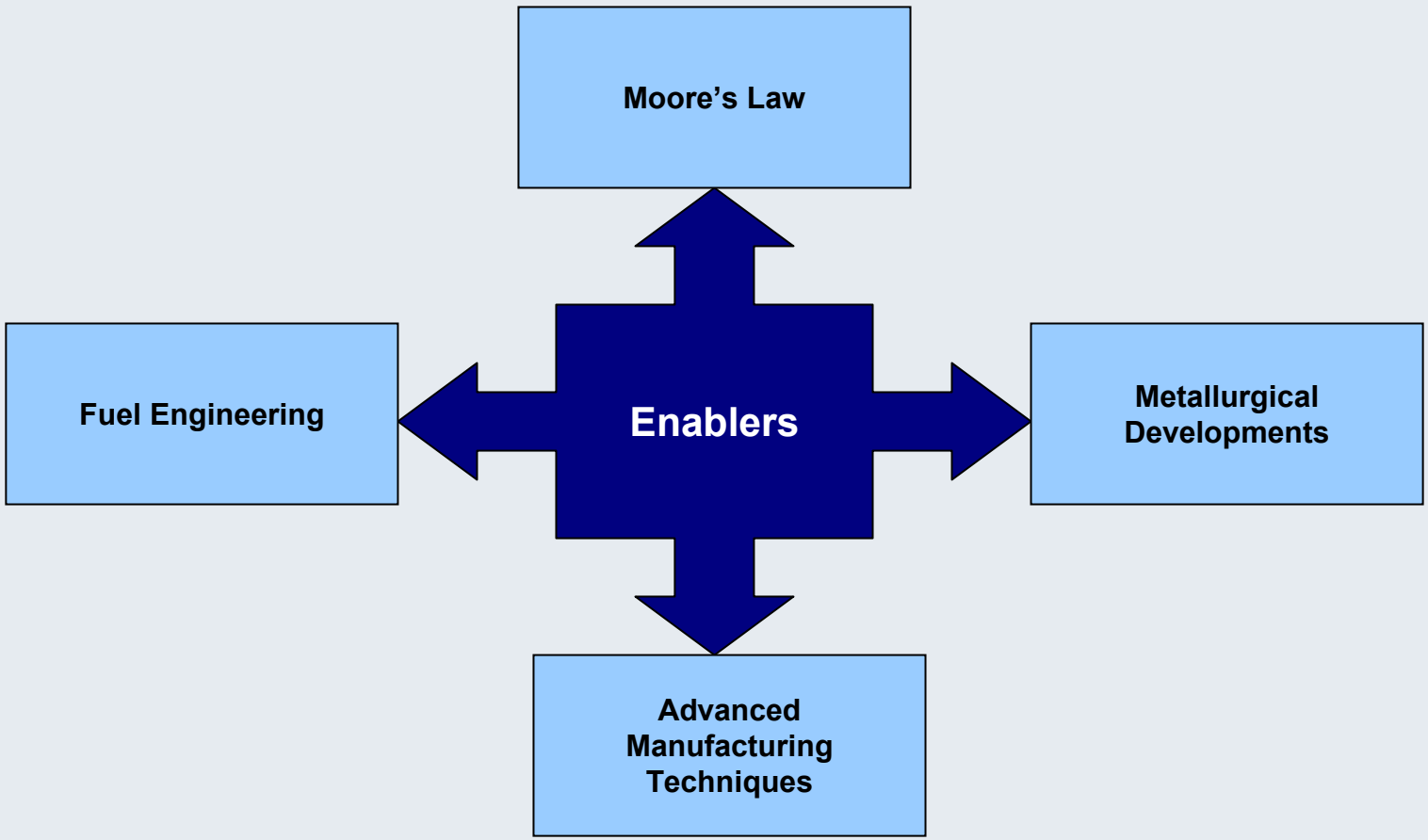
What Are We Looking at Today?

- Fuel Security is one of critical factors affecting global economies today.
- From the automotive perspective, the fuel availability and prices directly influence consumer choices on vehicles in the short term.
- We see today an automotive industry caught in the crosshairs of the environmental lobby and government regulators.

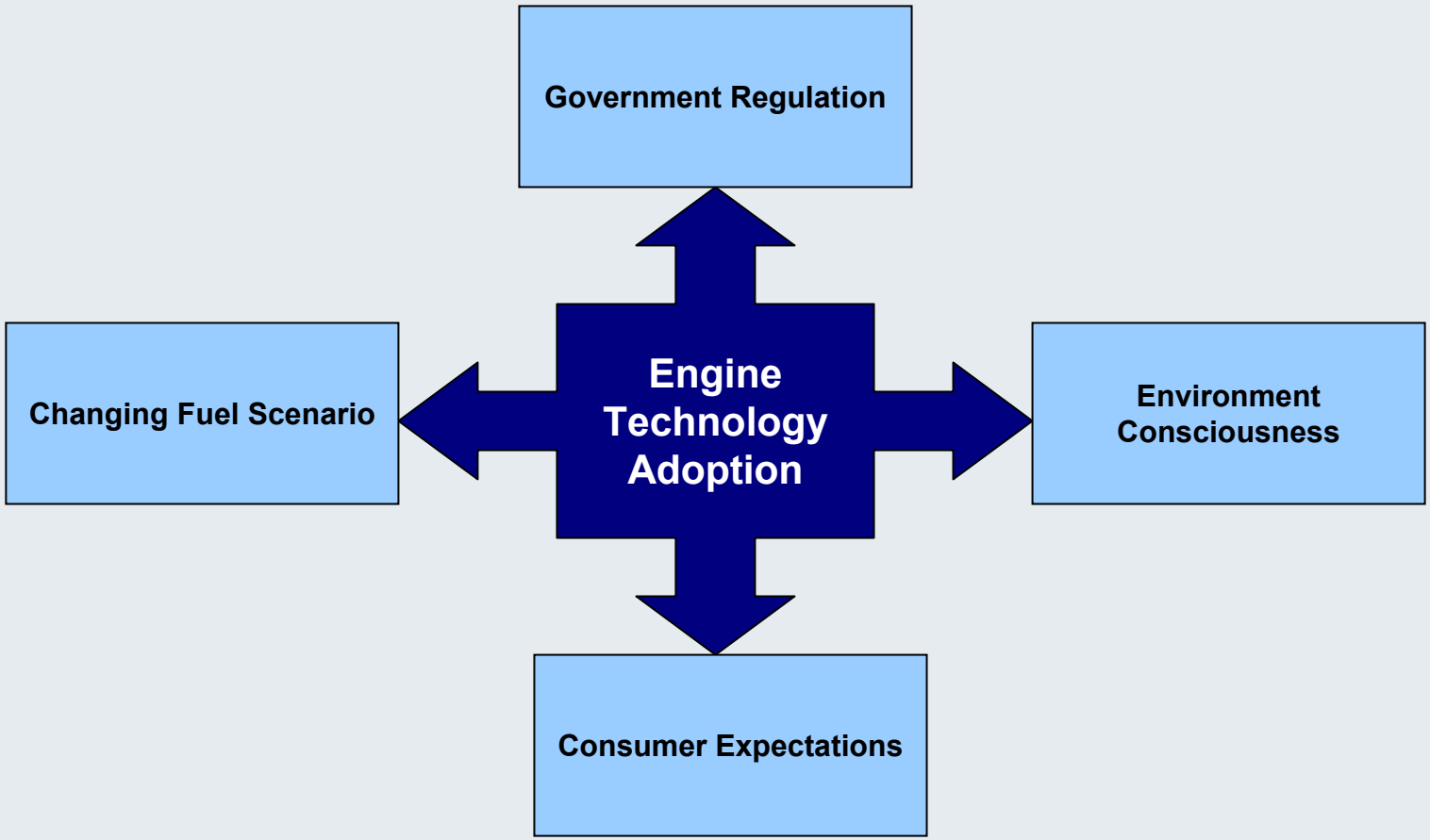
Focus Points of the Briefing

- Engine Technology – Drivers and Challenges
- Key developments in Industry.
- The View Forward.
- Conclusions.

Major Enablers of Engine Technology



Major Drivers of Engine Technology Trends



Major Challenges facing Engine Technologies

- Meeting emission regulations.
- While achieving high power outputs
- Fast Changing Market Preferences

Factors Changing Engine Technology

- Strict Emission Regulations
- Emergence of Biofuels
- Fuel Efficiency Awareness

Factors Changing Engine Technology

- Need for Fuel Economy
  1. Moving towards Displacement on Demand – Cylinder deactivation
  2. Higher level of electronic control on the power train.
  3. Moving toward mild hybrids might make sense for some auto manufacturers while others are exploring full hybrids.

Factors Changing Engine Technology

- Strict Emission Regulations
  1. Cheaper, longer lasting emission control systems.
  2. The industry is moving towards solutions like AdBlue that require direct customer involvement.
  3. Cleaner combustion technologies including techniques like HCCI are being investigated.

Homogeneous Charge Compression Ignition

- Combines the characteristics of both gasoline and diesel engines.
- Combustion initiates at several point automatically without any spark ignition as is common in gasoline engines.
- The lower peak temperatures result in very low NOx emissions but HC and CO are high.
- Provides diesel like efficiency with gasoline like emissions

Homogeneous Charge Compression Ignition

- Timing control in HCCI remains a major problem.
- Conventional engine designs with HCCI exhibit limited power range.
- A variety of approaches are being tried to overcome this though they are still in early stages.

Homogeneous Charge Compression Ignition

Frost and Sullivan's take on HCCI

- Will be extremely hard to implement in production units. Will match with requirements of hybrids though.
- Extra efficiency achieved will probably be negated by a variety of factors including a limited power range and heavier mass of the engine (to cope with higher peak pressures).
- Knock control needs to be foolproof or the engine can destroy itself in short order. This is true for all engines, but HCCI has a higher propensity to knocking if the control system should fail.

Factors Changing Engine Technology

- Biofuels
  1. As the chemical composition of fuels change, engines need to adapt.
  2. In addition to fuel injection hardware, the changes also include a redesign of combustion characteristics in most cases.
  3. There are however advantages in the new set of fuels – Biodiesel's natural lubricity solves the lubricity problem with ULSD.

The Critical Biofuels - Today

Ethanol

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Biodiesel

Why are biofuels relevant today?

- Biofuels can be used in normal internal combustion engines with a few modifications. This makes it easier to adapt to than, say, hydrogen fuel cells.
- Shifting to Ethanol requires electronic controls or software updates to gauge the fuel mixture. However, it is significantly cheaper than shifting to other fuels.
- Shifting to Biodiesel requires no modifications to the engines in small blends.
- Both can be mixed with conventional fuels in the same tank simplifying the logistics involved.

Why are biofuels relevant today?

- Current oil prices finally make it attractive to switch from petroleum to biofuels with no financial penalty.
- Public awareness of global warming and the need to be ecofriendly have made these carbon neutral fuels attractive.
- The final incentive is the fact that consumers can switch between petroleum and biofuels with ease.

The Critical Biofuels of Tomorrow

Biobutanol

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Algae

Biobutanol

- Biobutanol is the common term for Butyl Alcohol, which is next in the carbon chain after propanol.
- Primarily used as a solvent and an intermediate in chemical synthesis. Can be used as a fuel.
- Can be fermented from petroleum or biomass.
- Can be blended with gasoline.
- Can also be blended with ethanol to reduce its evaporative rate.

Biobutanol

- Biobutanol can be 100% substituted for gasoline without any changes. Some changes like optimizing the fuel injected would help efficiency, but no changes are *required.*
- Unlike Ethanol, it can use the existing gasoline pipeline infrastructure.
- Dupont and BP have announced in 2006 that they will produce biobutanol from sugar beets.

Algae

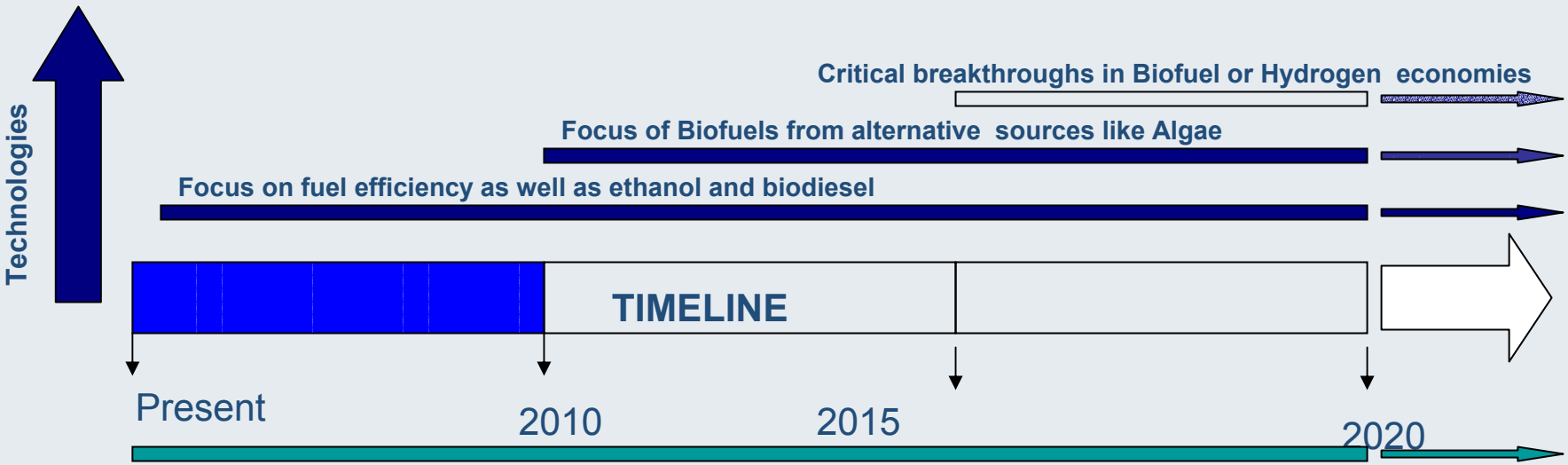
- Algae promises to be the fuel of the future.
- Existing biofuels do not have the capability to make a significant dent in our petroleum consumption.
- This is a factor of the number of hectares of land required to grow them.
- Algae, as a game changer, is significant because it produces a huge amount of fuel per acre.

Algae

- Yield per acre expected by agriculturalists:
  - Soya – 20 gallons.
  - Jatropha curcas – 202 gallons
  - Palm – 635 gallons
  - Algae – 10,000 to 15,000 gallons.

- Biomass from algae has been used to manufacture both ethanol and biodiesel

Technology Adoption Roadmap



Some Interesting Developments in Engine Tech

- Ethanol Boosting Systems, USA – Engine downsizing with Ethanol injection.
- Smartplugs Inc, USA – Spark Plug replacement that can combust ethanol water mixtures
- The Brazilian unit of Magnetti Marelli introduces an ECU that can handle any mixture of gasoline and ethanol completely in software without any additional sensor.
- Ohio State University – Microreactors for Biodiesel production.

The View Forward

- High oil prices are factor of supply-demand equations and security costs. Both are not about to go down significantly in the long term.
- As a result of high prices, there will be a continuous focus on
  - energy efficiency technology for existing drivetrains
  - alternate drivetrain technologies like electric and hybrid automobiles.
  - renewable fuels sources like ethanol and biodiesel.
  - and the hydrogen economy, though it remains more hype than hope.

The View Forward

- With farm subsidies being removed under WTO pressure, European farmers will embrace biofuels as an alternate source of income, boosting availability.

- Biofuel technology will improve as genetics and manufacturing economies enter the fray.

- In the short term, financial incentives in the form of tax concessions or fuel prices subsidies will enable entrepreneurs and corporations to establish the necessary infrastructure. Microreactors, still in the research stage, could change the economics completely when they do hit the market in the next five years.

The View Forward

- Engine advances will largely be technologies that can be quickly and cheaply brought into production. For manufacturers to choose a particular technology, the payback has to be quick and the technology needs to be sufficiently mature.

- Some areas to look for improvements will be better combustion engineering – though control remains a problem, lighter weight and higher reliability.

- Plug and Play technologies like the Smart Plug will be preferred to advanced technologies that might require a costly redesign of the whole engine.

CONCLUSIONS

Conclusions

- Remember the Wankel – Manufacturability matters.
- Historically, most of the big advances have come from individuals and small companies. It is quite possible that some of the biggest advances of tomorrow are totally off the radar today.

For Additional Information

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