Automotive Prime Movers: The future is **electric…**

From Detroit to Delhi, consumers and regulators are vociferously demanding vehicles that burn less fuel and pollute less. As manufacturers continue to evaluate multiple options to meet this demand, there is no clear solution in sight.

Arindam Chakrabarti, Madhura Sekhsaria and Anshul Ailawadi of Tata Strategic Management Group question the future of the IC engine as the electric motor emerges as the prime mover of choice.

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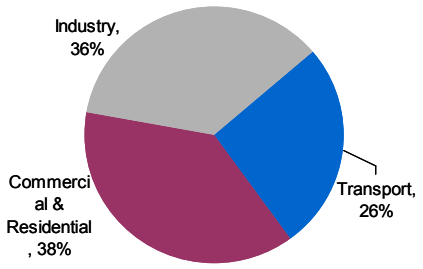
A crying need for greater energy efficiency in transportation sector

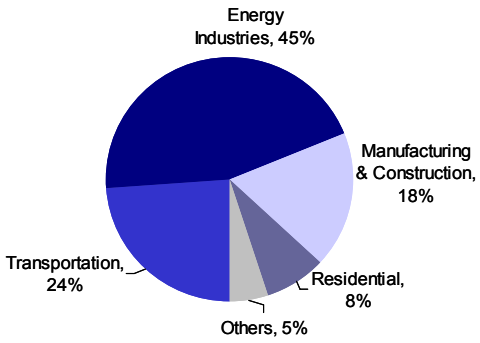
With crude prices hovering around USD 90~00/ barrel range, cars having greater fuel efficiency are becoming the rage. Declining SUVs sales in the US market bear ample testimony to customers' preference for fuel efficiency over power. Simultaneously, global warming indicators are forcing regulators in developed countries to contemplate increasingly stringent norms for CO_2 emissions. Jointly, these two factors threaten to disrupt the current prime mover technologies in automobiles.

CHART 1: Contribution of transport sector to energy consumption & CO_2 emissions

Share of Energy Consumption



Share of CO_2 Emissions



Source: Energy Information Administration, Integer

Challenges facing automobile manufacturers: The European Story

The advent of Euro V norms is expected to introduce the concept of "fleet average CO_2 emissions" for all automobile manufacturers. The key objective will be to reduce CO_2 emissions to 120 gm/km levels on a fleet average basis for all new registrations. While adherence to such norm is expected to be voluntary under Euro V, under Euro VI regime such violations will attract stiff financial penalties.

Currently, on an average, automobiles compliant with Euro IV emission norms emit 150~170 gm/km of CO_2. Lighter cars already meet the forthcoming norms, but for heavier cars having emissions upwards of 180 gm/km, there are serious concerns. This has made many marquee automobile manufacturers revisit their drawing boards. Investments are being made in exploring greener technologies that improve overall drive cycle efficiencies thereby reducing CO_2 emissions.

What is on the radar? An evaluation of emerging technologies

Currently prime mover research is largely focused around three major thrust areas:

Use of Blended Fuel: Fuel blends with bio-diesel and bio-ethanol can possibly satisfy upto a maximum of 10% of overall requirement and hence remain at best an interim

solution. Increased usage of bio-fuels appears to have limited potential owing to competition for arable land from food grains.

Alternate fuel/ feedstock: Already introduced dual fuel vehicles, notably CNG/LPG with petrol IC engine vehicles, reduce emissions and offer better economy to the user.

Future use of hydrogen from natural gas as a fuel in an IC engines can potentially eliminate concerns of "Tank-to-Wheel" emissions. However hydrogen extraction, distribution and storage present a major challenge to successful implementation. Moreover, costs related to carbon sequestering, as a by-product remain unanswered.

New prime mover technologies: The first and most potent supplement to IC engine has already made its appearance in the form of a rechargeable battery that augments operating efficiencies from 18~20% to 35~40% efficiency.

Hybrids as they are commonly referred to, incorporate batteries that are recharged by the IC engine or on recovery of energy during braking (regenerative braking) and drive electric motors.

The gradual evolution of hybrid variants from a "micro" hybrid to a "plug-in" hybrid reflects the increasing importance of the electric motor.

CHART 2: Evolution of hybrid vehicle technology

Type	Micro hybrid	Mild hybrid	Full hybrid	Plug-in hybrid
Feature	• Stop-start electric operation	• Electric operation during acceleration and braking	• Electric operation at low speeds	• Battery operated; charged through mains & IC
Example	Citröen C3	GM Saturn Vue	Toyota Prius	Chevrolet Volt
Main Drive	IC Engine	IC Engine	IC Engine	Electric Motor

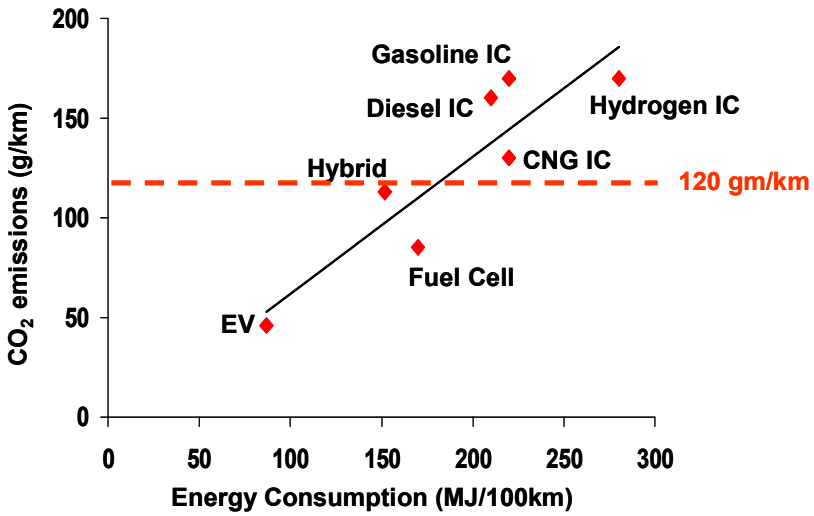
Increasing use of electric motor as a source of power

Comparison of various technologies

Vehicle technologies are increasingly being evaluated on energy efficiency and emission of CO_2 on a "Well to Wheel" basis. "Well to Wheels" analysis takes into account GHG emissions and energy use that arise from both fuel production pathways as well as power train efficiency.

Chart 3 below shows a comparison between various current and future technologies.

CHART 3: Plot of emission Vs energy consumption for major technologies



Note: 1.The results apply to compact passenger car applications

2.The analysis above assumes natural gas as a source for producing electricity for Electric Vehicles.

Source: European Commission, Joint Research Centre; Tesla Motors

From the chart above, it is evident that pure electric and fuel cell vehicles are far more efficient than conventional the IC engine and its derivatives. Hybrid, Fuel Cell and Electric vehicles can meet the stringent emission norms.

Challenges to commercialization

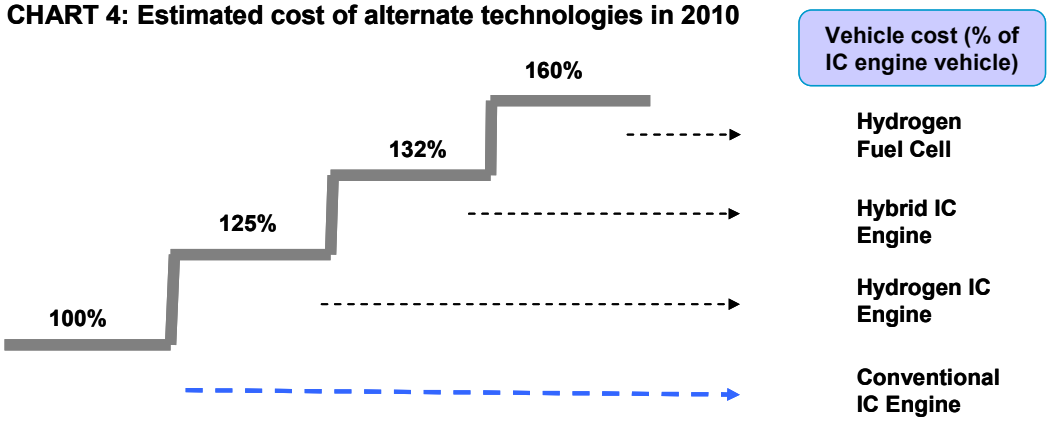
Whatever the technology pursued there is no denying that the switching costs are significant. High cost of batteries and their low energy stored to weight ratio pose challenges to commercial success of hybrid vehicles. In addition to limitations in battery technology, pure electric vehicles also face challenges associated with charging infrastructure.

In comparison, fuel cell vehicles using natural gas as a feedstock may not face significant distribution challenges in many countries. However, high cost of the fuel cell stack currently using metals such as platinum as a catalyst poses a major hurdle.

Chart 4 below draws a comparison of cost of production for various technologies. However, the following factors may eventually change the cost equation in favor of battery driven or fuel cell driven vehicles in the future:

- Cost of carbon if introduced for conventional fuel vehicles
- Cost reduction due to mass production for new technologies
- Advancements in battery and fuel cell technology

CHART 4: Estimated cost of alternate technologies in 2010



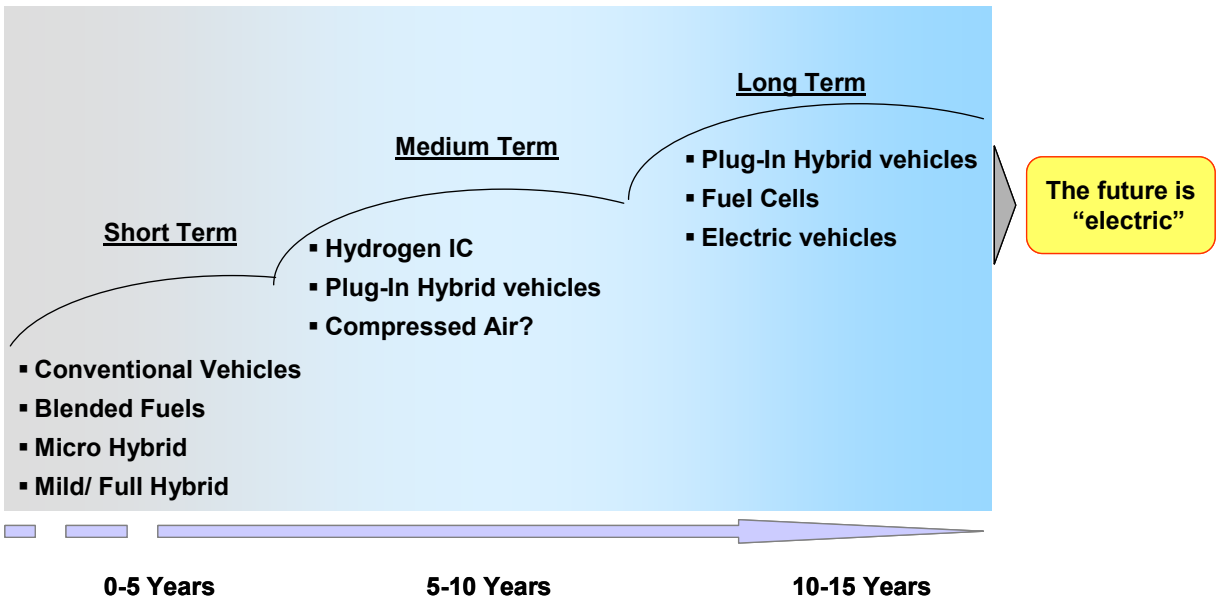
Note: 1. Production cost derived for annual production of 50,000 units
2. The analysis above refers to an M1 category vehicle
3. M1 category vehicle refers to vehicles used for carriage of passengers and comprising not more than 8 seats including driver's seat

Source: The Institute for Environment & Sustainability

Implications for the Automotive Industry

Given the complexities discussed above, Chart 5 indicates a possible evolutionary path for automotive prime mover technology in the coming years.

CHART 5: Evolution of prime mover technology



Irrespective of initial commercial challenges, the automotive industry is likely to witness an increasing use of electric motors as prime movers and batteries for storage of energy.

While fuel cells may replace batteries as the source of energy, the trend towards electric prime movers is unmistakable.

It is possible that compact cars may continue to use IC engines with alternate fuels and blends and meet CO_2 norms. However, larger cars and SUVs will have to switch to electric drives (“Plug In”, Fuel Cell or Electric Vehicle). As the share of electric vehicle grows, it will create its own challenges for players in the automotive component sector – OEMs, Component Suppliers and Down Stream Services.