CO2 REDUCTION AND AUTOMOTIVE TECHNOLOGIE: THE ROAD AHEAD

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ABSTRACT

CO_2 reduction in global road transport requires an integrated approach, involving the implementation of measures by automobile manufacturers, energy/fuel suppliers, governments, and vehicle users.
For auto manufacturers, the challenge is to increase fuel efficiency through the application of cutting-edge vehicle technologies. This presentation will examine the outlook for greater fuel efficiency in conventional as well as alternative-energy/next-generation vehicles.

1. CO_2 EMISSIONS IN ROAD TRANSPORT: A GLOBAL OVERVIEW AND THE CASE OF JAPAN

Global CO_2 emissions continue to increase. The transport sector's share of global CO_2 emissions, which is roughly 20%, is also increasing with the expansion of motorization worldwide.
The transport sector includes air, maritime, rail, and road transport, with road transport accounting for about 70% of the sector's total CO_2 emissions.
CO_2 reduction is essential to addressing climate change and countering the problem of global warming. Significant reductions in CO_2 emissions can only be achieved through the efforts of all the stakeholders involved.
Japan's road transport sector is a case in point. Road transport CO_2 emissions in Japan peaked in 2001 and have been declining steadily ever since.
The sector's target for 2010 was a reduction down to a maximum of 243 million tons of CO_2, as shown here. In fact, however, CO_2 emissions in Japan's transport sector totaled 229 million tons in 2009.

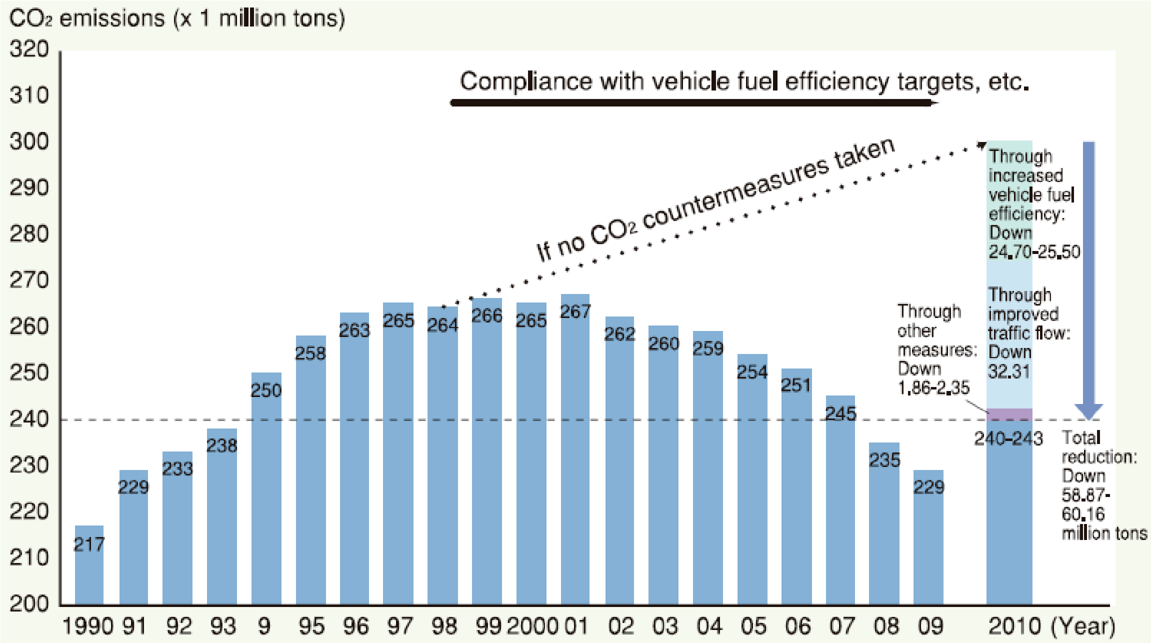

Figure 1 - CO_2 emission volumes in Japan's transport sector, 1990-2010 [1]

That reduction was achieved through the adoption of multiple measures including road congestion mitigation, ecodriving, and the use of alternative fuels, in addition to increased vehicle fuel efficiency.

2. OUTLINE OF THE INTEGRATED APPROACH TO CO2 EMISSION REDUCTION

To reduce CO_2 emission volumes in road transport, we must first understand how those volumes are generated.

As a rule, the volume of CO_2 emissions generated by human activity can be calculated by multiplying emissions intensity by the volume of activity. In the case of the road transport sector, "emissions intensity" is equivalent to automotive fuel consumption rates, or fuel efficiency performance, and "activity volume" is equivalent to the total distance travelled. More specifically, emissions intensity comprises the factors we see in the following formula.

CO_2 Emissions [2] ＝ Emissions Intensity X Activity Volume

＝ On-road fuel efficiency X CO_2 emissions coefficient X Total distance travelled

＝ Certified fuel efficiency $(km/l)^{-1}$ X Travelling coefficient

X CO_2 emissions coefficient（gCO_2/l）× Total distance travelled (v-km)

Fuel efficiency: Kilometers/liter are the units of measurement used in Japan.

Travelling coefficient: Ratio of on-road fuel efficiency and certified fuel efficiency

v-km: Vehicle-kilometers

“Certified fuel efficiency” is the official fuel consumption value for a given vehicle model, as measured by nationally-regulated test cycles. Improvements in certified fuel efficiency are achieved primarily through the application of new technologies by vehicle manufacturers. The “travelling coefficient” is the comparison between on-road fuel efficiency and certified fuel efficiency and is based on averages of all in-use vehicles. It can be reduced through road congestion mitigation and fuel-conserving ecodriving. The “CO_2 emissions coefficient” is the volume, in grams, of CO_2 emissions per one liter of fuel, and is lower in the case of biofuels. The “total distance travelled” can be reduced by shifting to other modes of transport.

Various factors, therefore, contribute to the generation of CO_2 emissions in the road transport sector. Those emissions can be successfully reduced by, as I mentioned earlier, adopting a range of measures in a comprehensive manner.

To put it another way, CO_2 reduction in road transport requires initiatives in the four areas shown here, and the cooperative efforts of automotive manufacturers, fuel and energy suppliers, governments, and vehicle users in implementing those initiatives. This is what is meant by the term “integrated approach.”

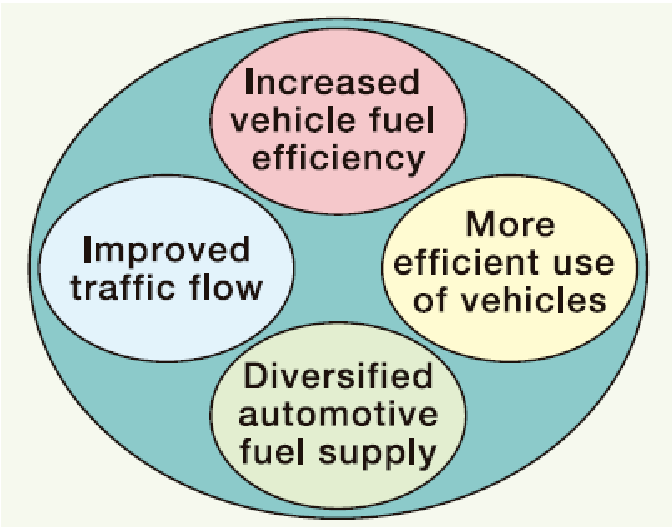

Figure 2 - The four areas of initiatives required under the integrated approach [1]

Let’s look at the specific measures involved in the integrated approach.

2.1 Measures to increase vehicle fuel efficiency

Maximizing the efficient use of fuel in vehicles while at the same time minimizing energy loss is a continuous challenge for automakers.

For passenger cars in particular, Japan’s automobile manufacturers rapidly achieved steady increases in fuel efficiency from the mid-1990s on. With the market introduction of next-generation conventional and alternative-energy vehicles in the years ahead, fuel efficiency in new vehicles is expected to improve even further.

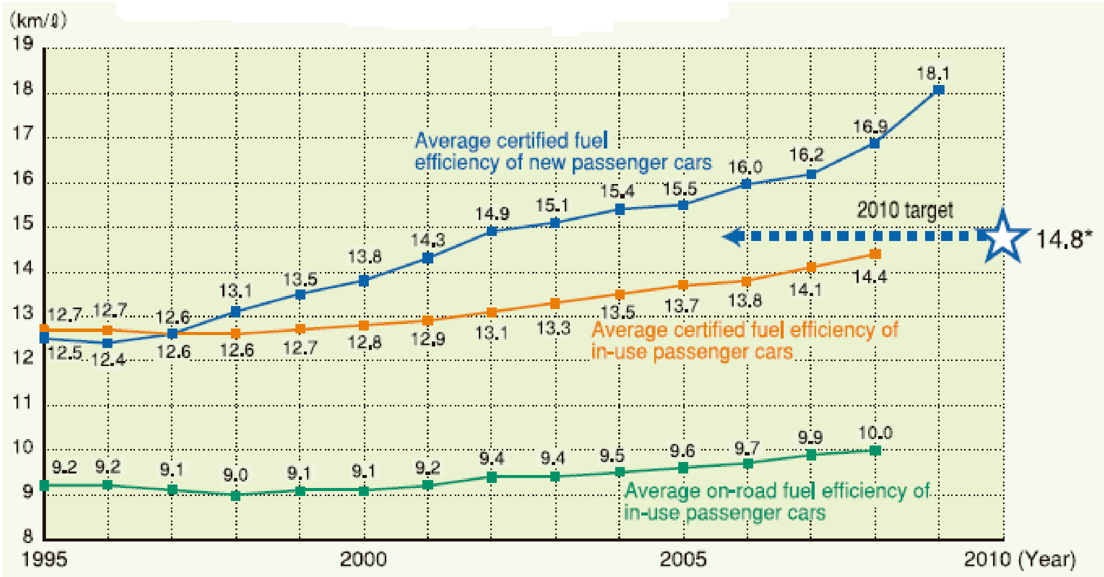

Figure 3 - Average fuel efficiency of gasoline-powered passenger cars in Japan, 1995-2010 [1]

To increase vehicle fuel efficiency, many new technologies have been introduced, including technologies for greater engine efficiency, for more efficient powertrains, for reduced aerodynamic drag, for reduced vehicle weight, and for reduced rolling resistance.

Technologies for greater engine efficiency include variable mechanisms such as variable valve timing, which helps reduce pumping loss. In-cylinder direct injection reduces fuel consumption by spraying fuel directly into each cylinder's combustion chamber. This is enhanced by high-pressure fuel injection enabling very fine atomization of the fuel particles, which in turn enables combustion at very high air-to-fuel ratios.

Technologies to improve powertrain performance include increasing the number of transmission gears and so-called continuously variable transmission, or CVT.

Reducing aerodynamic drag means improving vehicle body configuration to reduce its resistance to air flow.

Reducing vehicle weight, meanwhile, involves using more lightweight materials and improving body structure.

Additional fuel efficiency-enhancing technologies include idling prevention—also called "stop-start" technology—and hybrid technologies, which I will discuss later.

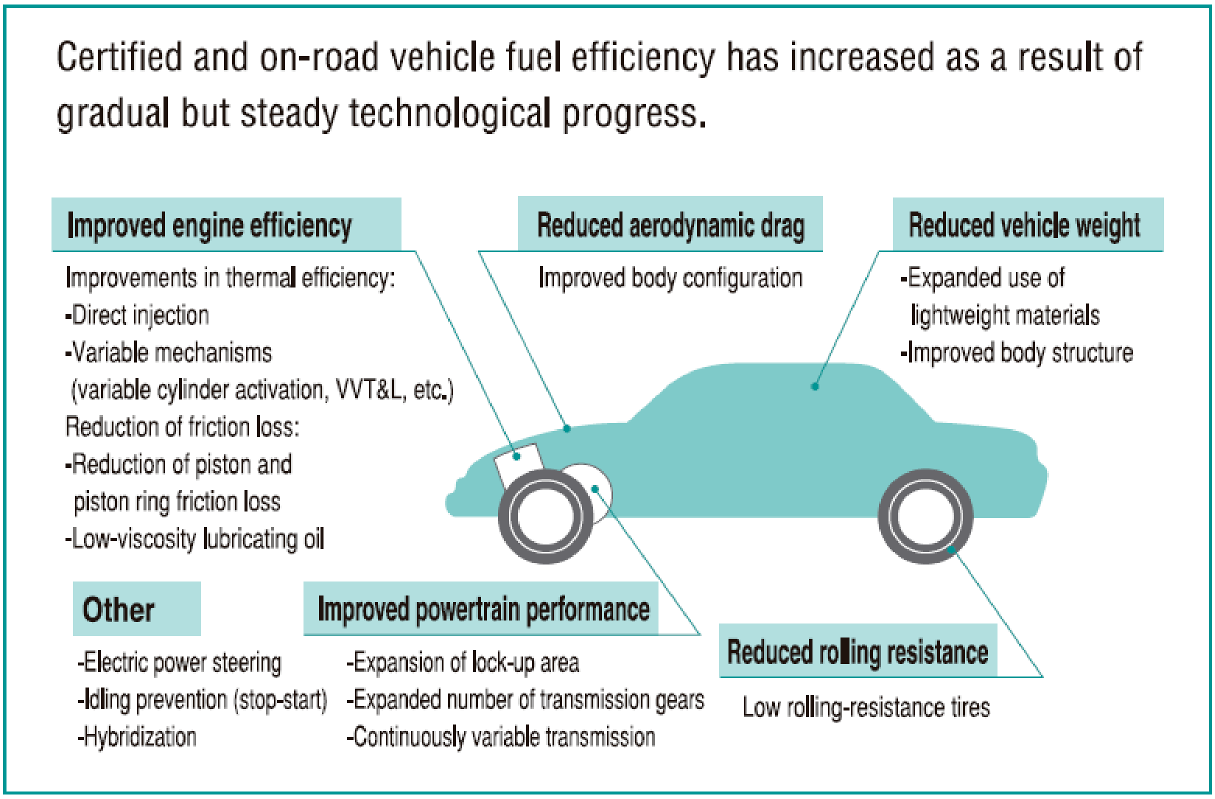

Figure 4 - Principal vehicle technologies for increased fuel efficiency [3]

2.2 Measures to diversify fuel/energy supply

Supplying the market with better-quality fuels is necessary in order to ensure the performance of highly fuel-efficient conventional gasoline and diesel vehicles with consequently lower CO_2 emissions. Also, the widespread use of low-carbon fuels, including biofuels, should be promoted in line with national requirements.

With respect to expanding the biofuel supply, the commercialization of cellulosic ethanol and BTL—or biomass-to-liquid—fuels, which have no adverse impacts on food supply and soil quality, will be crucial.

2.3 Measures to improve traffic flow (congestion mitigation)

The following graph shows the relation between average vehicle speed and CO_2 emissions. As indicated, the index of 100 for CO_2 emissions represents a vehicle speed of 40 kilometers per hour. Vehicles moving at low speeds have lower fuel efficiency and increased CO_2 emissions.

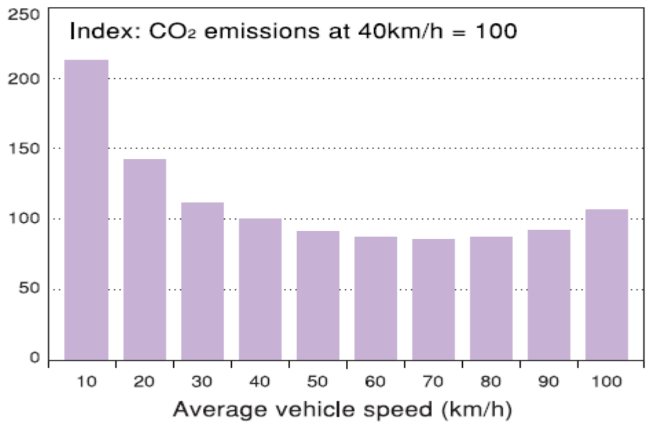

Figure 5 - The correlation between vehicle speed and CO_2 emissions [2]

CO_2 emission volumes can be reduced by alleviating road congestion, and thereby improving traffic flow, through road network and infrastructure upgrades, including the implementation of ITS, or Intelligent Transport Systems, technologies.

Individual countries should adopt road traffic-related measures that represent the most effective responses to local conditions, whether that be adopting advanced signal-control systems or introducing other congestion-mitigating solutions.

Improving traffic flow through road infrastructure development is an especially urgent priority in the major emerging economies, where motorization is expanding at a rapid pace. And in areas where large population influxes are expected, effective road congestion-mitigation measures, including road network development and ITS applications, should be integrated into urban planning initiatives from their earliest stage.

2.4 Measures to promote the more efficient use of vehicles

In addition to such measures as optimizing the efficiency of vehicle use in logistics, ecodriving helps reduce fuel consumption and CO_2 emissions, so drivers everywhere should be encouraged to practice it.

When adopted by truck fleet operators and their drivers, ecodriving also helps reduce operating costs. Ecodriving is facilitated by the use of onboard equipment such as fuel-efficiency gauges in the case of passenger cars, and digital tachographs in the case of trucks.

Figure 6 - Examples of onboard fuel-efficiency gauges [1]

3. ALTERNATIVE-ENERGY/NEXT-GENERATION VEHICLES: CURRENT STATUS OF USE IN JAPAN AND OUTLOOK FOR FUTURE USE

In addition to their development of new-generation conventional cars, trucks and buses with increased fuel efficiency, automakers are advancing the development of vehicles that run on alternative fuels and energy sources. These vehicles are pivotal to making low-carbon transport a reality, and will contribute very significantly to energy conservation and energy security in the future.

3.1 Profile of alternative-energy/next-generation vehicles

Clean diesel vehicles and hybrid vehicles are increasingly in use today. The years ahead will see the widespread use of plug-in hybrids and alternative-energy vehicles including electric, fuel-cell, and, eventually, hydrogen vehicles.

Here we see the range of alternative-energy/next-generation vehicles that are either already on the road or will become increasingly in use in the coming years.

Figure 7 - Alternative-energy/next generation vehicles [3]

3.2 Current status of alternative-energy/next-generation vehicle use in Japan

In Japan, the use of alternative-energy/next-generation vehicles, and particularly the use of hybrid vehicles, is steadily increasing. In 2009, the number of these vehicles on the road already exceeded one million. Although that represented only 1.4 % of Japan's total fleet, the use of these vehicles is expected to grow exponentially in the future, contributing to very important reductions in CO_2 emissions.

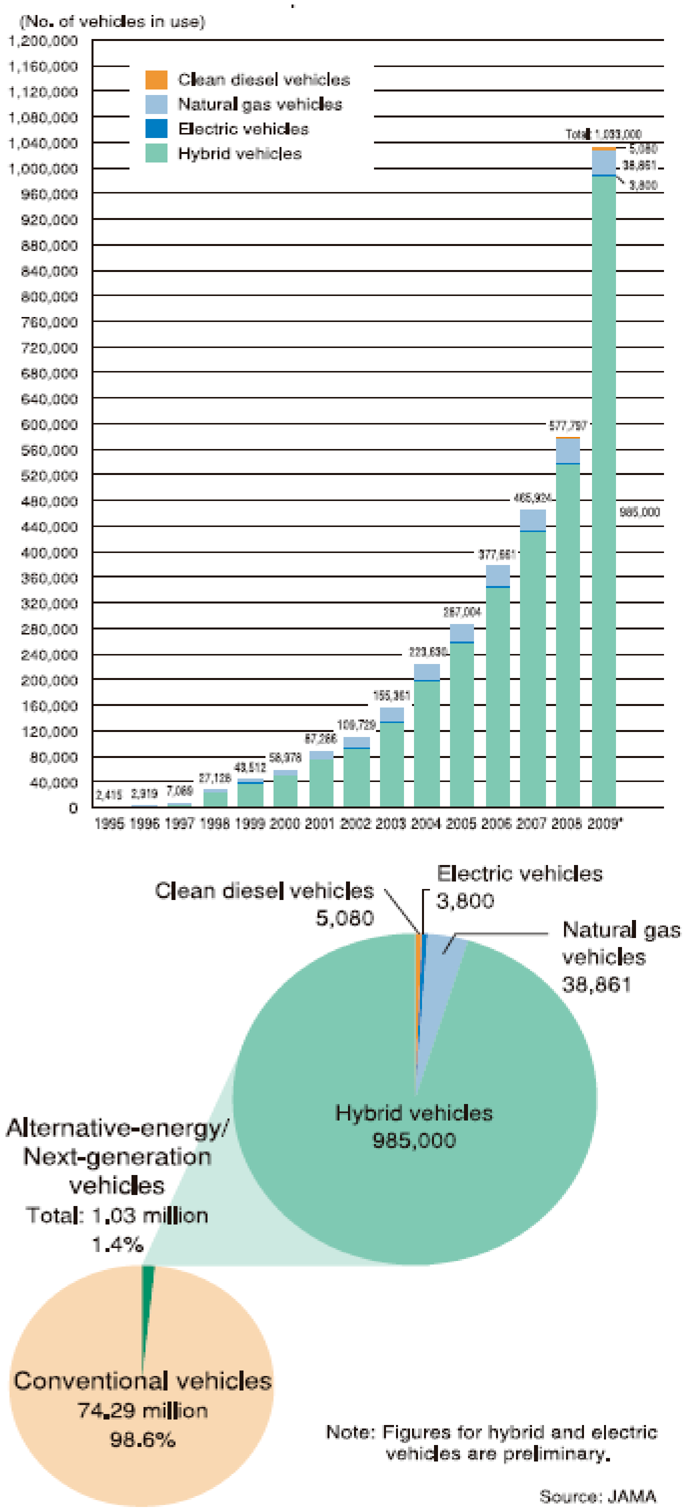

Figure 8 - Alternative-energy/next-generation vehicle use in Japan: Trends & status in 2009 [3]

Let's take a closer look at these vehicles and the challenges that must be met to enable their widespread use, with a particular focus on electric, including fuel-cell, vehicles.

3.3 Hybrid vehicles

Hybridization is a key technology for improving fuel efficiency. Hybrids are characterized by the combined use of an internal combustion engine and an electric motor, and also integrate regenerative-braking and idling-prevention technologies.

In 2009, there were almost one million hybrid vehicles in use in Japan. Most of these were passenger cars, but there are growing numbers of hybrid trucks and buses in use in Japan. With their proven environmental performance in terms of CO_2 reduction, these vehicles, and especially hybrid cars, are expected to be in widespread use in the near future, assuming that cost reductions can be achieved and battery performance improved.

3.4 Electric vehicles

Electric vehicles have in the past been introduced to the market on a number of occasions, but they never gained a significant share. Today they are increasingly in the spotlight, especially with the development of the lithium-ion battery. The major challenges for EVs are their driving range, cost, and durability which, notwithstanding the introduction of lithium-ion batteries, will ultimately be resolved only by new, breakthrough battery technology. The research required for such breakthrough technology should be undertaken on a collaborative basis by industry, government, and academia.

The development of a recharging infrastructure for EVs is also a core issue. In Japan, a first-of-its-kind demonstration called "EV/PHV Town," focusing on the infrastructure network with which these vehicles will interact, has been held by 18 local governments. Many similar demonstrations are scheduled to take place in other countries, and further initiatives promoting the practical introduction of electric vehicles will be forthcoming.

3.5 Plug-in hybrid vehicles

The primary characteristics of plug-in hybrid vehicles are, one, their use of batteries featuring external charging and, two, their extended EV-mode driving range. For long-distance driving, they operate as standard hybrids.

Their anticipated widespread use will help reduce CO_2 emissions and conventional fuel consumption in road transport. The major challenges in terms of achieving widespread PHV use are cost cuts and improved battery performance.

3.6 Fuel-cell vehicles

Assuming their eventual widespread use, fuel-cell vehicles, which are being developed independently by individual manufacturers, are expected to drastically reduce our dependence on fossil fuels, since they are powered by electricity generated onboard by an interaction of hydrogen and oxygen exclusively. Also, they produce no harmful exhaust gases whatsoever, emitting only water. Trial demonstrations of the use of FCVs are being conducted in Japan and abroad.

However, breakthrough technologies are needed in order to reduce FCV costs and improve their durability. Another major challenge is the development of the hydrogen-supply infrastructure necessary for their widespread use. Industry, government, and the academic sector should work in a concerted fashion on the research and development of the innovative technologies required. In addition, national policies for the supply of hydrogen will need to be formulated.

3.7 Related issues

Promoting the widespread use of electric and fuel-cell vehicles will, furthermore, require that advances be made in the following areas.

3.7.1 International standardization:

EVs and FCVs comprise parts and systems not used in conventional vehicles. To assure optimal efficiency in the delivery of energy or fuel to power these vehicles, standardization of the vehicle-energy delivery interface is therefore essential. International standardization will be instrumental in expanding the use of these vehicles worldwide.

3.7.2 Establishment of smart grids integrating information technology:

Smart grids that integrate electric power demand-and-supply with IT infrastructure will play a major role in boosting the use of electric vehicles. The smart-grid concept should therefore be actively promoted.

3.7.3 Infrastructure:

As explained earlier, recharging infrastructures must be established to encourage the widespread use of electric and fuel-cell vehicles. Promoting the development and integration of these fuel and energy-delivery infrastructures within the overall public infrastructure is also, therefore, an essential task.

4. SUMMARY

CO_2 reduction in road transport requires an integrated approach involving 1) initiatives in the four areas of increased fuel efficiency, fuel/energy diversification, improved traffic flow, and more efficient vehicle use, and 2) the efforts of automakers, fuel and energy suppliers, governments, and vehicle users in implementing those initiatives.

In addition to promoting the use of hybrid and plug-in hybrid vehicles, development of the breakthrough technologies required for the widespread use of electric and fuel-cell vehicles must be energetically pursued, on the basis of cooperative initiatives undertaken by industry, governments, and academia worldwide.

At the same time, the establishment of the necessary fuel-and-energy supply infrastructures enabling the widespread use of next-generation alternative-energy vehicles must be actively promoted, because there is a limit to the progress that can be made in further increasing fuel efficiency and reducing CO_2 emissions in conventional vehicles.

In the years to come, the Japanese automobile industry will continue to develop and introduce to the market vehicles that promote sustainable mobility.

Note: Except for Figure 5 (source: Japan Automobile Research Institute), all of the above charts, graphs and illustrations are JAMA-sourced.

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