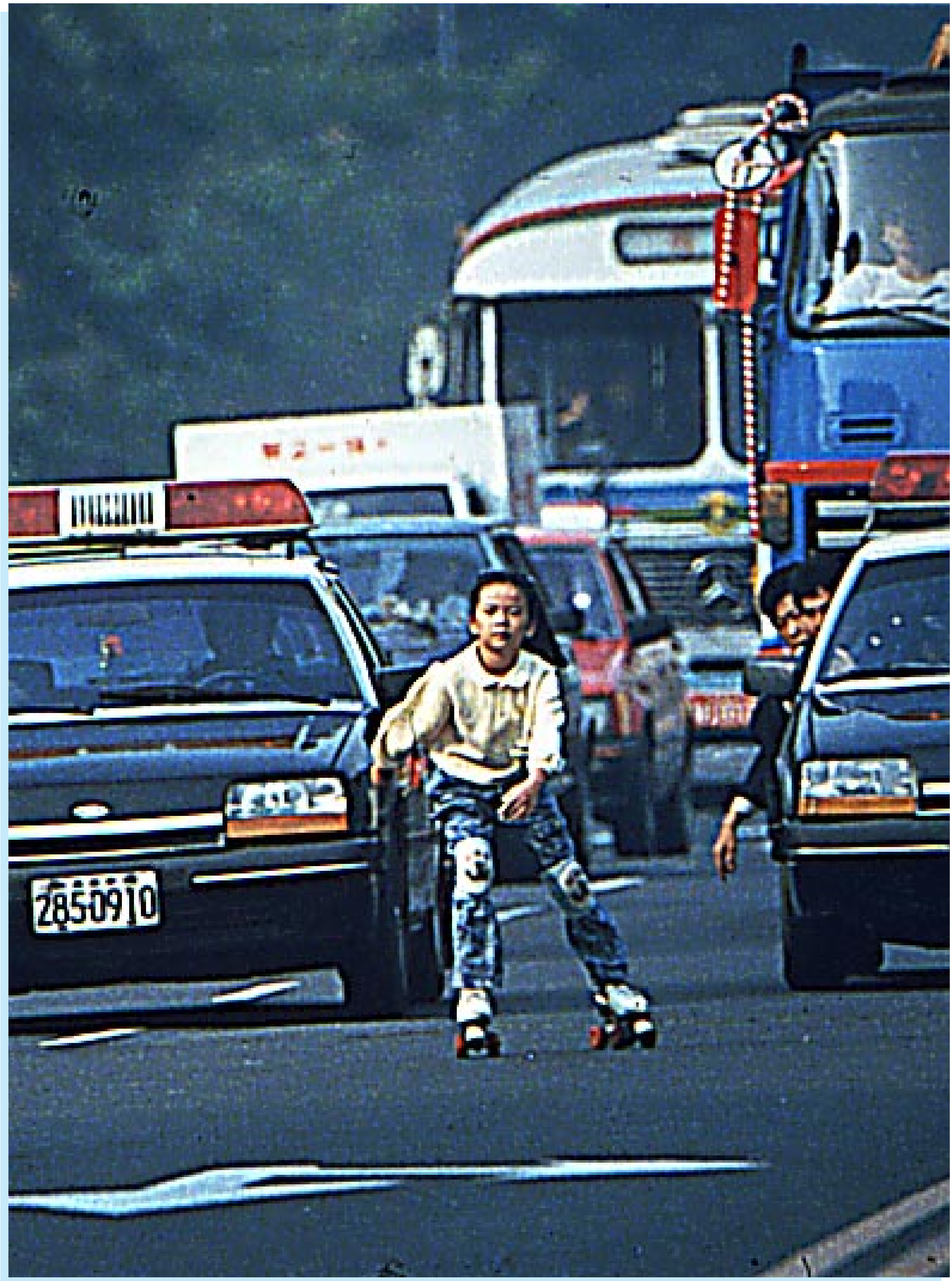

With 50 million new motor vehicles
entering the world market each year,
the total number of vehicles could
reach 1,000 million within 12-15 years.

ESTs for road transportation 11

With the number of road vehicles rapidly growing throughout the world, pollution from road transport has become one of the most urgent environmental problems facing policy makers today. The Organisation for Economic Co-operation and Development (OECD) has highlighted the key role of environmentally sound technologies (ESTs) in any "comprehensive emissions control strategy". They include technologies to improve fuel efficiency and reduce emissions from vehicles, as well as a range of alternative fuels and new kinds of vehicles, including electric cars.

There have been considerable technology improvements in the field of transport, and new cars today are roughly 90 per cent cleaner than they were 25 years ago. But clearly more needs to be done to produce lower-emission/lower-consumption vehicles, if only to keep pace with the rapidly increasing amount of traffic on the world's roads. More action is needed on several fronts: fuel efficiency, pollution controls and the development of alternatives to gasoline as a vehicle fuel. ESTs in the transport sector have an important role to play in meeting this challenge. They fall into three broad categories, addressing all three priority areas:

- catalytic converters and other devices that reduce or convert pollutants from gasoline and diesel engines into harmless or less harmful emissions;
- technology that reduces fuel consumption, so reducing the amount of pollutants from vehicles;
- more advanced technologies based on alternative non-polluting fuels, such as electricity, hydrogen and solar power.

ESTs in the first two groups are already on the market, but are still subject to intensive research and development to achieve further refinement. Other ESTs are still at the experimental stage.

Fuel efficiency technologies

Vehicle emissions can be reduced in two ways: by applying pollution control technologies to decrease them directly, or by improving fuel efficiency – less fuel in means less dirt out. A number of technologies is now available to achieve both objectives.

- Reducing vehicle body weight and aerodynamic drag lowers energy demands on the engine, thus cutting fuel consumption. Streamlined designs lead to fuel efficiency gains, while advanced polymer composites and other net-shape materials also reduce vehicle weight and lead to fuel efficiency improvements.
- A vehicle using a super or turbocharged high power density engine and combining electronic fuel injection and engine regulation with an electronically controlled continuously variable transmission system can achieve a high fuel efficiency, while offering high engine power.
- Smaller engines can reduce fuel consumption and, when designed in concert with turbochargers or other power-boosting technology, can compensate for the reduced power. Variable valve technology, which changes the number of valves in use per cylinder, can pull more power from a given engine, allowing downsizing. Oxygen

Bridas

A CLEAR VISION

Bridas Corporation is a growing international energy company with important assets in the energy sector in Argentina, South America, North America and Central Asia, certified reserves of 1,530 MM BOE (millions of barrels of oil equivalent) and uncertified reserves of 3,700 MM BOE – as well as a share in electricity generation and in the transport and distribution of hydrocarbons. Owning 5 trillion cubic feet of natural gas in South America and 20.5 trillion cubic feet in Central Asia, it is in a particularly strong position to meet those regions' future growth.

Bridas has been prompt in responding to global market trends. It has invested heavily in the Central Asian region and was one of the first western companies to set up in Turkmenistan. In 1997, it joined with Amoco to create a new company to exploit opportunities in the Latin American energy market. Pan American Energy is now the second largest company in Argentina.

Policies
Bridas fully supports the goal of sustainable development, and the United Nations Environment Programme's work. The company's aim is to reduce to zero all personal accidents, occupational illnesses and contamination of the environment, and to create a working environment which contributes to the well-being and professional and personal fulfilment of its staff.

It has introduced a Code of Conduct for Health, Safety and Environment, one of the pillars of its operational strategy, which reflects the company's conviction that improving safety practices and protecting the environment contribute to the well-being of the individual and the company, and to the sustainable development of the enterprise. Staff familiarization sessions are held frequently as part of the ongoing drive to reduce risks.

Bridas also has

- *Programmes for Total Quality and Continued Improvement and Re-engineering* of all its processes. The introduction of new technologies is a key element in the company's drive for continuous improvement.
- *A health, safety and environmental management system*, conforming to ISO 14000 and BS 8800 standards, and covering the entire organization.

Bridas operates gas fields and oilfields in very varied and fragile environmental areas and each must be treated in a different way. The company's strategy for protecting the environment in these areas is implemented through comprehensive programmes of remediation and prevention.

Prevention
The aim is to prevent negative environmental impact as far as possible.

Everything the company does in each field is monitored annually, and every new project is evaluated to assess its environmental consequences. The results of this monitoring process are used in developing an annual plan to improve safety, health and environmental performance throughout the company – and the plan is revised every three months. Each area has a management plan to treat residues in line with local characteristics, and to reduce residue levels through reuse, recuperation and recycling.

Remediation
Bridas has inherited a legacy of contaminated land from previous operators. To date, it has invested about US$12 million in remediation efforts – for example, cleaning more than 1,400 earthen pits containing oil and drilling fluids, and replanting some 500 pits. The company's objective is to reduce the amount of hydrocarbon parts per million to levels lower than the usual regulations require, so that by reconditioning the soil, it can be re-exploited.

Major improvements carried out in the oilfields of Keimir, Turkmenistan, include recovering about 20,000 cubic metres of crude oil and drilling mud deposited in earthen pits, and cleaning up numerous oil spills.

The company has also focused on improving the disposal of water produced and gas flared into the air. Today, 96 percent of all water produced is being re-injected in the reservoir, with the aim of re-injecting all of it by mid-1998. In an effort to reduce CO_2 emission, in accordance with the Rio Summit, vented or flared gas has been reduced to 0.4 percent of the total daily production.

Mission

Bridas believes that ongoing sustainable development should create a 'waterfall effect' in the environment. Therefore, it demands that all its contractors and suppliers conform to the requirements of its environmental management system – which improves their standards and quality of service, and encourages an exchange of know-how and best practice. This is a condition of doing business with Bridas.

Bridas also works closely with the local communities in which it operates – for example, organizing training courses and meetings, and producing a range of materials for local authorities and schools, to raise awareness of environmental conservation issues. It has planted trees and lawns in the Patagonia region, in Argentina and in Turkmenistan where – in a desert-like climate – natural re-vegetation is difficult.

Bridas and its employees have a clear vision and mission. They believe that the world energy industry will only ever be competitive if, in its strategies for continued economic growth, it also includes the preservation and upkeep of natural resources – so that in meeting the needs of today's generations, it also safeguards the needs of future ones. The company is determined to play its part in achieving this goal.

Lindero Atravesado Field, Marimenuco Lake, Neuquén

San Sebastián Plant, Tierra del Fuego

Gas Treatment Plant, Luján de Cuyo, Mendoza

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BOX 11.1

The biggest challenge

According to the Organisation for Economic Co-operation and Development (OECD) and the International Energy Agency (IEA), transportation – especially road transport – "presents perhaps the biggest challenge of any energy end-use sector" for reducing air pollution. Two statistics show why:

- there are between 500 and 700 million motor vehicles on the world's roads, and with 50 million new vehicles put on the market each year, the number could reach 1,000 million within 12-15 years;
- during its lifetime, an average car travels 160,000 kilometres, uses more than 11,500 litres of gasoline and over 200 litres of oil, and discharges more than 35 tonnes of pollutants.

With the world's car fleet alone producing 10 trillion cubic metres of exhaust fumes every year, motor vehicles, not industry, have become the single biggest source of emissions of several key pollutants, among them carbon monoxide, nitrogen oxides and toxic volatile organic compounds, as well as the major cause of the world's worsening air pollution problem, particularly in urban areas. In addition, road vehicles are a major contributor of non-natural carbon dioxide emissions, accounting for about 30 per cent of carbon dioxide emissions from oil use, and around 15 per cent of worldwide carbon dioxide emissions from all fossil fuel use, including coal burning.

It is little wonder, therefore, that the vehicle industry has been identified by both legislators and environmental groups as a prime target, with the result that making vehicles 'cleaner' through technology improvements has leaped to the top of the industry's agenda.

separation is another technology for reducing engine size without power loss.

- Two-stroke engines are being intensively developed by engine manufacturers and could enter the market on a large scale around 2005. Two-strokes have a higher power output and torque per unit of engine displacement than conventional four-stroke engines, which means the engine can be smaller, with lower friction and lower heat losses to the engine coolant, so improving fuel economy. However, a distinct disadvantage of two-strokes is that they emit high levels of hydrocarbons and smoke.
- Considerable effort is being devoted to developing low-heat rejection or adiabatic diesel engines. The use of these engines eliminates the engine cooling system, with its power losses and reliability problems. They could also improve fuel efficiency by using turbocompounding techniques to harness the increased energy of exhaust gases from the uncooled engine.
- Lean-burn combustion has been explored, both for fuel efficiency and as a nitrogen oxide reduction strategy. In a lean-burn engine, combustion occurs in the presence of large amounts of excess air, and the increase in air-to-fuel ratio improves fuel combustion and efficiency. However, at high speeds, or with heavy loads, the exhaust gas contains too much oxygen for the currently available three-way catalyst to control nitrogen oxide emissions, and these rise sharply – a factor which is likely to limit lean-burn technology to smaller engine vehicles. However, one Japanese car producer has developed a lean-burn engine which it says cuts nitrogen oxide emissions by 90 per cent.
- Direct fuel injection used to have a poor emissions performance. But recent advances in emission control technology have improved this, and vehicles using direct fuel injection can show fuel efficiency improvements of up to 10 per cent over similar indirect-injected engines. Electronic fuel-injection control boosts performance further.

The Organisation for Economic Co-operation and Development (OECD) has pointed out that while there was a flurry of developmental activity into increasing vehicle fuel efficiency in the wake of the 1970s' oil crisis, interest slumped when oil prices fell in the 1980s. The result has been that "many of the potential improvements in efficiency that could have been accomplished over the last ten years have been left unrealized". But it is confident that various state-of-the-art fuel-efficiency technologies, either in production, production-ready or prototype-tested, can achieve "very substantial" benefits. One study predicts that combinations of these different technical options could achieve an average fuel-efficiency improvement of up to 55 per cent for cars, compared to 1986 vehicles.

Technologies to reduce emissions

Technologies aimed at reducing emissions include those discussed below.

- In-engine emission controls, many of which also improve fuel economy, include advanced air/fuel management systems such as fuel injection, electronic control of spark timing, advanced choke systems and improved transmissions. These can also improve combustion conditions, reducing exhaust emissions further.
- Exhaust gas after-treatment techniques, such as catalysts, have long been in use in the United States but are relatively new in Europe and elsewhere. Catalytic converters, containing platinum compounds or other materials, are fitted upstream of the exhaust pipe to minimize the emission of carbon monoxide, nitrogen oxides and unburned hydrocarbons. Industry experts predict that such emission control technology will continue to improve, notably catalysts which can work with variable specification fuels, sensors, fuel injection and engine controls.

But these improvements will not come cheaply. The World Bank estimates that using catalytic converters may raise costs by 4 US cents a litre. For diesel vehicles, recently developed devices for removing particulates (the largest pollutant), nitrogen oxides and sulphur have similar costs. The World Bank calculates that the cost of phasing in cleaner fuels and emission controls over 20 years would rise to US$10 billion a year (0.2 per cent of world gross domestic product (GDP)) by 2000, and US$35 billion a year (0.5 per cent of world GDP) by 2010. However, even using the most advanced emission control technologies, available now or in the foreseeable future, gasoline-fuelled vehicles will still be substantial contributors to air pollution. It is therefore necessary to improve the quality of gasoline in order to cut emissions this way.

Currently oil companies are investing billions of dollars in trying to produce lower-emission gasoline. For example, the commercialization of unleaded gasoline (where the lead oxide originally added to improve engine performance is removed) was a significant technological change in fuel. The use of unleaded fuel in conjunction with catalytic converters represents an important modification from the standpoint of emissions control.

Reformulated gasoline reduces the amount of problematic chemicals. A Finnish company has launched a new kind of gasoline, containing a higher degree of oxygen and fewer aromatic compounds, which it says cuts vehicle emissions by up to 20 per cent. Although emission control technologies help address tailpipe pollution problems, the real environmental gains are likely to come from switching from gasoline to alternative fuels, or to other energy options altogether.

BOX 11.2

Better traffic management vital too

Solving the problem of pollution from road vehicles will require more than technical improvements to the vehicles themselves.

An Organisation for Economic Co-operation and Development (OECD) study in eight countries has found that technologies will achieve about a third of the required improvements, while the rest will come from demand-side management and "cultural behaviour changes".

Increasing attention is being paid to logistics technologies to manage the movement of vehicles, in the expectation that these could achieve considerable benefits at less cost, especially in the freight sector.

Alternative carbon-based fuels

Methanol, produced from natural gas, crude oil, coal, wood biomass and organic wastes, promises two air quality benefits over gasoline: lower ozone-forming potential, and minimal emissions of benzene and other polycyclic aromatic hydrocarbons. In addition, pure methanol produces only small amounts of sulphur oxides. The area of concern with methanol vehicles is the emission of formaldehyde, which is toxic and probably carcinogenic, although the United States Environmental Protection Agency (EPA) says any increased cancer risks from formaldehyde emissions would be more than offset by the big reduction in cancer risk from the decrease in buta-1,3–diene emissions produced when gasoline is burnt.

Methanol is being encouraged for use in some heavily polluted areas in the United States (particularly the Los Angeles basin) and Scandinavia, where it can be produced as a ‘renewable’ fuel from biomass. There has also been a push in the United States to introduce methanol in flexible-fuel vehicles burning methanol-gasoline blends, and one United States automotive manufacturer has developed a variable fuel engine car that runs on both methanol and gasoline.

Ethanol, which is similar to methanol, but much cleaner and less toxic, can be produced by processing agricultural crops such as sugar cane or corn. However, it is more expensive to produce and needs large crop harvests and large amounts of energy in its production. It also produces higher nitrogen oxide emissions than methanol, though still considerably lower than those from diesel engines. Ethanol has a high octane quality, which is why it has been used mainly in blends with gasoline, notably in Brazil and the United States.

Although about 90 per cent of cars made in Brazil in the past ten years use ethanol as a fuel, the government has cut subsidies for sugar cane ethanol. This has pushed up fuel prices, with the result that the fleet has shrunk from 4.5 to 4.2 million. However, the government says it is committed to supporting the alcohol fuel programme by, for example, maintaining a 22 per cent minimum alcohol content in gasoline. It is also looking at ways to promote a ‘green fleet’ in the country by encouraging buses, taxis and other urban public vehicles to switch to fuel with a higher alcohol content.

Gasohol (nine parts gasoline, one part ethanol) accounted for about 6 per cent of United States vehicle fuel consumption in 1991. Ethanol blended with gasoline contributes to the formation of photochemical smog, and can also produce many more times acetaldehyde than gasoline vehicles, though the cancer risk associated with acetaldehyde is much lower than that of buta-1,3–diene.

Producing ethanol from corn requires large amounts of land: in the United States, to fuel a typical car for a year on pure ethanol would take nine times the amount of cropland needed to feed the average citizen. Moreover, growing crops year after year causes serious soil erosion. However, in June 1994, the EPA decided to give special preference to ethanol over methanol-based fuel, by announcing that 30 per cent of the additives used in its new cleaner burning gasoline programme must come from a renewable source. The United States has an ethanol programme, based on maize, of about 2 million tonnes a year, but the high production cost has required considerable government support. In September 1992, the government boosted the programme by allowing ethanol to be used in reformulating gasoline in nine of the most heavily smog-afflicted United States cities, starting in 1995. Government subsidies would make ethanol cost-competitive with methanol (unsubsidized ethanol sells for three times more).

Vegetable oils, produced from processing rapeseed, sunflower seeds, coconuts or soya beans can be used as blends with diesel fuels.

However, there are environmental problems associated with their use. The German Environmental Protection Agency found that large emissions of nitrogen dioxide during the production cycle was a major disadvantage. In addition, as with ethanol, there are soil protection issues to address. Moreover, growing crops specifically for biomass energy and dedicated energy feedstock plantations means large commitments of land and resources to make this a realistic alternative.

However, even with these limitations, between 20,000 and 30,000 tonnes of biodiesel were produced in Germany in 1994, constituting a small but steadily growing share of the overall amount of diesel fuel used there (about 20 million tonnes annually). The federal government has exempted biodiesel from fuel tax to make it more attractive to consumers, and there has been a steady increase in the number of service stations selling biodiesel. One study calculates that biodiesel production in Germany could reach 2 million tonnes a year by 2010. A report by Germany's federal and state agriculture ministers in August 1994 found that, compared to normal diesel, biodiesel reduces carbon dioxide emissions by up to 65 per cent, produces less soot, carbon monoxide and non-combusted hydrocarbons, and is biodegradable. However, the World Resources Institute (WRI) contends that, in many parts of the world, growing energy crops for motor vehicles could compete with food production at a time when climate change could put a strain on agricultural production.

Gas-powered vehicles

Natural gas can be used as a motor vehicle fuel, either compressed in cylinders as compressed natural gas, or as liquefied natural gas. This latter form, however, is rarely considered because it is more expensive and more difficult to handle. Between three-quarters of a million and a million vehicles worldwide, mainly in Argentina, Canada, Italy, New Zealand and the former Soviet Union, use compressed natural gas, emitting much less carbon dioxide and carbon monoxide than gasoline or methanol vehicles; similar or possibly higher levels of nitrogen oxides; and virtually no benzene, smoke or sulphur oxides.

The authorities in Mexico City, faced with the worst air quality in the world, have ordered 1,000 taxis to be converted to natural gas, based on studies which show that they would emit 96 per cent less pollution than conventional vehicles. Two major barriers keep gas-powered vehicles off the road: the need for bulky gas storage tanks, especially in cars, and the absence of a network of refuelling stations. These problems of distribution and limited vehicle range, together with possible leakage of methane during transport, distribution and use, still have to be overcome before such vehicles can be used on a large scale. However, there is growing support for gas-powered vehicles in a number of countries, including the United States, where one foreign car manufacturer estimates that they will represent 5 per cent of its sales in the next five years. In Japan, local authorities are using gas-powered vehicles for collecting rubbish and on local bus routes, and the government aims to put 600 refuelling stations in place by the year 2000 to encourage the number of vehicles to climb to 200,000.

Liquefied petroleum gas, a mixture of mainly butane and propane produced as a by-product from crude oil refining and natural gas processing, is the most widely available of the alternative fuels. Currently it is being used by an estimated 4 million vehicles found predominantly in Australia, Canada, Italy, the Netherlands, New Zealand and the United States, as well as in Asia, which accounts for around a third of world use. Australia, Canada, France, Italy, Japan and the Netherlands favour the fuel with subsidies and/or lower rates of duty.

Liquefied petroleum gas allows the use of

GREEN OASIS: AT THE *LEADING* EDGE OF WASTE OIL RECOVERY AND REUSE

Green Oasis Environmental Inc. is a new and rapidly developing, socially conscious organization. Its proprietary process for converting used motor oil into a clean diesel fuel that is environment friendly does its share towards helping to solve many of our world's pollution problems.

Waste automotive and industrial oils amount to 5.2 billion gallons a year globally. The pollution generated by the indiscriminate dumping of some of this oil is further complicated by its only present use of being consumed as poor quality burner fuel. Such fuels require costly technology to clean their emissions to an acceptable level. Often that never happens, either through unavailability of this technology or the significant cost associated with its use.

Green Oasis has combined a solution to this problem with an economic incentive to the individuals or companies that wish to invest in their own future. The Green Oasis process permits the utilization of what is currently an undesirable waste item, turning it into a valuable and saleable product. Because of this important economic factor, Green Oasis has named its processor and process the 'EnviroEconomics System'.

The EnviroEconomics plant uses a one-step method of distillation and thermal cracking by applying process heat in an oxygen-free environment. Each 100 gallons of waste oil processed yields approximately 70 gallons of #2 diesel fuel and 20 gallons of high heat #5 fuel oil. The remaining ten gallons generate 'light ends' that are recaptured to fuel the conversion process. The plant is compact in size and can be operated by one person. Its computer controlled operating system offers the greatest in flexibility and minimizes the skill level requirements for its operators.

The EnviroEconomics process is now attracting considerable international attention. The company is also expanding rapidly within the United States.

The operation of the processor has recently been verified with both local and national environmental agencies as a non-polluting entity in itself.

The EnviroEconomics technology has put Green Oasis at the leading edge of the waste oil industry, and firmly in the forefront of efforts both in the United States and other countries, to mitigate a real environmental issue.

Detailed information on both the company and its processor can be obtained by contacting P. Woessner at < grno@awod.com > or by fax on 1-803-722-5785.

lean-burn calibrations, which increase efficiency and reduce emissions. It produces fewer non-carbon dioxide greenhouse gases during combustion and, when used in spark-ignition engines, it produces virtually zero emissions of particulate matter, very little carbon monoxide and moderate hydrocarbon emissions. However, its supply and availability are linked directly to crude oil and natural gas production which will limit its potential as a substitute for conventional fuels. A recurring problem is the lack of existing refuelling infrastructure. Liquefied petroleum gas is probably best suited as a special fuel for vehicles such as urban buses and delivery trucks operating in pollution-sensitive areas.

Do they work?

The use of alternative fuels is generally promoted to reduce oil dependency and local air pollution. If it can be established that they also contribute to reducing global greenhouse gas emissions, this would be an important additional argument in their favour. The evidence on this is contradictory. A 1993 study by the International Energy Agency (IEA) found that it is technically possible to reduce greenhouse gas emissions by up to 80 per cent by using alternative fuels. The problem is that this technical potential is unlikely to be achieved in the short term. Moreover, most of the fuels (except liquefied petroleum gas and compressed natural gas, as well as diesel) are likely to be more expensive than gasoline to produce for the next 20 years. However, the IEA also found that cars using liquefied petroleum gas, compressed natural gas or diesel can have life-cycle greenhouse gas emissions 10-30 per cent lower than those from gasoline-powered cars. A 1996 report by AEA Technology for the United Kingdom government similarly said that liquefied petroleum gas offers some emissions benefits, mainly for nitrogen oxides, hydrocarbons and particulates; compressed natural gas brings substantial reductions in most pollutants; while alternative alcohol-based fuels have low net carbon dioxide emissions, although other emissions are similar to conventional fuels.

However, other studies take a different position. The WRI accepts that methanol and ethanol blends for gasoline could reduce carbon monoxide emissions, but says they would not necessarily slow global warming, while switching to compressed natural gas would only do so slightly. “For reducing carbon dioxide emissions, alternatives based on fossil fuels are not the answer. Using biomass as a feedstock for alcohol production would help, but is it feasible and practicable to produce large amounts of carbon-based fuels this way on a sustainable basis?”

Cheaper to use?

The IEA study produced another interesting finding: that cars run on liquefied petroleum gas, compressed natural gas or diesel may be cheaper to use for some drivers. The agency calculated driving costs in France and the United States. In the United States it worked out that, while few drivers would find diesel-powered cars cheaper to run than gasoline-powered cars, cars run on compressed natural gas are likely to have lower costs for the average driver, compared with conventional gasoline. But they are also likely to be confined to niche markets for the foreseeable future. One reason for this is cost. Currently in France, for example, using a car powered by compressed natural gas is likely to be more expensive than using a gasoline-powered car.

On financial grounds alone, the IEA concluded that the economic potential for cars powered by compressed natural gas is large in both France and the United States. But their reduced range, long filling time and the lack of compressed natural gas refuelling stations impedes their use. If the problem of reduced range were addressed through increasing fuel storage capacity, the cost of cars powered by compressed natural gas would be likely to rise to a point where they became more expensive than gasoline-powered cars because their fuel tanks would have to be so large.

Zero-emission vehicles

If the various alternative carbon-based fuels have too many drawbacks to be ideal options for replacing gasoline, what are the alternatives? Zero-emission vehicles, either hydrogen-powered vehicles or battery-driven electric vehicles (or a combination of the two), are generating considerable interest and excitement.

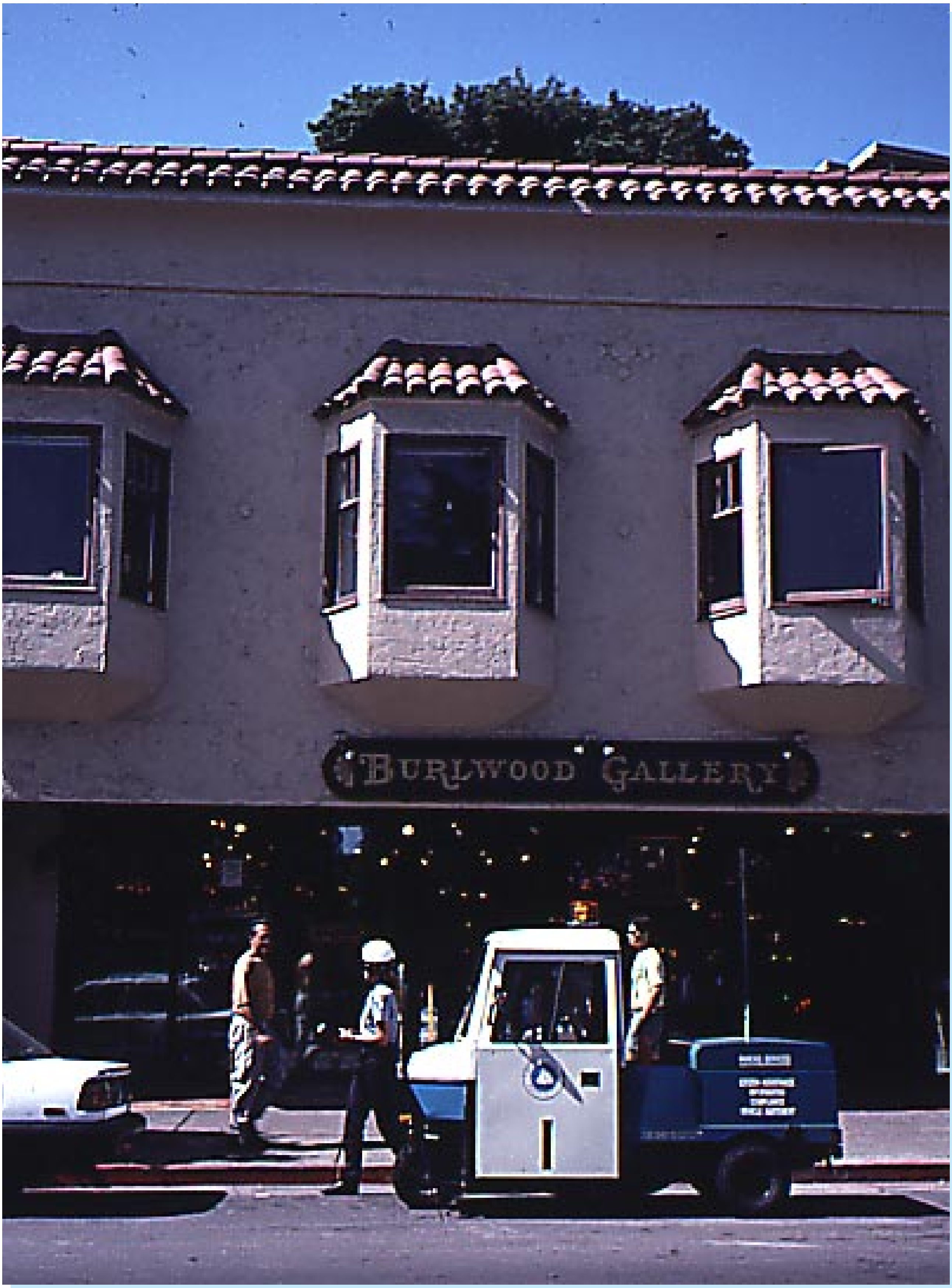
Hydrogen is attractive as an alternative fuel because, aside from nitrogen oxide emissions, it is virtually non-polluting, containing no carbon, sulphur or other polluting materials. Using hydrogen in a fuel cell, rather than an internal combustion engine, would also practically eliminate nitrogen oxide emissions. Storage, however, is a problem, and safety concerns will have to be addressed before winning public acceptance. Hydrogen engines also need to be larger to compensate for the fuel's low energy density. Another issue is that although hydrogen itself does not cause much pollution or contribute to global warming, its manufacture does. The gas is produced commercially by electrolysis, which uses considerable energy and which, in effect, shifts the pollution from the tailpipe to the smokestack.

Germany, Japan and the United States all have research and development programmes on hydrogen-powered vehicles, and the Musashi Institute of Technology in Japan has developed a number of vehicles, including a small car with a two-stroke engine, running on liquid hydrogen. In addition, several leading car manufacturers are currently testing hydrogen vehicles. One Japanese car company is developing a hydrogen-powered car, which emits only steam as exhaust, by converting the rotary gasoline engine to run on hydrogen, while a German car maker has hydrogen-powered versions of many of its larger cars, using cryogenic (very low temperature) storage. The introduction of hydrogen into vehicles may follow its use for power generation, but unless regulations are introduced compelling zero-emission vehicles in certain areas, the cost of hydrogen will probably keep it away from the market in the short term.

Electric vehicles

In the early years of the century, there were more electric-driven cars on the roads than gasoline ones. There is now a revival of interest in electric vehicles, spurred in no small measure by California's legislation on zero-emission vehicles (see Chapter 5). Their supporters say they would reduce urban pollution and greenhouse gas emissions significantly over the coming decade. They could also lay the foundations for a pollution-free transport system, although this would only be the case if the electricity they need is itself originally generated without producing pollution – otherwise the pollution is merely transferred back a stage. But electric vehicles have some distinct disadvantages: their range is extremely limited and they can take up to six hours to recharge, but the major constraint to their development has been the lack of a light, compact, durable low-cost battery.

Electric vehicles currently on the market rely on off-the-shelf, lead-acid batteries, charged from a standard wall plug. Alternatives include nickel-cadmium, nickel-iron, sodium-sulphur, sodium-nickel-chloride, nickel-metal-hydride, nickel-hydrogen and lithium-polymer electrolyte batteries. One Israeli company has developed a zinc-air battery, with ten times the energy density of lead batteries. The German postal service has been testing these and plans eventually to convert 80 per cent of its 25,000 vehicle fleet to electric vehicles powered by zinc-air batteries. California also uses electric vans for mail distribution, while electric buses are now running in some cities in the United States, as well as Italy, Switzerland and the



The renewed interest in and use of electric vehicles can contribute to the reduction of urban pollution.

United Kingdom. Ultracapacitors, which store large amounts of electricity and can charge and discharge quickly, and flywheels, which store energy in a spinning rotor, are being developed as replacements for batteries.

Fuel cells

The real breakthrough in electric vehicles is likely to come with fuel cells: mini power plants which convert chemical energy to electricity very efficiently, and without pollution. Fuel cell technology is not new but costs and indifferent performance have blunted its advance. However, recent progress in both cutting costs and improving performance have boosted its prospects. Development of proton exchange membrane fuel cells is regarded as the most promising for use in vehicles.

In the United States, the development of fuel cells is the centrepiece of the ongoing Partnership for a New Generation of Vehicles between the government and the three major car manufacturers. The first vehicle powered by a fuel cell entered the United States marketplace in late 1995, with a range of 72.5 kilometres and a top speed of 25 kilometres per hour. They were intended for use in operations such as airport cargo handling and grounds maintenance. One German car producer has already unveiled the world's first car powered by a fuel cell which is suitable for everyday operation, and has announced it could start selling hydrogen fuel cell equipped production models as soon as 2006. Progress on fuel cells will also have a direct influence on the technical and commercial viability of hydrogen-powered vehicles. Indeed, the ideal zero-emission vehicle is an electric vehicle powered by hydrogen fuel cells.

Hybrid electric vehicles are also being developed. They supplement the electricity with other sources, such as on-board gasoline-powered engines; have a longer range than electric-only vehicles; and pollute much less than comparable internal combustion engine cars. However, they do still emit air pollutants (because of this they do not qualify as zero-emission vehicles under California's legislation). Experimental hybrid buses using a diesel engine to operate an electric generator are on the streets in Munich, and one European manufacturer has produced a gas-turbine hybrid with a range of 50 kilometres, operating on batteries.

Further down the road may be the so-called 'hypercar', promoted vigorously by Amory Lovins of the Rocky Mountain Institute in the United States. Under this concept, the standard engine is replaced by a super-light, ultra-efficient hybrid drive system, with small electric motors powering the wheels, the energy for the motors being generated on board by a small gas-burning power plant. Through reduced engine weight and the use of advanced composite plastics, the vehicle weighs between a quarter and a third less than standard cars today. Lovins says it could run at 65 kilometres per litre and have a range of 975 kilometres.

A promising future

Every major car manufacturer in the world is now investing in electric vehicle development. There has been a flurry of activity in the past two to three years, including the commercial introduction of a number of models, and there have been rapid technological advances. This suggests electric vehicles have a promising future. How promising it is remains to be seen. According to one forecast, there could be a million electric vehicles on the roads worldwide by the year 2000; and by 2005 this number could climb to 1.8 million (800,000 in the United States and 500,000 in each of Europe and Japan). Other estimates regard this forecast as optimistic.

The German Environmental Protection Agency has estimated that it costs an additional US$3,000-5,000 to buy an electric car rather

BOX 11.3

Transport challenges in developing countries

Developing countries already face serious air pollution and other problems from cars and freight traffic, which will worsen as they industrialize, and rising incomes lead to more vehicles on the road.

In 1993, for example, Asian countries accounted for about 23 per cent of the vehicles sold worldwide; by the year 2000 they are expected to account for 29 per cent of the forecast sales of 57 million. Currently it is estimated that road transport contributes 14 per cent of global carbon dioxide emissions. Already the developing countries are responsible for about 30 per cent of this, and the figure is expected to rise to 35 per cent by the end of the century.

The situation concerning fuel consumption and emissions can be particularly unsatisfactory in many developing countries because the average lifetime of vehicles, and thus the proportion of older vehicles, may be quite high. This is often compounded by the continuous inflow of used vehicles from industrialized countries. In addition, maintenance is often very poor and the quality of fuel may be low, leading to high emissions and high consumption. The result is that in developing countries, emissions per vehicle are generally higher than in industrialized economies, particularly emissions of lead, sulphur oxides and particulate matter. One reason is the high lead content: introducing unleaded fuel is quite costly and only some of the higher income countries have done so. Also, older, poorly maintained vehicles emit more pollutants and few vehicles are fitted with emission control devices. The large number of two-stroke engines, which emit high levels of hydrocarbons and smoke, is another factor.

There are a number of automotive manufacturers in developing and transitional economies. In 1988, these accounted for about 10 per cent of all car production. Most of these vehicles were made under joint ventures with Organisation for Economic Co-operation and Development (OECD) car makers, but several countries, among them China and India, have their own go-it-alone manufacturers, and the fuel efficiencies of the vehicles produced are significantly below OECD standards. Moreover, few of these countries have the technological capacity for electronics or materials production which is necessary to implement current levels of vehicle technology.

Because incomes in rural areas are expected to grow slowly, it is unlikely there will be any significant increase in access to motorized transport in these areas. The major growth is occurring, and is predicted to continue, in urban areas. In some cities, the rate of urban motorization has outstripped the rate of population growth, and vehicle growth could be higher if manufacturers in nations such as China become major exporters of cheaper vehicles.

Meeting this challenge will require transferring technology in order to:

- improve fuel quality;
- introduce more efficient power units with emissions controls;
- improve standards of maintenance;
- introduce improved versions of low-cost/low-power motorized transport, designed specifically for high fuel efficiency and low emissions.

What are the prospects? The level of fuel efficiency and the emissions characteristics of vehicles produced by some developing-country manufacturers has improved markedly, thanks to exports to developed economies. For example, companies in the Republic of Korea, Malaysia and Taiwan are now producing vehicles that meet European, Japanese and United States standards. As the demand increases in their own countries, these car manufacturers should be ideally placed to fill this market. The question is whether they will incorporate ESTs into the vehicles they build.

than a conventional gasoline-powered vehicle, and states that a switch to electric vehicles “simply isn’t cost-effective”. Both the agency and other experts contend that ultra-low-emission technologies offer a better bet than electric vehicles for reducing emissions. However, the World Health Organization says “we must start planning now for vehicles based on renewable energy resources, and if we do not invest in research and development to improve electric vehicle technologies, we risk a catastrophe when fossil fuels run out”.

Bringing down the high cost of electric cars (likely to be the biggest deterrent to consumers) is the priority for manufacturers. The short range may be less of a drawback: over 80 per cent of Europe’s journeys are less than 15 kilometres, while the total distance travelled by all the cars

EGPC
really working for the environment

Egypt's energy prospects have never looked so promising – with oil and gas production continuing apace, and new reserves of both fuels ready to be explored and developed. But this situation reinforces the need to take steps to protect the environment.

Under the leadership of the Egyptian General Petroleum Corporation (EGPC), the petroleum sector is implementing a series of important reforms to do so.

Measures include:

- eliminating the addition of tetraethyl lead to gasoline
- installing hydro-desulphurization units for petroleum products
- fitting isomerization units to increase the octane number
- installing used oil recovery units
- installing a sulphur producing unit to reduce pollution
- building a hydro-cracking complex to improve product quality and upgrade fuel oil to lighter products
- fitting a unit to distil petroleum wastes
- installing biological and industrial sewage units
- setting up four pollution-fighting centres fitted with the latest equipment
- using computer simulation programmes to study oil leaks into the Suez Gulf, Red Sea and Mediterranean
- working with other agencies on gaseous, liquid and solid waste issues
- preparing environmental maps and databases for all sites
- introducing environmental safety programmes for employees
- switching power stations from fuel oil to natural gas
- using natural gas instead of gasoline for moving different types of vehicles

Energy is important to Egypt. But so is the environment. The EGPC is working to ensure that the two go forward together.

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in an average American household is only 66 kilometres a day. This suggests a market for electric vehicles for short trips in cities and towns, where vehicle pollution is worse. Few experts expect zero-emission vehicles to replace gasoline-filled vehicles on a massive scale, even in the medium term. But they clearly have a role in the future reshaping of the world's pattern of travel and transport, and are likely to make an increasingly important contribution to tackling air quality and pollution problems. For the moment, however, the best estimate is that conventionally powered vehicles will continue to dominate for the next 10-15 years.

As the OECD emphasizes, technology improvements to vehicles are only part of the solution; traffic management and control measures are also needed. In addition, the number of cars and trucks on the roads has to be reduced. One alternative is to move people and goods by rail. Trains not only cause less pollution than road vehicles, but a shift from road to rail transport would also cut traffic congestion and significantly ease worsening air pollution problems, particularly in the big urban areas.

Meanwhile, transportation remains a serious environmental challenge, and not only because of the pollution caused by road vehicles. There is also increasing concern about the environmental impact of aircraft, for example emissions of nitrogen oxides. Aircraft manufacturers are continually improving engine and fuel efficiencies but, as with road vehicles, the growth in air traffic is outstripping these technological advances. Shipping, too, causes some worries, and shipbuilders are under pressure to ensure that their vessels produce less marine pollution in future.

But it is the inexorable growth in road transportation that poses the major threat, and new technologies will contribute powerfully to addressing this. As the OECD says: "Improvements in the fuel efficiency of vehicles will play an important, and perhaps profound role in a larger strategy to reduce vehicle pollution. Until more sustainable options such as alternative fuels become practical on a large scale, reducing the specific fuel consumption of conventional vehicles appears to be one of the least disruptive means of lowering carbon dioxide emissions from transport. As part of a more general strategy to reduce demand for fossil fuels, steady improvements in the fuel efficiency of conventional vehicles could buy time for the gradual implementation of more radical measures, while stimulating the development of technologies that could ultimately be applied to vehicles powered by alternative energy sources."

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