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Strategies for a better environment

THE TRANSPORTATION BOOM IN ASIA

CRISIS AND OPPORTUNITY FOR THE UNITED STATES

James S. Cannon

The Transportation Boom in Asia:
Crisis and Opportunity for the United States

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Foreword

The world's two largest nations, China and India, with a combined population of more than 2.2 billion, are home to more than a third of the world's people. Between 2000 and 2010, the total population of these two countries is projected to grow by 246 million, virtually the equivalent of another United States. As these countries move to join the ranks of the world's leading industrial nations, their soaring rates of oil consumption are changing the equation for the rest of the world's users of the most rapidly dwindling fossil fuel. Asia's growing demand for oil will impact no nation more than the US, which, for the better part of a century, has had a free hand at exploiting the world's oil resources and whose economy has become more dependent than any other nation's on foreign oil.

Today the US, with just 5 percent of the world's population, uses 25 percent of all the oil consumed worldwide. Sixty-seven percent of that oil (more than the total amount produced in the US) is used to power this country's 220 million vehicles. But the era of oil is coming rapidly to a close.

The Transportation Boom in Asia: Crisis and Opportunity for the United States addresses four key questions:

- What exactly do the trends in transportation development and oil consumption in China and India look like, and what forecasts are being made for the future of oil?
- How has the United States been affected to date by its oil dependence (mainly for its vast transportation system), and what are the implications of Asia's soaring oil use for the US?
- What goals do these three countries have for developing sustainable transportation in the long run?
- What steps are the two Asian giants taking today to address the brewing near-term crisis over access to the world's oil? What steps is the US taking?

Among the most significant findings of this new INFORM report are two trends that are under way in India and China. One is the soaring rates of oil use in both countries that far exceed their domestic production capabilities and have sent them seeking foreign sources to meet their future needs. These rates of oil use will soar ever higher as these countries' new transportation systems grow. The choices India and China make regarding vehicle fuels and efficiency, along with mass transport and land use planning, will all profoundly affect their transportation and oil use futures. But a second trend already taking shape involves the recognition by both countries of how unwise it would be for them to build transportation systems that depend totally on oil-derived fuels—because of the diminishing supply of world oil, because of the expanding competition of nations for access to this oil, and because of the severe health impacts that use of gasoline and diesel fuels is already having on their urban dwellers. China and India have assessed their options and chosen to take aggressive advantage of natural gas vehicle (NGV) technology. Already India has surpassed the US in the use of NGVs. China is not far behind. The use of NGVs in China and India is not only diversifying their fuel use and addressing severe urban air pollution problems, it is also paving the way in both countries for the use of another gas—hydrogen—to power pollution-free transportation in the longer term.

In the US, INFORM's research also documented two trends. However, these, if both continue, will spell economic, national security, and environmental disaster for America well within the decade. Already the world's most voracious consumer of oil, the US continues to use more and more oil (mainly in transportation) and its reliance on foreign oil continues to grow. US national security has been in increasing jeopardy as the country has steadily put more and more of its supplies in the hands of unstable and questionably friendly Persian Gulf countries. Since the end of the Cold War, the US has closed military bases around the world and centralized its troops and equipment in the continental US, making oil the absolute key to deploying troops and supplies to regions of conflict. Only because of Saudi Arabia and Iran were the US and its allies able to fuel the successful Desert Storm campaign to drive Iraq out of Kuwait.

On the US economic front, reliance on foreign oil has meant the elimination of more than a million jobs in the last 30 years; the economy has been sapped of millions of dollars in related tax revenues. The oil price spikes and disruptions caused three times since l970—a result of decisions or supply interruptions involving the Arab OPEC nations—have battered the US economy, sent companies into recession or bankruptcy, and led to soaring inflation. These broad economic costs, combined with the military costs of safeguarding US sources of Persian Gulf oil, have drained our economy of approximately $300 billion a year. The health costs incurred by the 158 million Americans who live in areas where the air does not meet US public health standards are incalculable, as are the growing costs of global climate change.

Turning to the second US trend, this country's leadership has, ironically, turned its back on visionary alternative-fuel programs launched more than a decade ago, which showed natural gas technology and hybrid electric technology to be winners and which led to development of some of the most sophisticated natural gas vehicles and infrastructure development capabilities in the world. While US leaders have allowed this key transportation sector to languish, they have at the same time expanded their research support for continued use of slightly cleaner forms of oil-derived fuels. And while the US has launched a $1.7 billion five-year research program for getting to hydrogen—the country's espoused long-term goal—it has eliminated its support for the very technologies that have proven their value in facilitating this transition.

The oil consumption trend in Asia portends a near-term crisis for the United States, but India's and China's push for natural gas vehicles offers this country a historic opportunity. With the writing now on the wall with regard to world oil, this new report clarifies how vital our national leadership is to re-energizing the natural gas vehicle movement—using a fuel that is dramatically cleaner than petroleum-based fuels, that diversifies our domestic fuel capabilities, and that paves the way to the use of hydrogen. While natural gas—like all fossil fuels—is ultimately depletable, natural gas fueling stations can be modified to provide hydrogen to the first generation of fuel cell vehicles. This will make possible the expanding use and refinement of these vehicles in anticipation of the day when they can be powered by hydrogen made from water using renewable energy, instead of from natural gas.

Taking the last step in the transition to sustainable transportation is vital because only then can the use of fuels containing carbon and greenhouse gases be totally eliminated, ending transportation's contribution to global climate change. However, this last step requires that policy makers provide significant support today not only for the deployment of natural gas vehicles but also for the development of renewable and solar energy. While a viable transition path to sustainable transportation is clear, further analysis (beyond the scope of this report) will be needed to define the total natural gas supply needed and the time frame and costs of the transition.

In the meantime, were the sophisticated natural gas vehicle technologies that have been developed in the US being strongly promoted domestically now—instead of being allowed to languish—it could reduce US oil dependence significantly. Further, were these technologies actively promoted for export, it could create jobs and strengthen a vital domestic industry, while helping India, China, and other Asian nations pursue goals to which they are committed. Without US action now, the path to hydrogen may well go through Beijing and New Delhi, rather than through Washington, DC.

The Transportation Boom in Asia lays out eight policy steps that could put this country on a new course, toward a better, healthier, and more secure future for Americans and toward collaboration with Asia's rising nations that could make an immeasurable contribution to a sustainable future for our world.

Joanna D. Underwood
President, INFORM

1. Introduction:
The Coming Collision in the Quest for Oil

China and India are the two largest countries in the world, with roughly five and four times the population of the United States, respectively. Each has a booming transportation sector, and burgeoning numbers of motor vehicles are straining the underbuilt oil supply infrastructure of both countries, choking major cities with severe air pollution, and saddling the economy with billions of dollars in annual oil import bills. In 2003, largely because of this transportation explosion, China and India became, respectively, the world's second and sixth largest oil-consuming nations, behind the US, which leads the world.[1]

China's and India's thirst for oil is of recent vintage, in contrast to the US, which has had a free hand in exploring and exploiting the world's oil resources for a century. Now, with just 5 percent of the world's population, the US accounts for 25 percent of the world's oil consumption—some 20 million out of 80 million barrels a day—used mostly to power the millions of cars, buses, and trucks that travel its roads. Until l947, the US met all its oil needs with domestic supplies; it even was able to provide oil to its allies during World War II.[2] However, since that date, US reliance on foreign sources of oil has steadily expanded. Today, the country relies on imported sources for 63 percent of its oil demand, with 25 percent of those imports coming from the volatile Middle East.

Avoiding a Crisis Over Oil: The Focus of this INFORM Report

What effects will the transportation revolution now under way in China and India and the soaring use of oil in these countries have on the United States? How has the US been affected by its own vast oil-fed transportation system, and how has the US prepared for the growing competition for world oil—especially for its transportation future? These are the questions INFORM addresses in this report. Specifically:

1. What have the trends in transportation development and oil consumption been in China and India, and what have the implications been for the United States?
2. What are these three countries' goals for developing sustainable transportation in the long run?
3. What steps are the two Asian giants and the US taking today to avoid a near-term battle for access to the world's most rapidly dwindling fossil fuel?

Findings of INFORM's Report

The following key findings of INFORM's research are discussed at greater length in the pages that follow.

1. **What are the oil use and transportation trends in China and India, compared to those in the US?**

   - **The emergence of automotive transportation in China and India and the growth of this sector in both countries have been nothing short of astronomical.** In l980, the number of motor vehicles in China was under two million. By 2002, that number had risen to almost 18 million vehicles.[3] Car sales soared 73 percent more in 2003 alone, and by 2030, China is projected to have more motor vehicles than the US,[4] which is home to more than 220 million

[1]Unless noted otherwise, oil use statistics cited in this report are from the US Energy Information Administration, **http://www.eia.doe.gov.**

[2]Milton R. Copulos, *America's Achilles Heel: The Hidden Costs of Imported Oil*, National Defense Research Foundation, October 2003.

[3]"Booming Car Market in China," *Hybrid Vehicles*, December 2003, 4.

[4]US Energy Information Administration, *International Energy Outlook 2004*, April 2004, **http://www.eia.doe.gov/oiaf/ieo/oil.html.**

cars, buses, and trucks.[5] Meanwhile, the number of motor vehicles in India reached 10.7 million in 2000, an increase of 245 percent since l986. Motor vehicle totals have risen to more than 14 million since then.[6]

- **China and India are increasingly turning to imports to meet their oil needs, which, even in the early stages of these countries' transportation development, is creating competition for oil with the US.** Both India and China embarked on aggressive domestic oil exploration ventures in recent years, with much fanfare but with disappointing results. Never an oil importer before 1993, China now imports about one-third of the oil it consumes; in 2003, it passed Japan to become the world's second largest consumer of oil. China is now competing with the US in what is becoming a two-way race for the world's most limited fossil fuel. Oil imports are growing in India as well, and now account for nearly two-thirds of total oil use, twice the level of just 15 years ago.
- **Despite the growth in China's and India's oil use, the US remains by far the largest user of oil in the world, primarily because of its transportation sector**. Of the 20 million barrels of oil consumed in the US each day, 66 percent is made into the gasoline and diesel fuels that power the country's huge population of cars, buses, and trucks.[7] The amount of oil used in transportation is greater than the US's total domestic production. From l975 to 2000, while oil use in all sectors other than transportation fell 17 percent, oil use in transportation skyrocketed 43 percent.
- **The US dependence on oil in transportation has jeopardized this country's national security, sapped its economic strength, and put the health of 158 million Americans at risk.**
  - With 63 percent of the oil the US consumes controlled by foreign sources (these are shown in Figure 1)—of which 25 percent comes from the volatile Persian Gulf nations—this country (with its oil-dependent military transport system) is more vulnerable than any other country in the world to the pricing dictates of the Organization of Petroleum Exporting Countries (OPEC), to any disruption of its supplies by OPEC or by terrorists, and to new competitors at the margin.
  - US vulnerability is increased by the fact that it has just 1.87 percent of global oil reserves (Figure 2)—22.6 billion barrels that, were the country required to meet its needs domestically, would last less than three years.[8]
  - Since the mid-1970s, the US economy has been weakened by the export of more than a million

Figure 1 Sources of US Oil Imports

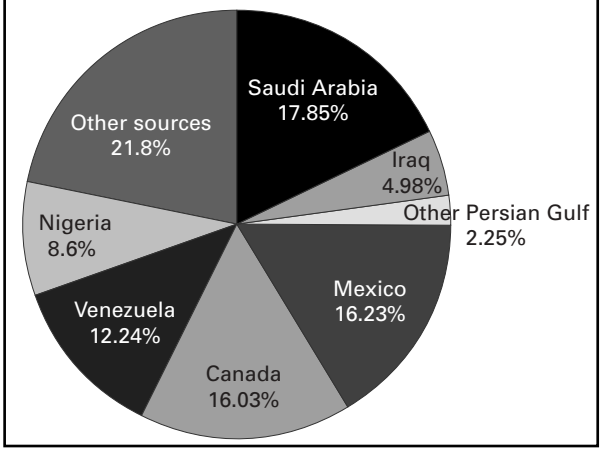
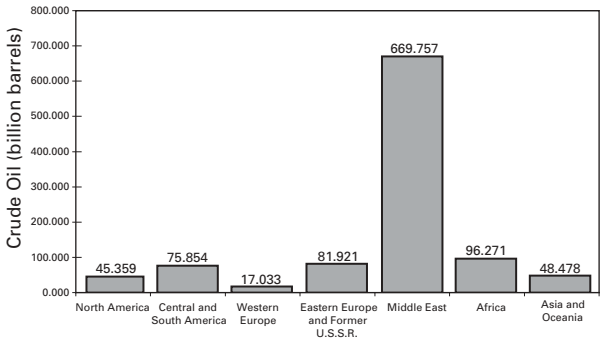


Figure 2 World Oil Reserves



Source: US Energy Information Administration

[5]*Ibid.*

[6]*Motor Transport Statistics of India*, cited by K. Gandhi, presentation, Society of Indian Automotive Manufacturers Seminar on Alternative Energy Driven Vehicles, New Delhi, India, January 2004.

[7]US Department of Energy, "Annual Energy Review 2003," **http://www.eia.doe.gov/emeu/aer/contents.html**.

[8]US Energy Information Administration, *International Energy Outlook 2004*, April 2004, **http://www.eia.doe.gov/oiaf/ieo/oil.html.**

oil industry-related jobs. The 25 largest oil companies shrank from 1.65 million employees down to fewer than 640,000.[9] With the loss of these jobs have gone related tax revenues. More than $100 billion a year is being sent abroad to foreign energy suppliers, while tens of billions of dollars are devoted to militarily securing our Persian Gulf oil supplies. Before the Iraq war began, the total economic costs of importing oil, combined with the military costs of protecting our Persian Gulf oil supplies, were calculated to range from $297 billion to $304.9 billion a year.[10]

- As of 2003, 15 million Americans were suffering from asthma,[11] predominantly in urban areas where concentrations of diesel buses and delivery and refuse trucks have been a key factor in high rates of asthma attacks, especially among children.

- **If current transportation and oil use trends continue, the consequences for the US of increasing competition from Asia for the world's oil will be dire. Within the decade, it could well set off a resource grab on a scale unparalleled in history.** Together, China, India, and the US, with a combined population of 2.56 billion (43 percent of the world's total in 2000), have less than 4 percent of the world's total crude oil reserves (by contrast, almost two-thirds of world oil reserves are located in the Middle East—with about 25 percent controlled by Saudi Arabia alone). By 2025, the populations of these three countries are expected to soar to 3.17 billion (an increase of 605 million people).[12] China's and India's oil consumption rates are projected to increase at an annual rate of 4 percent and 3.9 percent, respectively, the fastest rates in the world by far (Figure 3). According to US National Intelligence Council projections, by 2015—just 11 years from now—only 10 percent of Persian

Figure 3 Projected Growth in Population and Oil Consumption in the US, Asia, and Worldwide, 2000 to 2025

	Population	% of World	Oil Use Barrels/Day	% of World
2000				
US	285,003,000	5%	19,700,000	26%
China	1,275,215,000	21%	4,800,000	6%
India	1,016,938,000	17%	2,100,000	3%
Asia	3,679,737,000	61%	14,500,000	19%
World	6,070,581,000	100%	76,900,000	100%
2005				
US	300,038,000	5%	NA	NA
China	1,322,273,000	20%	NA	NA
India	1,096,917,000	17%	NA	NA
Asia	3,917,508,000	61%	NA	NA
World	6,453,628,000	100%	NA	NA
2010				
US	314,921,000	5%	22,700,000	25%
China	1,364,875,000	20%	7,600,000	8%
India	1,173,806,000	17%	2,800,000	3%
Asia	4,148,948,000	61%	20,200,000	22%
World	6,830,283,000	100%	91,400,000	100%
2015				
US	329,669,000	5%	24,800,000	25%
China	1,402,321,000	19%	9,200,000	9%
India	1,246,351,000	17%	3,500,000	3%
Asia	4,370,522,000	61%	23,700,000	24%
World	7,197,247,000	100%	100,500,000	100%
2020				
US	344,270,000	5%	26,400,000	24%
China	1,429,473,000	19%	11,000,000	10%
India	1,312,212,000	17%	4,400,000	4%
Asia	4,570,131,000	61%	27,600,000	25%
World	7,540,237,000	100%	110,300,000	100%
2025				
US	358,030,000	5%	28,300,000	23%
China	1,445,100,000	18%	12,800,000	11%
India	1,369,284,000	17%	5,300,000	4%
Asia	4,742,232,000	60%	31,600,000	26%
World	7,851,455,000	100%	120,900,000	100%

Sources: UN Secretariat, Dept. of Economic and Social Affairs, Population Division, and US Energy Information Administration

[9]International Labour Organization, "The promotion of good industrial relations in oil and gas production and oil refining," Geneva, 2002, **http://www.ilo.org/public/english/dialogue/sector/techmeet/tmor02/tmor-r.pdf.**

[10]Milton R. Copulos, *America's Achilles Heel: The Hidden Costs of Imported Oil*, National Defense Research Foundation, October 2003.

[11]National Heart, Lung, and Blood Institute, "Who Gets Asthma?" **http://www.nhlbi.nih.gov/health/dci/Diseases/Asthma/Asthma_WhoIsAtRisk.html.**

[12]US Energy Information Administration, *International Energy Outlook 2004*, April 2004, **http://www.eia.doe.gov/oiaf/ieo/oil.html.**

Gulf oil will go to Western nations, while 75 percent will be directed to Asia (compared to 60 percent today).[13]

Even today, with foreign sources controlling 11 million barrels of the 20 million barrels of oil consumed in the US each day, any large-scale disruption in imported oil supplies would be catastrophic. Its consequences are only hinted at by the major oil supply disruptions that occurred in 1973, 1979-1980, and 1990, which wreaked havoc on our economy, causing inflation, job loss, and price hikes that affected everything from airline travel to the trucking of goods to grocery stores to the use of petroleum feedstocks at chemical plants to consumer access to gasoline across the country.

2. **What long-term vision do China, India, and the US have for their heavily oil-dependent transportation sectors?**

   - **China, India, and the US are part of a growing world consensus that hydrogen fuel cell vehicles may be the ultimate solution to the problems of energy supply and pollution associated with oil-derived fuels.** All three countries have launched programs to develop this technology, with the US having recently made one of the largest national commitments in the area ever—$1.7 billion over five years. Yet the hydrogen-powered transportation economy will still take at least several decades of hard work to create.

3. **What steps are China, India, and the US taking now to avoid the crisis over oil that lies ahead?**

   - **China and India have launched aggressive programs to develop transportation fuel alternatives, recognizing the immediacy of the threat to public health and fuel security stemming from their reliance on gasoline- and diesel-fueled vehicles.** Both of these countries, being relatively free from the political dominance of oil-based energy and vehicle interests that exists in the US, have chosen natural gas vehicles (NGVs) as their preferred option, and in just a few years have become two of the world's ten largest users of NGVs. From only a few thousand NGVs five years ago, India's population of 200,000 NGVs is already the fifth largest in the world today, while China's 70,000-strong fleet of NGVs ranks seventh in size worldwide.[14]
   - China's and India's natural gas vehicle programs are helping these countries meet their near-term air quality and fuel security challenges, while also putting them on the road to hydrogen fuel cell vehicles in the longer term. These programs are building experience in the use of a gaseous fuel and establishing a refueling infrastructure that can deliver natural gas today and, with some modifications, hydrogen tomorrow.
   - Although the US initiated ambitious alternative-fuel programs in the early l990s, government support for these programs has eroded in the last few years. The budget at the US Department of Energy for natural gas vehicle R&D went from $7.8 million to being zeroed out for 2005. By not continuing to support NGV programs, the US is missing an opportunity to develop technologies that can not only meet critical national security, economic, and environmental needs but also serve the rapidly growing markets in Asia. Focusing on hydrogen research, while ignoring the synergies between natural gas and hydrogen technologies, the administration has cut back on the very programs that would facilitate a US transition to hydrogen.

Today, 99 percent of motor vehicles in the US are still powered by gasoline or diesel fuel, while the natural gas vehicle industry, offering the cleanest and most domestically plentiful alternative fuel, is struggling to grow and is facing increased competition from clean diesel (cheaper and cleaner than conventional diesel but still petroleum-based), as well as from less broadly valuable options such as ethanol and biodiesel, which are used mainly with gasoline and diesel fuel.

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[13]US Central Intelligence Agency, *Global Trends: 2015*, December 2000, **http://www.cia.gov/cia/reports/globaltrends2015/.**

[14]International Association for Natural Gas Vehicles, **http://www.iangv.org.**

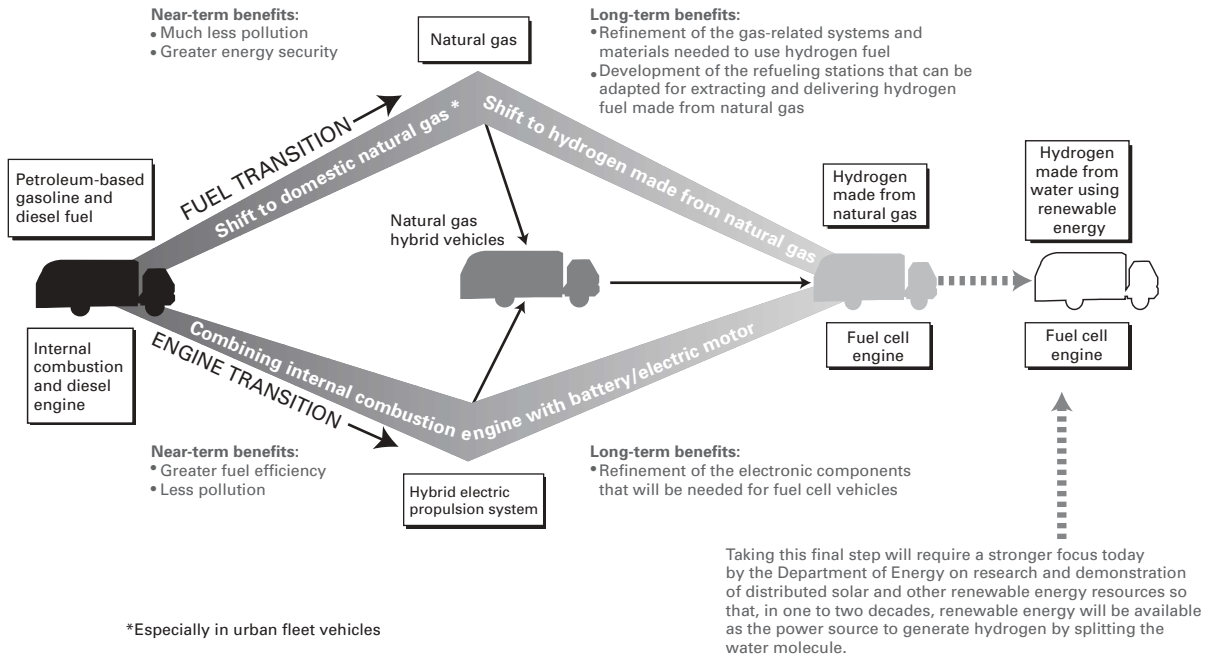
Recommendations of INFORM's Report

The findings of this report suggest that US leaders must take immediate steps to restructure this country's transportation policy. The US, the world's largest consumer of oil, has the means and the responsibility to avoid the coming crisis, as well as the opportunity to capitalize on Asia's demand for natural gas vehicles by exporting its technologies and expertise abroad. The ball is in its court. The eight INFORM recommendations below aim to promote the restructuring that is needed—and that can, further, catalyze progress toward some of the country's most important overarching goals. In addition to preventing the destructive collision with China and India over use of the world's remaining oil, US action now could help shape a secure, economically vibrant, and healthy future for America, and make this country a collaborating partner with Asia and other industrializing nations in building a sustainable world.

INFORM's recommendations for the restructuring of US transportation policy are aimed at achieving three major policy objectives:

1. **Expansion of the natural gas vehicle industry in the US,** which would provide cleaner air and greater energy security in the near term and, because of the synergies that exist between natural gas and hydrogen, create a clear path to the era of hydrogen-powered transportation in the longer term.
2. **Deployment of the sophisticated commercial natural gas vehicle and related technologies developed at high cost in the US to China, India, and other industrializing Asian nations** —and, by serving these rapidly growing international markets, build a strong clean-fuel vehicle industry in the US, promote environmental improvement worldwide, and lessen tensions over global oil.
3. **Research and development of distributed renewable energy technologies** (such as wind power, photovoltaics, and hydropower) that, in the years ahead, will be essential to making the shift in the fuel source for this country's growing fleet of fuel cell vehicles from natural gas-derived hydrogen to hydrogen generated from water using fully sustainable renewable energy (Figure 4).

Figure 4 A Viable Transition Path to Pollution-Free Hydrogen Fuel Cell Vehicles



INFORM's eight recommendations for action by government policymakers include the following:

Recommendation 1

Congress and the president must make Americans aware of the crisis being created by the increasing worldwide demand for oil and the potential implications for the US over just the next 10 to 15 years. It is important that Congress and the president publicly acknowledge the dimensions of this crisis in clear terms and its causes: It is a result predominantly of US dependence on and increasingly extravagant use of oil-derived fuels in transportation, while the world's rapidly expanding economies (especially in Asia) demand their share of this dwindling resource.

Recommendation 2

Congress and the president must outline a realistic and achievable national energy plan to address this crisis step-by-step. An essential ingredient is recognition of the technologies that provide the greatest near-term petroleum displacement and environmental and fuel efficiency gains while creating the most direct and rapid transition path to hydrogen. After 20 years of government funding and experimentation with a range of fuel options, it has become evident that the most promising and assured path forward involves exploiting the many synergies between natural gas and hydrogen technologies, as well as promoting hybrid electric (including natural gas hybrid) vehicles for the greater fuel efficiency they offer today and for the key role they can play in refining the electronic componentry that is essential for commercial hydrogen-powered fuel cell vehicles. A goal for use of natural gas, biogas, and hybrid natural gas technologies could reasonably be set at 20 percent by 2020.

Recommendation 3

Congress and the president must give full support to creating a package of economic incentives that would encourage the purchase and use of vehicles powered by cleaner nonpetroleum domestic fuels and more efficient engines. Such a package, called CLEAR ACT, which was under consideration by Congress as part of the Foreign Sales Corporation/ExtraTerritorial Income (FSC-ETI) "JOBS" bill in the Senate, was killed in October 2004. This was unfortunate, as it would have been the right approach at the right time, providing incentives for purchasing alternative-fuel vehicles, for using alternative fuels, and for building infrastructure for the delivery of alternative fuels to vehicles.

Recommendation 4

Congress and the president should provide especially visible leadership at the local level—in communities across the country—by supporting the conversion of school buses from diesel to cleaner fuels. The Green School Bus Act, included in both the Senate and House versions of the 2004 energy bill, by authorizing $140 million for alternative fuels, would help safeguard the hundreds of thousands of children who ride these buses to and from school each day. It would fund the replacement of existing school buses with new alternative-fuel buses. (Cleaner diesel buses and the retrofit of existing diesel buses with current pollution control technologies would get $60 million and $100 million, respectively.) By supporting the use and continuing refinement of natural gas school bus technology, the federal government would be developing a vehicle sector that also may be in high demand in Asia. This act relies on passage of the 2004 energy bill, which, as the year ends, becomes less and less likely. Should the national leadership needed to pass this bill fail to materialize, there may be another chance next year. Otherwise, the only backup will be to ensure continued funding of the Environmental Protection Agency's (EPA's) Clean School Bus USA program, which received $10 million in the last two years, spent on 17 projects in 2003 and 20 projects in 2004. (The agency received 120 grant applications, however, for a total request of $60 million, indicating the strong interest existing at the community level.) However, even this funding is at risk.

Recommendation 5

Congress and the president must support substantially expanded funding for natural gas and other alternative-fuel vehicle R&D. Today's available alternative-fuel vehicles—especially natural gas vehicles—are fully commercial but they can be made even cleaner and more efficient. The federal government should invest significantly in the R&D required to achieve these goals as a comple-

ment to R&D being funded by the private sector, which has identified $60 million in vital research needs aimed at developing even more vehicle platforms and engines that can operate on alternative fuels in more applications.

Recommendation 6

Congress and the president should expand support for the Department of Energy's Clean Cities domestic and international programs. Its domestic program is the best program to date engaging citizens and local communities in being part of the solution. The primary mission of this program is to engage local government, business, and community leaders in voluntary initiatives that help reduce petroleum consumption in transportation. Clean Cities carries out this mission through a network of more than 80 volunteer coalitions that develop public/private partnerships to promote alternative fuels and vehicles, as well as strategies for greater fuel efficiency. Clean Cities provides funding for local coalitions. In 2003, it reported that its coalitions had more than 173,000 alternative-fuel vehicles in their fleets, displacing 148 million gallons of petroleum.[15] The Clean Cities programs have been very effective, but would be even more effective with increased funding.

The Clean Cities international program, established in 1995, has sought to foster information exchange on technologies and policies and development around the world of partnerships for alternative-fuel vehicle programs. It is active in countries including India, Bangladesh, the Philippines, Brazil, Mexico, Peru, and Chile.

Recommendation 7

Congress and the president should immediately elevate the importance of sustainable transportation technology exports and make export a high priority in US trade and energy policy. This would enable the US to compete in the rapidly growing markets for natural gas vehicles in Asia (as the Canadians have been doing successfully for some time). By means of such an export policy, the alternative fuel and vehicle industries in the US—which over the past 20 years have developed some of the world's most sophisticated natural gas vehicle and refueling technologies at great cost—could grow and flourish, while contributing to the creation of modern, environmentally sustainable transportation systems in China, India, and other developing countries.

Recommendation 8

Congress and the president must accelerate funding for the rapid development of renewable energy technologies, such as wind power, photovoltaics, and hydropower, as well as the deployment of these technologies across the country. Funding for these technologies has been far from aggressive. From 1978 to 1999, $12 billion was invested in renewable energy R&D, compared to $26 billion for nuclear energy and $15 billion for fossil fuels.[16] Since natural gas is ultimately a depletable fossil fuel, hydrogen must eventually be made from water using renewable energy.

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[15]US Department of Energy, Clean Cities Program, **http://www.eere.energy.gov/cleancities/.**

[16]US Department of Energy, *Federal Financial Interventions and Subsidies in Energy Markets 1999: Primary Energy*, Table C1, Summary of US Department of Energy Research and Development Expenditures, Fiscal Years 1978-1999, September 1999, **http://www.eia.doe.gov/oiaf/servicerpt/subsidy/pdf/sroiaf(99)03.pdf.**

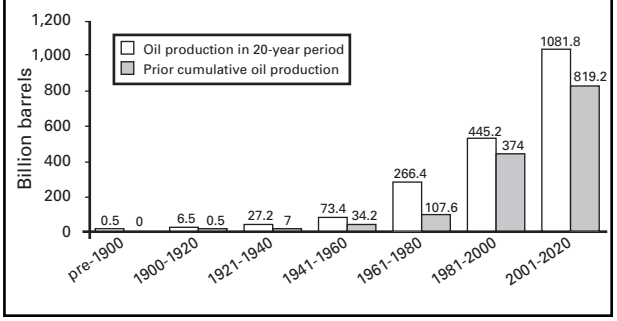
2. Motor Vehicles:
The Key to Asia's Soaring Oil Consumption

It is only in the past decade that growth in oil use to supply the booming motor vehicle markets in the industrializing nations of Asia has become a major factor in the world oil economy. While world oil production has grown—by 14.5 percent between 1992 and 2001, from 65.2 to 74.7 million barrels a day—the competition for global oil supplies also has been escalating steadily.

Much of the industrializing world aspires to replicate the gasoline- and diesel-dependent transportation systems of the US and other industrialized nations. However, a forecast of world oil consumption made in the mid-1990s—before the Asian oil boom began—suggested the impossibility of this coming to pass. It indicated that, were trends in global oil use since its discovery in 1859 to continue, oil use in the 20-year period from 2001 to 2020 would likely exceed the amount used worldwide during the entire industrial era (Figure 5).[17]

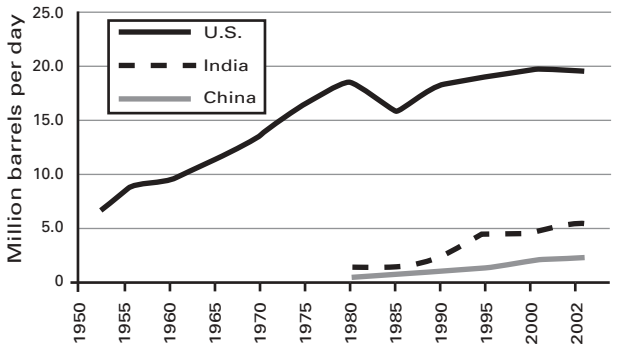
Although oil use in China and India remains far below US levels, and the risk that competition from these countries presents to the energy security of the US is still small, the oil needs of these three countries are on a collision course. Figure 6 compares the growth in US oil consumption since 1950 with the much smaller growth in China and India. If the predictions of oil use in the world's two most populous countries come to pass, the US will face a dangerous shortfall of fuel—and it will do so soon.

Figure 5 History of World Oil Use



Source: INFORM, Inc.

Figure 6 Growth in Oil Consumption in the US, Compared to India and China, 1950 to 2002



Source: US Energy Information Administration

In the next few years, transportation fuel use could easily become the single most important factor affecting global oil supply, cost, and availability. Yet all this change is occurring while the number of motor vehicles per capita in Asia remains at low levels—levels that were reached and passed by the industrialized world in the early 1900s, during the very early days of the automotive industry.

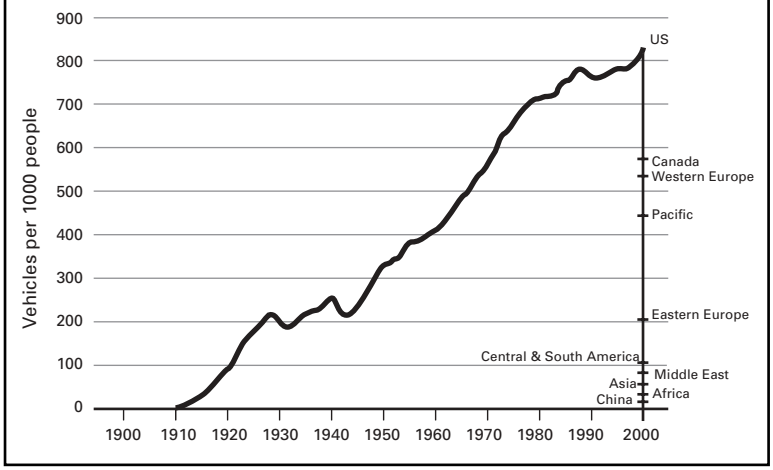
Figure 7 shows the growth trend in the US of vehicle ownership per 1,000 people between 1900 and 2000, as well as the relative rates of vehicle ownership in other countries in 2000. In the US, vehicle ownership now averages 850 vehicles per 1,000 people. In Asia, by contrast, there are fewer than 100 vehicles per 1,000 people; in China, the number is even smaller—a rate of ownership equal to that of the US during World War I. By 2030, China's total motor vehicle fleet is projected to exceed that of the US.[18] However, were this giant country to equal the

[17] James S. Cannon, *Harnessing Hydrogen: The Key to Sustainable Transportation*, INFORM, Inc., 1995.

[18] US Energy Information Administration, *International Energy Outlook 2004*, April 2004, **http://www.eia.doe.gov/oiaf/ieo/oil.html.**

current US rate of per capita ownership, its vehicle population would number 972 million, almost 27 percent more than the entire vehicle population of the world in 2001.[19]

Figure 7 The Rising Trend in Vehicle Ownership in the US, 1900 to 2000, and Relative Vehicle Ownership in Other Countries in 2000



Source: S. Davis *et al*., *Transportation Energy Data Book*, 2003

Replacing the US as the Top Oil-Consuming Region by 2015

As China and India seek access to the same levels of mobility that the US has today, oil use for transportation will surge. According to *International Energy Outlook 2003*, published by the US Energy Information Administration, the strongest total growth in oil use during the next two decades will occur in developing Asia, where demand is expected to more than double over the forecast period. This compares to a 58 percent projected rate for the world as a whole.[20]

The annual growth rate for oil use in all of industrializing Asia is projected at 3 percent. This accounts for nearly 40 percent of the total projected increment in world oil consumption, and 69 percent of the increment for the industrializing world alone. The highest annual percentage growth rates for oil consumption in the world are expected to be in China (4 percent) and in India (3.9 percent).

A 2001 report on energy trends from the National Intelligence Council (part of the US Central Intelligence Agency), *Global Trends: 2015*, agrees with analyses performed by the International Energy Agency, the US Energy Information Administration, and other organizations on the growing importance of Asia in world oil markets, predicting that the region will replace North America as the leading oil-consuming region long before 2015. According to *Global Trends: 2015*, total world oil demand will increase from roughly 75 million barrels per day in 2000 to more than 100 million barrels per day in 2015. This 25-million-barrel increase would be huge, almost as large as the total current production of nations belonging to the Organization of Petroleum Exporting Countries (OPEC).[21]

The National Intelligence Council expects Asia to account for more than half the world's total increase in petroleum demand between 2000 and 2015. China, and to a lesser extent India, with a combined population of more than 2.2 billion and their governments pressing for transportation progress, will see especially dramatic increases in oil consumption. In its most startling conclusion, *Global Trends: 2015* projects that, by 2015—11 years from now—only one-tenth of Persian Gulf oil will be directed to Western markets; 75 percent will go to Asia, compared to 60 percent today.

Although there are considerable differences of opinion on the issue, most oil supply experts believe that global oil supply is likely to peak sometime within

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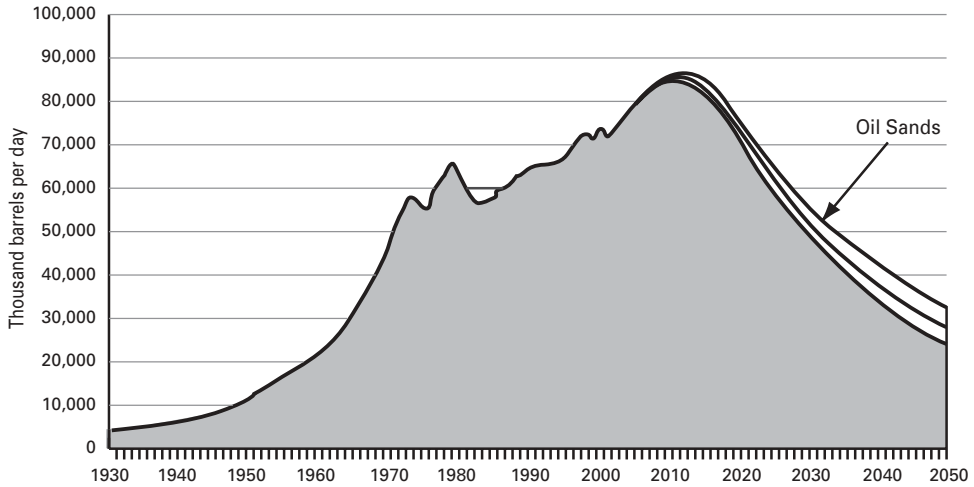
[19]S. Davis *et al*., *Transportation Energy Data Book*, 23rd ed., Oak Ridge National Laboratory, 2003.

[20]US Energy Information Administration, *International Energy Outlook 2003*, May 2003, **http://tonto.eia.doe.gov/FTPROOT/forecasting/0484(2003).pdf.**

[21]US Central Intelligence Agency, *Global Trends: 2015*, December 2000, **http://www.cia.gov/cia/reports/globaltrends2015/.**

the next 30 years—many say by 2010. Figure 8 shows projected oil growth from a study by Douglas Westwood, a global business research firm based in the United Kingdom. Many other forecasts by industry and government leaders show a similar peaking in the decades ahead, and one well-known group of scientists, called the Association for the Study of Peak Oil & Gas, predicts that the peak will be reached in 2008.[22] Virtually none projects the tripling of global oil production that would be needed to fuel oil-based transportation systems in just China and India.

Figure 8 Recent Global Oil Production Forecast



Source: Douglas Westwood

Paying the Costs of Oil Dependency in Deficits and Death

OPEC producers are expected to be the major beneficiaries of increased production requirements to supply oil to Asia. The Energy Information Administration expects OPEC production to increase 83 percent between 2001 and 2025, to 55.6 million barrels per day. The percentage of global oil production from Middle Eastern OPEC members is expected to increase from 26.7 percent in 2001 to 34.1 percent in 2025, putting control of more world oil in their hands.

China is paying for its oil imports with a portion of its huge trade surplus with the US, which was $124 billion in 2003, the highest deficit ever paid by one country to another. But even this has entailed a huge opportunity cost by diverting funds desperately needed domestically in China for economic and social development. India is harder-pressed for funds to pay for its oil imports, but it too is looking to the US to finance its economic growth.

The health and economic costs of China's and India's transportation revolutions are also escalating. In both countries, the environmental toll of urban gridlock created by the growth of vehicles powered by oil-derived fuels has been catastrophic. The World Bank estimates that 178,000 people die prematurely in Chinese cities every year because of exposure to air pollution, much of it emitted by motor vehicles.[23] A recent study from the Woodrow Wilson International Center for Scholars reports that nine of the ten cities in the world with the worst air pollution are in China.[24] Another survey named New Delhi, India, as the most polluted city in the world in terms of suspended particulate matter.[25]

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[22]Association for the Study of Peak Oil & Gas, **http://www.peakoil.net.**

[23]World Bank, "Clear Water, Blue Skies: China's Environment in the New Century," 1997, **http://www.worldbank.org/nipr/china/clrwt-sum.htm.**

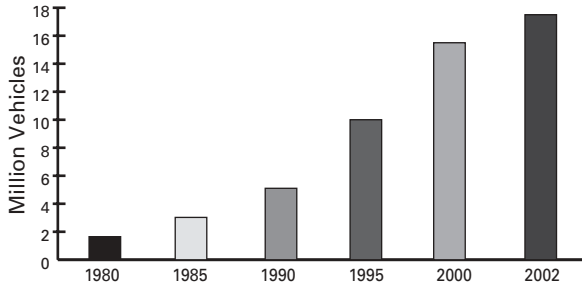
[24]Pamela Baldinger and Jennifer L. Turner, *Crouching Suspicions, Hidden Potential: US Environmental and Energy Cooperation with China*, Woodrow Wilson International Center for Scholars, 2002, **http://wwics.si.edu/topics/pubs/crouchtiger.pdf**.

[25]J. Lin *et al*., "Urban Transport Infrastructure and Air Quality Characteristics: A Comparative Analysis of China and India," *Proceedings of the 83rd Annual Meeting of the Transportation Research Board*, Washington, DC, January 2004.

China: A Population of 1.3 Billion with Vehicle Use Soaring

The pace of transportation change in China—with a population of 1.3 billion people and growing—is mind-boggling. The last doubling in the world's motor vehicles took just over 25 years to occur; in China, it took less than six years. The total number of vehicles on Chinese roadways—including cars, trucks, and buses—did not exceed one million until 1977, at which time there were already about 140 million vehicles in the US. The startling tenfold growth in China's motor vehicle fleet from 1980 to the end of 2002 (a period in which the US fleet grew by just 36 percent) is shown in Figure 9.

Figure 9 Growth in China's Motor Vehicle Population, 1980 to 2002

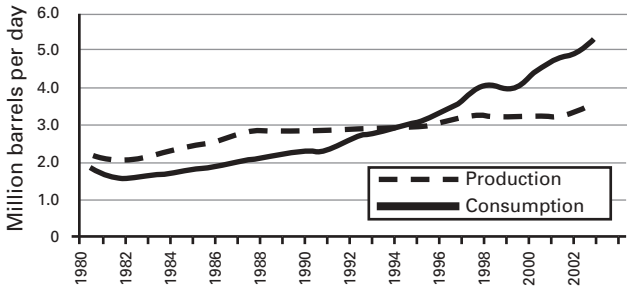


Source: China Sustainable Energy Project

Many cities in China are just now beginning to share in the automotive boom. The interior city of Chongqing is a striking example. Chongqing has a population of 30 million—nearly as many people as all of Canada—yet it already has roughly one-third as many buses as the entire US. And rising conventional automobile use here or in any number of other huge cities in China could have major ramifications for oil availability in the rest of the world.[26]

China's vehicle production has also grown rapidly in the past two decades. As recently as the early 1970s, a mere 5,000 passenger cars were manufactured in China per year, mostly for use by top Communist Party cadres. By 1980, total vehicle production jumped to 222,000; by 2002, production grew to over three million. Production in 2003 was estimated to exceed four million.

Figure 10 Trends in Total Oil Production and Consumption in China, 1980 to 2002



Source: US Energy Information Administration

China's Thirst for Oil

The growth of motor vehicles in China has created an enormous thirst for oil to fuel them. Estimated motor fuel use in China in 2001 totaled 16.6 billion gallons, roughly twice the amount used in 1991. China's fuel use is expected to continue to grow rapidly, to 22.2 billion gallons by 2005. Since 1980, total oil consumption has grown 191 percent, from 1.8 to 5.7 million barrels per day. But, as Figure 10 shows, domestic production has lagged, growing only 52 percent, from 2.1 to 3.3 million barrels per day.

Little oil exploration took place in China before the 1980s, and hopes were high that the country would be able to find and develop domestic supplies equal to its growing demand. However, when China launched efforts to become a major oil producer in the last decade, its hopes were dashed by low exploration returns and the enormous expense of building an oil distribution infrastructure from China's remote oil regions. Reserves of oil in China have proven to be very limited. Only about 2.3 percent of known global reserves, 24 billion barrels out of 1,068 billion barrels worldwide, are located in this country (see Figure 2, page 2).[27]

Stagnating oil production in the late 1980s and 1990s, while consumption soared, led inevitably to

[26]"Chongqing Express," *Chemical & Engineering News*, March 29, 2004.

[27]US Energy Information Administration, Country Analysis Brief, "China," June 2003, **http://www.eia.doe.gov**.

reliance on imported oil. The complete reversal in China's oil supply and demand dynamics is shown in Figure 11. A positive net oil balance—meaning domestic production exceeded demand—peaked in 1986, allowing China to export about 0.7 million barrels per day of oil in that year. The oil balance declined steadily and became negative in 1993, turning the country into a net oil importer.

In just four years, from 1994 to 1997, imports grew to 0.8 million barrels per day, or 20 percent of China's oil supply. (By comparison, it took nearly 20 years of gradually increasing oil imports for the US to reach that 20 percent oil import milestone in 1964.) Concerned, the Chinese government stepped in with a series of policies to control imports, incentives to increase domestic production, price increases to dampen demand, and a crackdown on smuggling. Nevertheless, oil imports in China grew to 32 percent in 2000, about equal to the US import level in l974, at the time of the highly disruptive OPEC embargo.

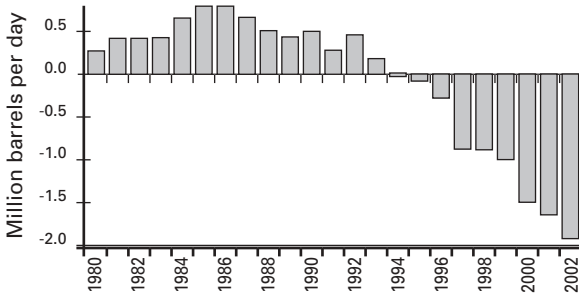
In 2002, Chinese oil imports rose to 36 percent of total demand. Suddenly, China was the world's third largest consumer of petroleum products, following the US and Japan. By the end of 2003, China had surpassed Japan to become the world's second largest consumer of oil.

China's oil demand is projected by the Energy Information Administration to reach 10.9 million barrels per day by 2025, with net imports of 7.5 million barrels per day. The International Energy Agency has projected that China will account for 10 percent of world oil consumption in 2020, compared to 7 percent today. Overall, China is expected to account for 23 percent of the total growth in oil use between 1995 and 2020. According to the International Energy Agency forecast, oil imports will account for 80 percent of oil use in China in 2020.[28]

Looking to Middle Eastern Oil Sources

Prior to the upswing in imports in the late 1990s, China relied mostly on nearby countries in Asia for the small amounts of oil that it needed to supplement domestic production. In 1990, for example, other Asian producers, mainly Indonesia, supplied 60 percent of China's imports, which were more than offset

Figure 11 From Oil Surplus to Oil Deficit in China, 1980 to 2002



Source: US Energy Information Administration

by exported oil. The remainder came from two Middle Eastern countries, Oman and Iran. By 1997, the relative amount of imports had switched: Asian imports dropped more than half to 26.2 percent, while Middle Eastern suppliers provided 47.5 percent.[29]

The shift to reliance on oil producers from the Middle East is perhaps the most significant and unsettling aspect of China's oil policy during the past decade. China is working hard to establish long-term relationships with these producers and to gain favorable trade partner status. For example, in one $1.5 billion deal, Saudi Aramco is offering to help finance the upgrading of two oil refineries in China in exchange for a long-term commitment to purchase crude oil from Saudi Arabia. Although international diplomacy has not yet resolved a host of thorny issues that plague this and other megaprojects, the headline of an article in the leading industry trade magazine, *Oil & Gas Journal*, could prove prophetic: "Long View of Caspian Oil Export Options Tilts to Kazakhstan-China."[30]

The Economic and Environmental Costs of China's Oil Dependence

China's oil imports in 2002, needed to meet 36 percent of its total demand, cost nearly $20 billion.

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[28]International Energy Agency, *China's Worldwide Quest for Energy Security,* Paris, 2000, **http://www.iea.org/dbtwwpd/textbase/nppdf/free/2000/china2000.pdf**.

[29]*Ibid.*

[30]R. Dion, "Long View of Caspian Oil Export Options Tilts to Kazakhstan-China," *Oil & Gas Journal*, June 7, 1999.

But the expanding number of vehicles on the country's roads has cost dearly also in terms of traffic congestion and public health. In China's megacities, vehicle travel speeds are frequently less than 15 miles per hour. As noted earlier, vehicle emissions are responsible for many of the 178,000 annual premature deaths in these cities, nine of which are among the ten cities in the world with the worst air pollution.

Figure 12 Growth in Motor Vehicles in India (thousand vehicles), 1986 to 2000

	Three-Wheelers	*Cars*	*Municipal*	*Commercial*	*Total*
1986	389	1,278	386	1,057	3,110
1991	763	2,281	731	1,744	5,519
1998	1,398	3,938	859	2,310	8,505
2000	2,510	4,715	1,104	2,386	10,715
Growth 1986 to 2000	545%	269%	186%	126%	245%

Source: Society of Indian Automotive Manufacturers

India: The Transportation Boom in the World's Second Most Populous Country

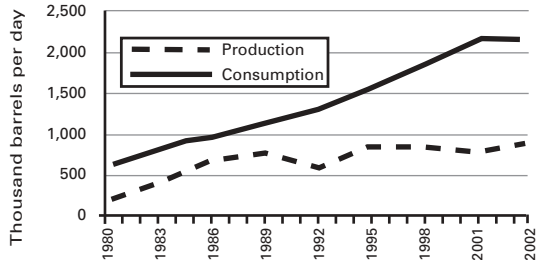
As in China, roadways in India since the 1980s have been flooded with a growing number of cars, municipal and commercial vehicles, and three-wheelers. The number of motor vehicles in India, as shown in Figure 12, jumped 245 percent between 1986 and 2000, to 10.7 million vehicles. Growth has been most extreme among the ubiquitous three-wheeled auto-rickshaws (widely used in taxi service), a market segment that grew by 545 percent during this period. More recent data suggest that India's total motor vehicle fleet now comprises more than 14 million vehicles.[31]

It is important to note that these data on India's vehicle population, and the comparable data for China, exclude tens of millions of two-wheeled motorcycles and motor scooters, which far outnumber the larger vehicles included in national surveys. There are now more than 40 million two-wheelers in India and more than 50 million in China. Per vehicle fuel use for two-wheelers is small compared to that of larger vehicles, but the contribution of these vehicles to urban noise and air pollution is quite severe. Two-wheelers account for more than 60 percent of the air pollution from transportation sources in many Indian cities.

India's Dependence on Imported Oil Has Surpassed China's

Oil consumption in India has tripled since 1980—from roughly 700,000 barrels per day to over 2.1 million barrels per day in 2002—mainly owing to the huge increase in the number of motor vehicles crowding the streets of major cities. While India's use of oil is less than half that of China and one-ninth that of the US, the subcontinent's dependence on this energy source started earlier and has been fed by imports to a much greater degree. Figure 13, which shows total oil production and consumption in India since 1980, makes clear how increasingly dependent the country has become on imported oil and how far oil production has lagged behind growth in consumption.

Figure 13 Trends in Oil Production and Consumption in India, 1980 to 2002



Source: US Energy Information Administration

[31] *Motor Transport Statistics of India*, cited by K. Gandhi, presentation, Society of Indian Automotive Manufacturers Seminar on Alternative Energy Driven Vehicles, New Delhi, India, January 2004.

A Bleak Outlook for India's Domestic Oil Production

India has little potential for increasing its domestic oil production. The country has only 5.4 billion barrels in oil reserves, roughly one-fifth the meager reserves of China or the US and just 0.44 percent of global oil reserves (see Figure 2, page 2). India's largest oil field, the offshore Bombay High, currently contributes less than 250,000 barrels per day. Total domestic oil production has languished at between 700,000 and 800,000 barrels per day since the late 1980s. Poor exploration results and low recovery rates compound India's oil woes.[32]

As a result, India has had to meet its growing demand for oil with imports, which have jumped from less than 500,000 barrels per day in 1980 to over 1.3 million barrels per day today. In the mid-1980s, imports accounted for only one-third of India's total oil supply; since the late 1990s, imports have accounted for nearly two-thirds of supply.

Until recently, India's oil import picture was complicated by a shortage of domestic oil refineries. As a result, the country had to import more costly refined oil products, including the gasoline and diesel needed by its motor vehicle fleet. In 1999, India increased its refining capacity to 2.1 million barrels per day with the opening of a major new oil refinery, allowing it to import less costly crude oil. However, India's refining ability is already once again at capacity, raising difficult financial questions about the need for new investments in oil refining.

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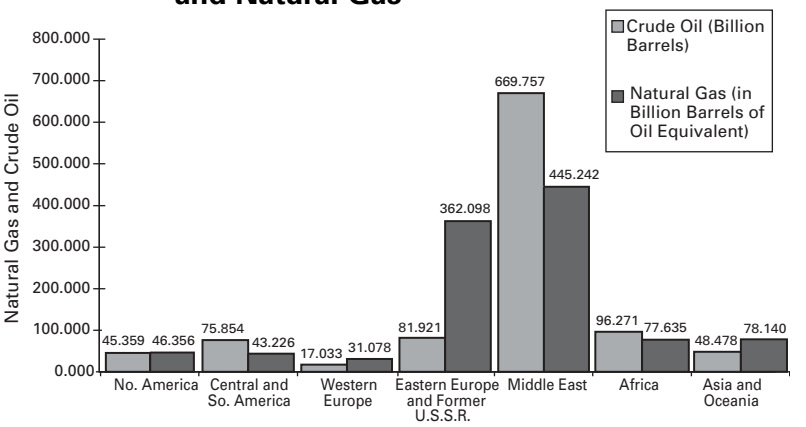
[32]US Energy Information Administration, Country Analysis Brief, "India," June 2003, **http://www.eia.doe.gov**.

3. Today's Challenge for China and India: Finding More Secure and Cleaner Transportation Fuels

Leaders in both China and India have grasped the challenges posed by their countries' soaring appetite for vehicles and the danger of relying on dwindling world oil supplies. They have seen the health impacts already caused by emissions from gasoline- and diesel-fueled vehicles, and they realize the urgency of making a transition—certainly within a decade or two—to a less polluting, more secure fuel.

Figure 14 World Reserves of Oil and Natural Gas



Source: US Energy Information Administration

Putting Natural Gas Vehicle Technology to Work

China and India, like a number of other countries around the world, have assessed their options and chosen to launch ambitious programs taking advantage of natural gas as a transportation fuel. They have chosen this alternative for many reasons:

- Global reserves of natural gas are more widely distributed than those of oil (Figure 14), and are located in areas more stable than today's Middle East. As a result, supplies over the long term may be more secure than those of oil.[33]
- Natural gas vehicles (NGVs) of many types—from sedans, pickup trucks, and vans to transit and school buses to refuse trucks—are commercially available now, after 20 years of development. Today, over three million natural gas vehicles travel the world's roadways.
- NGVs are as safe as (and arguably safer than) vehicles powered by gasoline or diesel. In case of accident, liquid fuels escaping from a ruptured fuel tank pool on the ground, where a single spark can cause a lethal vehicle fire or explosion. In contrast, should a rupture occur in a natural gas canister, the gas (which is lighter than air) rises and dissipates harmlessly.
- The infrastructure and technologies needed to produce, transport, store, and refuel with natural gas are well developed.
- Natural gas vehicles are significantly less polluting than their gasoline-fueled counterparts. Light-duty vehicles emit more than 90 percent less carbon monoxide, 60 percent fewer nitrogen oxides, 80 percent fewer hydrocarbons, and 30 to 40 percent less carbon dioxide. In medium- and heavy-duty applications, natural gas vehicles have demonstrated reductions of more than 90 percent in carbon monoxide and particulate matter and more than 50 percent in nitrogen oxides relative to commercial diesel engines.[34]
- Heavy-duty natural gas transit buses and refuse trucks are dramatically cleaner than diesel fleets serving the public in urban areas. In 2002, an analysis of the US refuse truck sector found that nearly 700 natural gas-powered garbage trucks were in use throughout the country, and that these trucks generated as much as 94 percent less particulate pollution

[33]US Energy Information Administration, *International Energy Outlook 2004*, April 2004, **http://www.eia.doe.gov/oiaf/ieo/oil.html.**

[34]US Department of Energy, Alternative Fuels Data Center, "Natural Gas Benefits," May 2004, **http://www.eere.energy.gov/cleancities/afdc/altfuel/gas_benefits.html**.

(and up to 98 percent less noise) than their diesel counterparts.[35] By 2004, the US fleet of natural gas garbage trucks had expanded to more than 1,300, with more than 500 on order but not yet delivered.[36]

In just the past few years, both China and India have become major users of natural gas vehicles. India now ranks fifth in the world and China seventh in total numbers of NGVs. Together, the two countries account for about 10 percent of the world's NGV population of three million vehicles. Figure 15 lists the top ten countries in terms of the size of their NGV fleets. India, the US, and China rank fifth, sixth, and seventh, respectively.

Figure 15 Top Ten Users of Natural Gas Vehicles

	NGVs	*Fueling Sites*
Argentina	1,200,000	1,105
Brazil	600,000	600
Pakistan	410,000	423
Italy	400,000	463
India	200,000	185
US	140,000	1,300
China	69,300	270
Venezuela	50,000	140
Egypt	49,111	79
Ukraine	45,000	130

Source: International Association for Natural Gas Vehicles, 2004

China: Seventh Place in the Use of NGVs

China has sizable natural gas resources—roughly 55 trillion cubic feet—although the fuel currently contributes only about 2 percent of the country's total energy supply. However, as China grapples with its huge environmental challenges, it is increasingly turning to natural gas as a cleaner alternative in all energy sectors, including transportation.

In China, the use of natural gas as a transportation fuel dates to the 1950s, when natural gas produced in Sichuan Province was used to power local buses in Chengdu, the province's capital, and other cities in the region. In the 1990s, China initiated a number of natural gas vehicle demonstration programs in other locations. By 1997, there were approximately 2,500 NGVs in China, served by 35 refueling stations. By 2001, China's fleet of NGVs exceeded 36,000 vehicles, out of 1.7 million NGVs operating worldwide. There are currently almost 70,000 NGVs of all types operating in China.[37]

Completion in 1997 of the first pipeline supplying natural gas to Beijing inspired the launch of a major NGV program in China's capital. This program already has placed 2,800 natural gas buses into service in Beijing, far more than in any US city. By the time the Beijing Olympics convene in 2008, about 90 percent of the city's buses, which now number 11,000, are projected to be powered by natural gas. Major bus conversion projects are under way in about ten other Chinese cities as well. More progress will undoubtedly take place before the Olympics, which China sees as an international showcase for advanced transportation technologies.[38]

More than two-thirds of China's NGVs are buses and taxicabs serving the mass transit needs of urban populations. The rest are mostly scattered among other public and private fleets. Figure 16 shows the distribution of natural gas-powered buses and taxicabs in major cities in China.

Figure 16 Natural Gas Buses and Taxis in China's Major Cities

	Buses	*Taxicabs*
Beijing	2,800	0
Shanghai	430	0
Tianjin	300	500
Chonqing	3,800	1,200
Sichuan	6,670	25,900
Ulumuqi	1,910	570
Xi'an	697	3,280
Changchun	404	0
Jinan	750	0
Langfan	200	340
Puyang	250	970

Source: China Sustainable Energy Project

[35]D. Gordon *et al.*, *Greening Garbage Trucks: New Technologies for Cleaner Air*, INFORM, Inc., 2003, **http://www.informinc.org/ggt.php**.

[36]INFORM, Inc., 2004.

[37]International Association for Natural Gas Vehicles, **http://www.iangv.org**.

[38]D. He, "Government NGV Policy and Programs: China," International Association for Natural Gas Vehicles Better Air Quality 2003 conference, Manila, Philippines, December 2003.

India: Surpassing the US in NGVs with New Delhi the World's Largest Urban User

In 2003, India surpassed the US population of 146,000 NGVs to become the fifth largest user of these vehicles in the world, with 200,000 NGVs nationwide. India has built 185 natural gas refueling stations to serve its NGV fleet. In the past five years, spurred by a Supreme Court mandate, vehicle operators in New Delhi have converted more than 13,000 buses and 50,000 three-wheeled auto-rickshaws to cleaner-burning natural gas. Most of these vehicles are operating in a few major cities—New Delhi and Mumbai in particular. New Delhi has the largest number of NGVs per capita of any city in the world.[39]

With continued government clean air directives, the number of NGVs in India is growing very rapidly, spurred on by the courts. In July 1998, the Supreme Court of India ordered the conversion of selected vehicle fleets in Delhi to natural gas by March 2001. Other court actions involved the banning of leaded gasoline and the requirement that new cars meet Euro II emission standards. These actions were taken in response to a 1985 lawsuit filed by M.C. Mehta, an activist and concerned citizen who invoked his constitutional right to fight the government's failure to protect the environment. For more than a decade after the suit was filed (not an uncommonly long period for the Indian legal system), government legislative and regulatory agencies initiated a number of environmental programs, but they failed to make a dent in motor vehicle pollution. The Supreme Court then stepped in and issued its natural gas conversion order and other mandates.[40]

India's NGV program has been aided by favorable prices (set by the government) for compressed natural gas, which are slightly more than half the price of gasoline and one-third the price of diesel. Even so, the launch of the program was a near disaster, as refueling stations were not built in time to supply the rapidly growing NGV fleet. At one point, New Delhi removed 80 percent of its buses from the road owing to lack of fuel, and the remaining natural gas buses and cabs faced waiting times of up to eight hours to refuel. Drivers, often supported by diesel engine manufacturers and fuel providers, picketed government offices demanding a withdrawal of the Supreme Court order.

The court refused to repeal its directive, but it did respond to NGV fleet operators' complaints by granting a series of delays from the March 2001 deadline. It also ordered the acceleration of fueling station construction. The program implementation problems have now been largely resolved, and the Indian NGV fleet is functioning well.

Figure 17 Growth in NGV Fleets in New Delhi and Mumbai, India, 1988 to 2003

Vehicle Category	*New Delhi*		*Mumbai*	
	1998	*2003*	*1998*	*2003*
Buses	6	8,874	10	46
Three-Wheeled Vehicles	0	49,810	0	35,678
Rural Transport Vehicles	0	4,934	0	0
Taxicabs	400	5,155	5,590	4,816
Private Cars	1,000	10,350	958	10,350
Total Vehicles	1,406	79,123	6,558	57,240
Natural Gas Fueling Sites	9	107	7	46

Source: Gail (India) Limited

NGV programs in India have focused on converting three-wheeled auto-rickshaw taxicabs, conventional four-wheeled taxicabs, and municipal transit buses. Figure 17 shows the distribution of NGVs in New Delhi and Mumbai as of March 2003. There are now nearly 81,000 NGVs in

[39]K. Gandhi, presentation, Society of Indian Automotive Manufacturers Seminar on Alternative Energy Driven Vehicles, New Delhi, India, January 2004.

[40]R. Greenspan Bell *et al*., "Clearing the Air: How Delhi Broke the Logjam on Air Quality Reforms," *Environment Magazine*, March 2004.

Delhi alone, including more than 13,000 buses, 50,000 auto-rickshaws, and 9,770 sedan taxis. These are served by more than 100 fueling stations. Another 57,240 NGVs are operating in Mumbai, including 35,600 auto-rickshaws, 4,800 taxicabs, and 10,350 private passenger cars. Other Indian cities with smaller NGV fleets include Vadodara, Surat, and Ankaleshwar. The government is now considering issuing a new directive requiring the use of natural gas in selected fleets in 16 additional cities served by pipeline distribution systems.[41]

NGV Initiatives in India Result in New Markets for Vehicle Suppliers

In 2004, several international suppliers of NGV equipment made announcements about their marketing efforts in India. Cummins Westport, a Canadian developer of heavy-duty natural gas engines, signed a memorandum of understanding with Cummins India in Pune that is expected to lead to a licensing and production agreement for its B series natural gas engine in India. Cummins India Ltd. is a 51 percent subsidiary of Cummins Inc., headquartered in Columbus, Indiana. Engine production is likely to begin in 2005 at the Cummins India Daman manufacturing site in western India. Through this project, Cummins India will extend its product line of natural gas engines to meet the growing horsepower and performance requirements of the transit bus market in India. The company is already the leading provider of natural gas engines for bus applications in India, with an installed base of approximately 4,000 buses.[42]

Dynetek Industries, Ltd., another Canadian company that manufactures natural gas and hydrogen high-pressure fuel storage cylinders, has signed a collaboration agreement with Veecon-IPA Gastechnik Ltd., headquartered in New Delhi, to market Dynetek's line of advanced lightweight fuel storage units in India and Bangladesh. The companies hope strong sales in India will help them expand the marketing of these cylinders throughout Asia.[43]

The Long-Term Role of NGVs: A Step Forward on the Path to Hydrogen

Natural gas vehicle programs in China and India are beginning to stem the tide of oil dependence in the transportation sector and environmental devastation that are critical near-term concerns of both nations. Perhaps even more important, INFORM's research over the past decade indicates that these programs are helping to pave the way to the hydrogen fuel cell vehicles of the future (see Figure 4, page 5).[44]

Leaders in both India and China have joined a growing consensus of energy experts around the world who see hydrogen as the long-term panacea to the world's oil dependence, offering a totally pollution-free, unlimited, and renewable energy resource. And while the link between natural gas and hydrogen has not been a major planning factor in these nations' aggressive adoption of NGVs, INFORM's research has documented the crucial role of natural gas in building a transition path to hydrogen:

- First, natural gas is today's most available and affordable source for making hydrogen (it has been the main hydrogen feedstock for the US space program for almost four decades). Unlike oil, which is 36 percent carbon and 64 percent hydrogen, natural gas is only 20 percent carbon and 80 percent hydrogen. With four hydrogen atoms and one carbon atom, natural gas is just one atom away from pure hydrogen, and the bonds between the atoms can be broken using a proven technology called steam reforming.
- Second, the natural gas refueling stations now being built to serve growing fleets of NGVs can be used as fuel production and distribution platforms for the first generation of hydrogen-powered vehicles. Adding a steam reformer and a hydrogen compressor to a natural gas refueling site makes it possible to produce hydrogen either for use in a fuel that combines natural gas and hydrogen, which is

[41]A. Dixit, presentation, Society of Indian Automotive Manufacturers Seminar on Alternative Energy Driven Vehicles, New Delhi, India, January 2004.

[42]Cummins Westport, press releases, **http://www.cummins westport.com.**

[43]Dynetek Industries, press releases, **http://www.dynetek.com**.

[44]James S. Cannon, "Gearing Up for Hydrogen," INFORM, Inc., March 1998, **http://www.informinc.org/gearinghydrogen.php**.

much cleaner than natural gas alone, or for use in fuel cell vehicles. Both natural gas and hydrogen can also be manufactured from a wide range of agricultural wastes commonly found throughout Asia.

- Third, many of the components developed over the past decade for use in NGVs—for example, the fuel storage and management equipment needed in vehicles powered by a gaseous fuel under pressure, rather than by a liquid fuel—are similar to those that will be needed in vehicles powered by hydrogen.
- Fourth, the use of NGVs provides drivers as well as maintenance and repair personnel with the learning curve needed for dealing with vehicles powered by a gaseous rather than a liquid fuel.

Because of these overlaps, promotion of NGVs in China and India—undertaken for their immediate air quality and energy security benefits—is also laying the groundwork for the use of hydrogen fuel cell vehicles in the longer term.

Hydrogen: Powering Vehicles for the 21st Century

The emergence of hydrogen as a key energy commodity in the twenty-first century could rival the growth of electricity in the twentieth century. The two commodities have much in common. Neither exists in nature in a usable state; both must be manufactured. Electricity is generated from the burning of fossil fuels, from nuclear heat, or from a variety of renewable resources. Hydrogen can be produced by extracting it from any one of a number of common materials, including not only water but also natural gas, methanol, or (with greater difficulty and cost) coal. Both hydrogen and electricity can be manufactured on a large scale or locally. Electricity uses power lines for distribution. Hydrogen can be distributed to the point of use by pipeline or truck, or it can be used at its point of generation, for example, at a fuel cell vehicle fueling station.

Once produced, both hydrogen and electricity can be either used directly or stored for future use. Electricity can travel through transmission lines for immediate use, or it can be stored in a battery or some other storage device. Gaseous hydrogen—which consists of two bound hydrogen atoms—can be burned directly as a fuel or fed into fuel cells to generate electricity. It can be stored in compressed-gas tanks or another storage system until needed.

Hydrogen storage systems, however, are emerging as vastly superior to electrical storage systems. While both systems are basically "carriers" of energy to the motor, vehicles powered by electricity stored on board in a battery have not succeeded in the transportation marketplace. This is because the batteries have never been able to overcome their inherent limitations. They are heavy, toxic, slow to respond to power demand, and slow to recharge. In contrast, vehicles powered by electricity made by feeding hydrogen through an on-board fuel cell promise to overcome the limitations of batteries.

Asia Explores the Hydrogen Future

Global expenditures on hydrogen-related research and development now amount to hundreds of millions of dollars each year. Most of this work is being done in North America, Japan, and Western Europe. However, the contributions of other nations, such as China and India, are growing, and both countries recently launched hydrogen development programs.

China's Hydrogen Program

The Ministry of Science and Technology in Beijing invested tens of millions of dollars in fuel cell research during the Ninth Five-Year Plan (which ended in 2000) and has approved a $120 million fuel cell program as part of its Tenth Five-Year Plan (2001 through 2005). Two major fuel cell research groups—at Tsinghua University and Tongji University—have led in the development of fuel cell city buses and car platforms. Several hydrogen fuel cell vehicles have been built in China during the past five years. China has also undertaken a fuel cell bus project with the Global Environment Facility and the United Nations Development Programme. A total of $32 million will be spent

on six advanced buses for Beijing and Shanghai. This progress is impressive, but it is still only a drop in the bucket compared to the $1.7 billion US program or the expenditures of major automakers on fuel cell prototypes in Japan and Europe.[45]

India: The First Steps for Its Hydrogen Initiative

India's hydrogen program is only beginning, but the country has some important efforts under way. The University of Madras has been a leading center of hydrogen energy research for several decades. Moreover, researchers at Banaras Hindu University have experimented with a wide variety of advanced materials capable of storing hydrogen on board fuel cell vehicles; in 2002, they built and tested a fuel cell-powered motorcycle. The US Agency for International Development is currently funding a project to build the first hydrogen fuel cell-powered auto-rickshaw in India, now scheduled for completion in late 2004. In February 2004, the Indian government formed a panel of automotive and energy experts to develop a national hydrogen energy "roadmap" for the country that will address hydrogen production, storage, distribution, and end use applications.[46]

In April 2004, the Indian Oil Corporation launched a $22.7 million Hydrogen Blue Print initiative that will include the use of a blend of hydrogen and compressed natural gas to power the company's bus fleet. The hydrogen will be produced at its Mathura or Panipat refinery. No engine modifications will be needed as long as a maximum of 10 percent hydrogen is blended with the natural gas. The buses are scheduled to be operational in 2005.

Realizing Asia's Hydrogen Vision: Decades Away

Despite the hydrogen fuel cell initiatives under way in China and India, hydrogen developments in both countries are primitive. Indeed, the barriers to commercialization of the key elements in the hydrogen economy anywhere in the world remain large.

Hydrogen is relatively easy to produce using steam reforming to extract it from natural gas, but economically viable small-scale steam reformers are not yet fully commercial. And while it is already feasible to produce hydrogen from water using energy from solar resources (solar thermal power, wind power, or geothermal power), few solar energy generation facilities exist and no fuel distribution system is in place to deliver this fuel to vehicles. Similarly, functioning fuel cell vehicles can be built today, but the cost of fuel cells capable of converting hydrogen into electricity is still at least ten times higher than what many experts believe would be acceptable in the commercial marketplace.

While fuel cell vehicles and vehicles that burn hydrogen directly in a modified internal combustion engine are being built today, it may be 20 years or more before hydrogen-powered vehicles begin to make a dent in the transportation economy. It took two decades of research and development before natural gas-powered vehicles and refueling capabilities could be marketed commercially. A recent report from the National Research Council concluded that hydrogen fuel cell vehicles would not make a significant impact on petroleum consumption until 2050.[47] Thus, while progress is being made, implementation of the hydrogen energy economy as a solution to oil dependence and pollution problems in transportation is currently a long-term strategy, and carefully designed transition steps are needed for getting there that will bring the fully commercial vehicles and vehicle maintenance and refueling capabilities together.

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[45]"China Announces New Investment in Auto Fuel Cell Development," *The Clean Fuels and Electric Vehicles Report*, March 2002.

[46]Indo-Asian News Service, press release, February 24, 2004.

[47]National Research Council, *The Hydrogen Economy: Opportunities, Costs, Barriers and R&D Needs*, National Academies Press, 2004, **http://www.nap.edu/books/0309091632/html.**

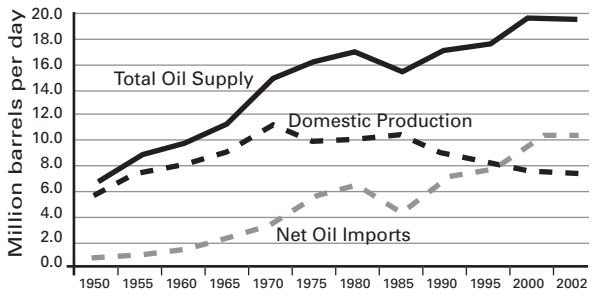
4. The United States:
A Century of Unbridled Oil Use

While oil consumption in China and India has begun to soar, no country in the world uses more oil or is more dependent on foreign sources of oil than the United States. Largely because of its transportation sector, the US, with just 5 percent of the world's population, today accounts for 25 percent of the world's oil consumption.

220 Million Cars, Buses, and Trucks: The Root of the US Oil Addiction

The 220 million cars, buses, and trucks on US roads are the main reason for this country's steadily rising dependence on foreign oil. In the 25 years from 1975 to 2000, because of public policy pressures and competition from other fuels, US oil use in all sectors—except transportation—fell 17 percent. By contrast, during that same period, oil use for transportation rose 43 percent. The US was actually an oil-exporting nation until 1947. But by 1973—the year that OPEC embargoed oil to the US in retaliation for this country's support of Israel—it had become reliant on foreign sources for 35 percent of its oil. By 1992, the US relied on foreign supplies for 40 percent of its oil, a figure that has risen to 63 percent today. Vehicles now account for 66 percent of all the oil consumed in the US, or 13.2 out of 20 million barrels a day.[48] The trend in overall oil production and use in the US is shown in Figure 18.

Figure 18 Trends in US Oil Supply and Demand, 1980 to 2002



Source: US Energy Information Administration

Why Has the Use of Oil in US Transportation Soared?

There are several reasons for the soaring use of motor fuels in the US:[49]

- The steadily growing vehicle population, which increased from just 8,000 licensed vehicles in 1900 to 17 million in 1925 to more than 40 million in 1950 to 108 million in l970—a number that has more than doubled in just the past 35 years. In the US today, cars alone account for 204 million of the nation's 220 million vehicles.
- Expanded rates of vehicle ownership, from fewer than 100 vehicles per 1,000 people in 1900 to 850 vehicles per 1,000 people in 2000.
- More vehicle miles traveled per person—an increase of 63.5 percent between 1975 and 2000 alone.
- The increasing popularity of vans, pickup trucks, and sport utility vehicles (SUVs), which barely existed as an option in the l960s but which today account for almost half the personal vehicles purchased. The inefficient use of fuel by most SUVs (12 to 15 miles per gallon) has long since outweighed the impressive fuel efficiency gains made in the l970s and '80s. SUVs are the main reason the US reached a 22-year low in average vehicle fuel efficiency in 2003.

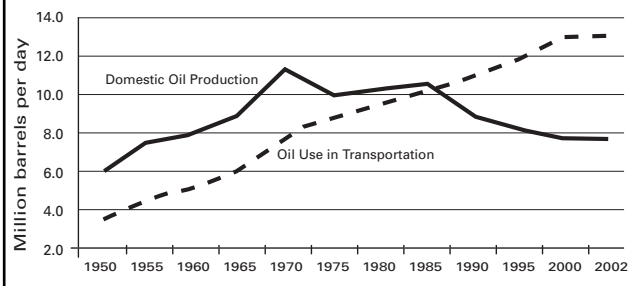
In short, today in the US, more cars are driven more miles per person than in any other country in the world.

[48]US Department of Energy, "Annual Energy Review 2003," **http://www.eia.doe.gov/emeu/aer/contents.html.**
[49]All data from US Bureau of Transportation Statistics, *National Transportation Statistics 2003*, **http://www.bts.gov/publications/national_transportation_statistics/2003/index.html.**

Growing Oil Demand and Declining Domestic Production

As the US transportation sector's demand for oil has steadily climbed, production has declined. Since its historic peak in 1970, oil production in the US has dropped more than 25 percent. And since 1986, oil use in transportation alone has exceeded total domestic production. This decline is charted in Figure 19.

Figure 19 Trends in Total US Oil Production and Oil Use in Transportation, 1950 to 2002



Source: US Energy Information Administration

The outlook for oil production in the US has become increasingly poor, not just because efforts to find oil have slackened in this country but also because there is less oil left to recover. The known US oil reserves amount to 22.6 billion barrels, less than 2 percent of the known global oil reserves.[50] Were the US forced to rely on its domestic oil resources (assuming it had the ability to tap into all of them), those 22.6 billion barrels would be barely enough to meet demand for three years (see Figure 2, page 2). (The Strategic Petroleum Reserve is only intended to meet short-term needs, and contains enough oil to meet demand for about two months.)

Gasoline and Diesel Dependence: Putting US Security and Economic Strength at Risk

Over the past 30 years, the US economy has been increasingly weakened as reliance on foreign oil has grown. During this period, the 25 largest oil companies slashed more than a million jobs. From 1982 to 1999, employment in the oil and gas industries shrank from a peak of 1.65 million employees to about 640,000. Over the past 12 years, US oil companies have shed an average of 5.2 percent of their work force annually.[51] These jobs have been sent abroad to those that produce and deliver oil to US shores, causing not only a loss of jobs domestically but also a loss of millions of dollars in tax revenues.[52] Further, the US has had to send billions of dollars abroad to buy this oil. In 2003 alone, US consumers paid about $97 billion for imported oil, the equivalent of roughly $346 per person, money that could have been invested in our domestic economy.[53]

The several oil supply disruptions and price hikes that have occurred since 1970 have each wreaked additional economic havoc, and show just how vulnerable the US might be today in the event of price spikes or supply interruptions by foreign sources of oil, which now control 11 million barrels of the 20 million barrels consumed by the US each day. The oil embargo of l973, imposed by the Arab OPEC nations, caused the price of crude oil to quadruple within a period of months. Within 18 months, unemployment more than doubled, inflation tripled, and millions of frustrated consumers sat in long gas lines waiting to refuel their cars.[54]

Another severe disruption occurred from l979 to 1980, caused by the Iranian Revolution and the Iran-Iraq war. This time the impact included a 20 percent

[50]US Energy Information Administration, *International Energy Outlook 2004*, April 2004, **http://www.eia.doe.gov/oiaf/ieo/oil.html.**

[51]International Labour Organization, "The promotion of good industrial relations in oil and gas production and oil refining," Geneva, 2002, **http://www.ilo.org/public/english/dialogue/sector/techmeet/tmor02/tmor-r.pdf.**

[52]Milton R. Copulos, *America's Achilles Heel: The Hidden Costs of Imported Oil*, National Defense Research Foundation, October 2003.

[53]US Energy Information Administration, "Value of Crude Oil Imports From Selected Countries, 1973-2003," **http://www.eia.doe.gov/emeu/aer/txt/ptb0520.html.**

[54]Milton R. Copulos, *America's Achilles Heel: The Hidden Costs of Imported Oil*, National Defense Research Foundation, October 2003.

jump in unemployment and double-digit inflation rates driven by high oil prices and interest rates. The economic impact of the Iranian Revolution and the war combined has been estimated at more than $1,104 billion.[55]

Most recently, the Persian Gulf War of 1990 to 1991 took its toll. That war, waged at least in part to protect US oil sources, involved close to 540,000 Americans in the military, about $61 billion in military costs (of which the US paid $6 billion), $39 billion in higher oil prices, and a related decline in the US economy.[56] More than 1.1 million jobs were lost, and unemployment rose 75 percent.

These three oil supply disruptions all occurred when the US was far less dependent on foreign oil than it is today. And during the Persian Gulf War, the ability of this country and its allies to conduct their military operations was due to the support of Saudi Arabia and other Gulf oil producers, countries that are now becoming less and less sympathetic to US interests.

According to the 2003 report *America's Achilles Heel: The Hidden Costs of Imported Oil*, the total economic penalty that the US pays for its reliance on foreign oil averages $248 to $255 billion a year. Adding to this the military costs of protecting our Persian Gulf oil sources (soldiers, equipment, supplies, transport, military bases, etc.), the US has been drained of between $297.1 and $304.1 billion a year.[57]

Precarious as US oil supplies are today—with 25 percent of our imports coming from the unstable Persian Gulf region (a region that controls two-thirds of the world's oil reserves)[58] and with Asia competing aggressively to meet its own supply needs—loss of even some of the imported oil on which this country relies would create a huge economic crisis, a severe fuel crisis in the huge US transportation sector, and a severe national security crisis as well. At this point in US history, a major spike in the price of oil, a cutback in supplies, a loss of supplies to Asian markets, or even, with terrorism growing, an attack on any of Saudi Arabia's eight huge oil fields or on its oil processing facilities, pipelines, or tankers would have devastating effects. Closer to home, US oil supplies could be endangered as well by a disruption or successful attack on the 800-mile-long Trans-Alaska Pipeline (TAP).

US Gasoline and Diesel Dependence: Taking a Toll on Public Health and the Stability of the Global Climate

Once oil is in hand and burned in motor vehicles, its emissions cause roughly two-thirds of the air pollution in most US cities. Smog—mainly ozone pollution caused by vehicle emissions—and the small particles from diesel exhaust get inhaled deeply into the lungs, causing significant respiratory distress. A US Environmental Protection Agency report concludes that roughly 158 million residents of the US live in areas where air quality is in violation of at least one of the six principal air pollutant standards set to protect public health.[59] In the vast majority of areas that experience unhealthy air, the major culprits are nitrogen oxides, volatile organic compounds, and particulates emitted by motor vehicles.

Children, whose developing bodies make them more vulnerable than adults to environmental contaminants, as well as the elderly suffer most from vehicle-related air pollution, which is the primary culprit in the virtual epidemic of asthma currently sweeping the US. More than 15 million Americans—including nearly five million children—are affected by this disease.[60] According to the Pew Environmental Health Commission, while asthma rates between 1980 and 1994 rose 75 percent among the US

[55] *Ibid.*

[56] *Ibid.*

[57] *Ibid.*

[58] US Energy Information Administration, *International Energy Outlook 2004*, April 2004, **http://www.eia.doe.gov/oiaf/ieo/oil.html.**

[59] US Environmental Protection Agency, *Greenbook Nonattainment Areas for Criteria Pollutants*, "Currently Designated Nonattainment Areas for All Criteria Pollutants," August 3, 2004, **http://www.epa.gov/oar/oaqps/greenbk/ancl3.html**.

[60] National Heart, Lung, and Blood Institute, "Who Gets Asthma?" **http://www.nhlbi.nih.gov/health/dci/Diseases/Asthma/Asthma_WhoIsAtRisk.html.**

population overall, the rate of increase among children under four was 160 percent. The commission forecast that the incidence of asthma could more than double between 2000 and 2020, from 14 million to 29 million.[61]

While not all the reasons for these rising asthma rates are understood, diesel emissions are widely recognized as a significant trigger of attacks. Furthermore, a growing number of public health organizations in the US and abroad have linked diesel emissions with cancer. The National Institute for Occupational Safety and Health, the International Agency for Research on Cancer, and the US Environmental Protection Agency have identified these emissions as, respectively, a "potential," a "probable," and a "likely" human carcinogen.

Finally, emissions from the US population of 220 million vehicles account for 25 percent of the greenhouse gases that have made this country the world's largest contributor to global climate change. These emissions—growing at an annual rate of 0.9 percent since 1990[62]—combined with the US refusal to support the 1992 Kyoto Protocol, have resulted in growing friction with countries around the world that are resentful of the high resource consumption patterns of the US and its failure to show good faith efforts to slow its greenhouse gas emissions.

The Rise and Stall of Natural Gas Vehicle Programs in the US

Every natural gas vehicle on US roads means progress—today—in reducing oil dependency, making the air cleaner and healthier, and creating jobs in the technologies of the future. According to US Energy Information Administration data, natural gas use in motor vehicles displaced more than 170 million gallons of gasoline and diesel in 2002. Although just a drop in the bucket compared to the 177 billion gallons of gasoline and diesel consumed that same year, this is a step in the right direction, taken in a difficult economic environment.

Natural gas vehicles are improving our environment both directly and indirectly. These vehicles meet the strictest air pollution control standards in the world, such as the super-ultra-low-emission vehicle (SULEV) standards set by the California Air Resources Board. SULEVs are more than 90 percent cleaner than the cleanest vehicles required by the US Environmental Protection Agency.

An indirect benefit of NGVs is the competitive pressure they have created in the marketplace, which has prompted automakers and oil companies to focus on improving the environmental performance of gasoline and diesel vehicles. For example, the development of cleaner grades of reformulated gasoline and ultralow-sulfur diesel, which has helped to reduce the environmental footprint of oil-fueled vehicles, might well not have occurred without the pressure created by the presence of NGVs already capable of achieving the very high levels of pollution control now found in conventional vehicles that burn the new fuels.

In China and India—countries that are just beginning to build their transportation systems and are not yet dominated by the oil-based transportation interests that have become so entrenched in the US—the twin goals of reducing dependence on precarious sources of foreign oil and protecting public health have stimulated the aggressive promotion of natural gas vehicles, especially for urban fleets.

Not so in the US. Here, alternative-fuel vehicle (AFV) programs, launched energetically 15 years ago with the same goals as those embraced by India and China, today have slowed to a crawl. As a result, the US bears the increasingly severe national security, economic, and health impacts of its growing reliance on foreign oil. Furthermore, its auto and fuel makers stand to lose out in the burgeoning global market for cleaner vehicles.

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[61]Pew Environmental Health Commission, *Attack Asthma: Why America Needs a Public Health Defense System to Battle Environmental Threats*, Executive Summary and Commission Recommendations, April 2000, **http://healthyamericans.org/reports/files/asthma.pdf.**

[62]US Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2002*, Executive Summary, November 2003, **http://www.eia.doe.gov/oiaf/1605/ggrpt/summary/pdf/0573(2002es).pdf.**

Figure 20 Growth in Alternative-Fuel Vehicles in the US, 1995 to 2004

	Liquefied Petroleum Gas (Propane)	*Natural Gas*	*Ethanol*	*Electricity*	*Methanol*	*Total*
1995	172,806	50,821	1,663	2,860	18,705	246,855
1996	175,585	60,807	4,897	3,280	20,437	265,006
1997	175,679	69,384	9,477	4,453	21,212	280,205
1998	177,183	79,954	12,802	5,243	19,848	295,030
1999	178,610	92,949	24,618	6,964	19,162	322,303
2000	181,994	102,840	87,574	11,830	10,426	394,664
2001	181,994	114,427	100,303	17,847	7,827	422,398
2002	185,053	123,547	120,951	33,047	5,873	468,471
2003	187,860	136,018	133,776	45,656	4,917	508,047
2004	194,389	146,876	146,195	55,852	4,592	547,904
2004 as % of Total	35%	27%	27%	10%	<1%	

Source: US Energy Information Administration

Money and Mandates: Jump Starting US Alternative-Fuel Vehicle Growth, 1992 to 2000

More than a decade ago, the US established one of the strongest programs ever to promote the use of alternative fuels: the 1992 Energy Policy Act (EPACT). To prevent the need for future wars over access to oil, this law, enacted after the Persian Gulf War, established ambitious mandates requiring government and other fleet operators to switch to alternative-fuel vehicles. Its goal was to displace 10 percent of petroleum-based fuels with alternative fuels by 2000 and 30 percent by 2010. EPACT targeted federal and state fleets and fuel-provider fleets—particularly those owning, leasing, or controlling at least 20 light-duty vehicles in the US. It targeted geographic areas with populations of 250,000 or more. EPACT was coupled with millions of dollars in financial incentives to promote progress. Another important law, the Clean Air Act Amendments of 1990, ratcheted down vehicle emission standards to force better pollution controls, as well as encourage replacement of oil with cleaner alternative transportation fuels.

According to the US Energy Information Administration, over 500,000 alternative-fuel vehicles are now on US roads, including 146,000 NGVs, largely as a result of these federal actions. Figure 20 shows the history of AFV use in the US and the results of the EIA's latest inventory. Vehicles powered by natural gas (the cleanest and most abundant of the domestically available alternative fuels) made a strong showing during the l990s, growing from 50,000 vehicles in 1995 (up from roughly 20,000 in 1992) to more than 146,000 vehicles in 2004.

Natural gas has been the most successful of the non-petroleum alternative fuels and its use has been greatest among heavy-duty vehicles, particularly the urban transit bus market, which is driven by clean air goals. Virtually nonexistent in 1990, natural gas buses now total nearly 7,000 and account for 12 percent of the US transit fleet. Nearly 25 percent of pending bus orders specify natural gas as their fuel.[63] Natural gas is also beginning to make inroads among refuse trucks, with more than 1,300 out of the US fleet of 179,000 refuse trucks having been shifted from diesel to this cleaner-burning fuel by 2004.[64] The most extensive research on alternative-fuel use conducted in this sector found that, compared to diesel-fueled refuse trucks, natural gas trucks emit from 67 percent to 94 percent less particulate matter, from 32 percent to 73 percent fewer nitrogen oxides, and from 69 to 83 percent fewer nonmethane hydrocarbons; they are also up to 98 percent quieter

[63]American Public Transportation Association, *Transit Vehicle Database*, April 2004.

[64]INFORM, Inc., 2004.

than their diesel counterparts.[65] Over 2,000 CNG-powered school buses are in operation nationwide.

The progress of the 1990s can best be viewed as a hard-won victory by the NGV industry in its battle to create some competitive fueling options in the transportation sector. In addition to bearing the costs of manufacturing new vehicles and installing new refueling infrastructure, the industry faced some of the cheapest gasoline and diesel prices of any industrialized nation—fuels that were delivered to consumers through about 130,000 fueling stations nationwide,[66] compared to about 1,021 fueling sites for natural gas.[67] All in all, growth in the natural gas industry has been achieved despite competition from one of the greatest economic powers in the country—the oil industry, which is responsible for one out of every six jobs—and despite the resistance to change of vehicle fleet operators.

EPACT: Why It Hasn't Worked

Despite the accomplishments of the 1990s, the resistance to change of government fleets and a loophole in the Energy Policy Act resulted in only marginal use of natural gas and other alternative fuels (such as ethanol) by the government's huge fleet of light-duty vehicles. With more government leadership, federal fleet changes could have gone far in creating a strong alternative-fuel vehicle market. But by 2002, while 75 percent of all federal vehicle fleet purchases should have been powered by alternative fuels, only 12.1 percent of covered federal fleet vehicles complied.[68] Further, the loophole in EPACT—its definition of an "alternative-fuel vehicle" as one "capable" of operating on an alternative fuel, but not necessarily one that uses an alternative fuel—led to the purchase by federal and state government fleets of thousands of vehicles that could use gasoline and an alternative fuel, but that ended up burning only gasoline.

2000 to 2004: Years of Backsliding in the US

Exacerbating the failure of EPACT and of government fleet operators to embrace the spirit of the law, the federal government seems to have largely turned its back on natural gas as a vehicle fuel altogether. It has:

- Withdrawn support for the Department of Energy's natural gas engine research program, which was funding new vehicle platform, infrastructure, and small-scale steam reformer development, a program that received $7.8 million in 2002 but was zeroed out for 2005.
- Failed to back the package of economic incentives in the national energy legislation debated since 2001 that would have created a level playing field for fuel and vehicle options (alternative fuels, electric hybrid, and fuel cell) that reduce both vehicle emissions and reliance on oil (while backing subsidies for clean diesel and selected less widely useful alternative-fuel options).
- Proposed elimination of EPACT mandates altogether because of their alleged inability to reduce oil use (this has led to at least one successful lawsuit, filed by Earthjustice, for noncompliance[69]).
- Joined forces with diesel engine manufacturers in overturning the country's most ambitious natural gas fuel-use mandate, which was implemented by the South Coast Air Quality Management District in southern California. The resulting 2004 Supreme Court ruling has had a chilling effect on the efforts of local pollution control agencies to grapple with pollution by promoting alternative-fuel use from California to New York City.

As a result of these actions, the initiatives of natural gas fuel and vehicle innovators, hailed in the early l990s, have stalled. Expansion of the US fleet of NGVs has slowed to a crawl, its population hovering near 146,000 vehicles for several years. In 2004,

[65]D. Gordon *et al.*, *Greening Garbage Trucks: New Technologies for Cleaner Air,* INFORM, Inc., 2002, **http://www.informinc.org/ggt.php.**

[66]US Census Bureau, *1997 Economic Census*, **http://www.census.gov/epcd/www/econ97.html.**

[67]US Department of Energy, Alternative Fuels Data Center, **http://www.eere.energy.gov/cleancities/afdc/infrastructure/station_counts.html.**

[68]US Department of Energy, *Alternatives to Traditional Transportation Fuels 2000*, Table 9, "Estimated Number of Alternative-Fueled Vehicles in Use by the U.S. Federal Government, by Fuel and Weight Category, 1998, 2000, and 2002," September 2002, **http://www.eia.doe.gov/cneaf/alternate/page/datatables/table9.html.**

[69]"Federal Court Cites Government in Violation of EPACT Mandates," *The Clean Fuels and Electric Vehicles Report,* December 2002.

Ford announced it would no longer produce any NGVs, and GM is reducing its offerings to one NGV model. Overall, alternative-fuel vehicles still account for far less than half of 1 percent of the total number of vehicles on US roads, and their use has displaced oil by less than 1 percent. Moreover, with government's lack of leadership, the alternative fuel and vehicle industries are barely hanging on to the small market they hold, while pressure from gasoline and diesel fuel interests to reaffirm their monopolies is growing.

Contradiction in the US: A Long-Term Hydrogen Vision While Supporting the Oil Status Quo

While US leadership has failed to support public policies and programs that would create at least a level playing field for fuel options promising air quality and energy security gains in the near term, it has articulated a commitment to hydrogen fuel cell vehicles as a long-term goal and is aggressively pursuing an expanded hydrogen research program.

The Hydrogen Fuel Initiative, announced in the president's 2003 State of the Union address, and the 2002 FreedomCAR Partnership allocate $1.7 billion to hydrogen research and development over a five-year period—expenditures that far exceed the amounts expected to be spent on hydrogen research in China and India combined. While this commitment to hydrogen use in the US is important, the likelihood of reaching that goal is being undermined by this country's oilcentric present course, and by its failure to take the interim steps that would actually constitute forward progress on a viable path for getting to the hydrogen era.

Expanded government funding and support for technologies that make gasoline- and diesel-powered vehicles just clean enough to meet evolving clean air standards has enabled these vehicles to avoid the fuel switching that would actually reduce their reliance on oil. Despite the many synergies between natural gas and hydrogen vehicles that would make expanded use of NGVs an important step in expediting the future deployment of hydrogen technologies, the current US leadership has cut back on the very NGV programs that would increase the effectiveness of its

Hybrid Electric Vehicles: Reducing Oil Use Today and Paving the Way to Fuel Cell Vehicles Tomorrow

The internal combustion engine (ICE) in gasoline- and diesel-powered vehicles—and the modified internal combustion engine in natural gas vehicles—can be replaced with more efficient hybrid electric propulsion systems that are fully commercial now. A hybrid electric vehicle uses two sources of power: a small ICE for sustained driving at the most efficient speeds, and an electric motor powered by batteries for start-up and for times when the vehicle needs a burst of energy to climb a hill or speed up. When a hybrid electric vehicle is running on power supplied by its ICE and the driver steps on the brake, the energy produced by this "regenerative braking" is stored in the car's battery for future use, thus saving on fuel. However, since gasoline- and diesel-burning hybrid vehicles still get all their energy from petroleum-based fuels, they only reduce the growth rate in oil use—they do not displace it.

Several gasoline-burning hybrid electric sedans have become available over the past several years, including the prize-winning Toyota Prius and Honda's hybrid electric Civic, which can achieve fuel efficiencies of 45 to 70 miles per gallon. This year, hybrid electric engines in SUVs promise to raise these vehicles' fuel efficiency from about 15 to 35 miles per gallon. Further, heavy-duty fleet vehicles, such as transit and school buses and refuse and recycling trucks, are beginning to be commercialized in hybrid electric models. In Denver, Colorado, a fleet of 36 hybrid electric natural gas transit buses demonstrates that natural gas in the transportation sector can be used more efficiently. These vehicles are still being refined and are being produced in small quantities.

Like natural gas vehicles, hybrid electric vehicles bring with them short- and long-term benefits. While they contribute to greater fuel use efficiency in the near term, their refinement involves development of the electronic componentry that fuel cell vehicles will need in the longer term (see Figure 4, page 5).

investments in hydrogen vehicle products. Missing this connection has led to some ill-conceived efforts, such as significant federal investments in R&D aimed at extracting hydrogen from coal and the promotion of major investments in hydrogen vehicle fueling stations along major highways. For example, California's proposed Hydrogen Highway Network initiative, which aims to install 150 to 200 hydrogen fueling stations along the state's major highways (approximately one every 20 miles), is expected to cost $90 million.[70]

Dropping the ball on NGVs by failing to put in place programs and incentives that would enable new and cleaner-fueled vehicles to compete with traditional gasoline and diesel vehicles ignores domestic and international economic opportunities as well. Natural gas vehicle and engine manufacturers in the US are struggling to find new customers now that the country's commitment to alternative fuels in transportation is not on solid ground. And their inability to flourish may result in their failure not only to meet the energy security and environmental needs of the US but also to compete for the rapidly expanding NGV market opportunities offered by China and India.

At present, US leaders are, paradoxically, creating the appearance of visionary action via a long-term hydrogen research program, while funding and support are enabling the country's entrenched oil interests to maintain their supremacy. Despite justified enthusiasm for the Hydrogen Initiative, it could turn out, given the trends under way in China and India today, that the shortest road to the global hydrogen economy will run through Beijing or New Delhi, instead of through Washington, DC.

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[70]California Office of the Governor, "Governor Schwarzenegger Announces the California Hydrogen Highway Network," press release, April 20, 2004, **http://www.governor.ca.gov/state/govsite/gov_htmldisplay.jsp?BV_SessionID=@@@@15217292 13.1094663360@@@@&BV_EngineID=cccgadcmgjeidihcfngcfkmdffidfof.0&sCatTitle=Press%2BRelease&sFilePath=/govsite/press_release/2004_04/20040420_GAAS15904_Hydrogen_Highways.html&sTitle=Governor%2BSchwarzenegger%2BAnnounces%2Bthe%2BCalifornia%2BHydrogen%2BHighways%2BNetwork&iOID=56196.**

5. Creating a Sustainable US Transportation Policy

US leadership, by taking immediate steps to restructure US transportation policy, can mitigate the effects of a destructive collision with China and India over use of the world's remaining oil supplies, while also ensuring progress toward some of the country's overarching goals: shaping a secure, economically vibrant, and healthy future for Americans and making this country a collaborating partner with Asia and other industrializing nations in building a sustainable world.

Understanding two fundamental linkages is central to success. They are:

- Coupling natural gas, a fuel of today, with hydrogen, a fuel of the future—expanding the use of natural gas vehicle technology today will accelerate the transition to hydrogen tomorrow (see pages 18 to 19).
- Coupling the development of NGV technologies in the US with implementation strategies in the developing world, notably China and India. International commerce will provide the markets needed to support a strong domestic industry in the US, while promoting environmental improvement worldwide and lessening tensions over global oil.

Three overall energy/transportation policy objectives are described below—policy objectives that are translated into eight INFORM policy recommendations laid out on pages 5 to 7 of this report.

The First US Energy/Transportation Policy Objective:
Supporting Growth in the Natural Gas Vehicle Industry

The 146,000 NGVs now operating in the US are a remarkable accomplishment, made with the significant involvement of companies such as Cummins Westport, John Deere, Clean Energy Fuels, Honda, Ford, and Fuel Maker. Deployment of NGVs has served to promote the development of improved engine, fuel management, and refueling station technologies that are among the most sophisticated in the world.

However, it is critical that a restructured transportation policy place a priority on building a strong NGV industry in the US, both for its own sake and for the facilitating role it can play in accelerating the transition to hydrogen (see Figure 4, page 5). It would be reasonable to target a goal of 20 percent use of natural gas in vehicles by 2020. The European Union, recognizing the peril of its reliance on oil-derived fuels, passed a directive with a similar goal.

The most important contribution of a vibrant NGV industry for the US may be its facilitation of the transition to hydrogen. Many prototype hydrogen vehicles on the road today, including most buses and a handful of hydrogen vehicles powered by internal combustion engines, use fuel storage and management systems originally developed for natural gas. Similarly, the siting process for hydrogen refueling stations and the certification procedures for new hydrogen vehicles frequently follow regulations established a decade ago by the emerging NGV industry.

The many potential synergies between NGVs and hydrogen-powered vehicles—in fuel storage, on-board fuel management, and refueling technologies—have already contributed enormously to the development of fuel cell vehicles, as major automakers building these prototypes are quick to acknowledge, even though fuel cells differ significantly from the internal combustion engines developed to burn natural gas. Leading companies in the US alternative-fuel business, such as Quantum Fuel Systems Technologies Worldwide, Inc., headquartered in Irvine, California, sell a range of products for both natural gas and fuel cell vehicles.

Formed several years ago as a spin-off of a supplier of natural gas and propane compressed-gas storage cylinders, Quantum now has a strategic alliance with General Motors, which has purchased a 20 percent stake in the company. Quantum uses sales in its natural gas storage cylinder segment to provide revenue streams and technical experience that the company is leveraging into the emerging hydrogen and fuel cell markets.[71]

A number of demonstration programs now testing new grades of gaseous fuels are also helping to build a hydrogen-fueling infrastructure. For example, a fuel called hythane, which mixes 20 percent hydrogen into a blend with 80 percent natural gas, has been found to reduce engine emissions of some key pollutants by more than 50 percent compared to gasoline.

Using Economic Incentives to Put Cleaner Fuels and More Efficient Vehicles on US Roads

Anticipating the coming oil crunch, many industrialized countries have already levied heavy taxes on gasoline and diesel, which are discouraging the use of automobiles, promoting fuel-efficient vehicles, and creating a strong impetus to use mass transit. In the United Kingdom, for example, regular unleaded gas cost the equivalent of $7.14/gallon in July 2004, a full 69.4 percent of which was tax.[72] Political leaders in the US, in the face of resistance from traditional oil and auto interests, have not shown the political will to do the same (in July 2004, taxes accounted for only 21.9 percent of the average US gas price of $1.91/gallon[73]). EPACT's mandates for government fleet conversions to clean fuels largely failed because they only required the purchase of vehicles that could use two fuels, not that the alternative fuel be used. Also, the requirements for reduced emissions embodied in programs under the Clean Air Act have taken years of court battles to have an effect.

Finding it difficult and slow to put powerful drivers of change in place, members of Congress and environmental advocates have turned to what promises to be a more effective approach: the use of economic incentives rather than government mandates.

Using Tax Credits, Grants, and Rebates to Build Transitional Vehicle Technologies with Immediate Environmental and Energy Security Benefits

In recent years, economic incentives have shown potential in promoting a shift to alternative-fuel vehicles. However, to have a significant impact on the overall market, tax credits, grants, and rebate programs must offer substantially greater incentives than they have to date.

Programs that show the promise of economic incentives include the following:

- The Congestion Mitigation and Air Quality Improvement Program (CMAQ) of the US Department of Transportation distributes grant funds for alternative-fuel vehicle programs, among many other projects. This program has a budget of $1.6 billion a year through fiscal year 2005, of which a small percentage has been used for alternative-fuel vehicles.
- State Energy Program (SEP) grants under the Clean Cities Program, sponsored by the US Department of Energy, provided $17.3 million for 187 projects in 2002, of which one-third—or $5.7 million—went to alternative transportation fuels projects.[74]
- The Federal Transit Administration's Clean Fuels Formula Grant Program provides capital and operating assistance to local transit agencies in urban areas for bus purchases; its Discretionary Capital Program provides assistance for buses and bus-related facilities.
- The Inherently Low Emission Airport Vehicle Program (ILEAV), created under the 2000 Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR-21), provided $20 million in 2002 and 2003 to increase the use of alternative-fuel vehicles and low-emission vehicles in commercial service airports in nonattainment and maintenance air quality areas. This program was recently made permanent by the Flight 100—

[71]Quantum Technologies, press release, **http://www.qtww.com.**

[72]Automobile Association Limited, UK Fuel Prices, July 2004, **http://www.theaa.com/allaboutcars/fuel/fuel_report_july04.html.**

[73]US Energy Information Administration, "What We Pay For in a Gallon of Regular Gasoline," **http://tonto.eia.doe.gov/oog/info/gdu/gaspump.html.**

[74]"Energy Department Awards $17.3 Million for 187 Projects," *The Clean Fuels and Electric Vehicles Report*, September 2002.

Century of Aviation Authorization Act of 2003, which could provide up to $300 million for air quality improvement projects.
- The Clean School Bus USA program, overseen by the US Environmental Protection Agency, provides funds for clean school buses. The program spent $10 million in 2003–2004.

The broadest and most important economic incentives package, however, which was incorporated into the 2001 energy policy bill, went down when the overall policy bill died in Congress at the end of 2002. Entitled the Clean Efficient Automobiles Resulting from Advanced Car Technologies (CLEAR ACT), it called for tax credits and rebates to help offset the higher capital cost of alternative-fuel vehicles compared to their conventional counterparts. CLEAR ACT also provided tax credits to builders of natural gas fueling stations and, perhaps even more important, a $0.50 per equivalent gallon of gasoline tax credit to sellers of alternative transportation fuels. In the face of the significant advantages afforded to petroleum, this tax credit sought to put natural gas on an equal footing with gasoline and diesel.

Not only did the energy bill fail to pass in 2002, but a similar $2.9 billion CLEAR ACT tax credits package that was inserted in the Foreign Sales Corporation/ExtraTerritorial Income (FSC-ETI) "JOBS" bill was killed in October 2004—more astonishing, with oil selling for $54 per barrel. The government tax credits and other incentives incorporated into CLEAR ACT would have created a level playing field for natural gas vehicles and helped build the market for hybrid electric vehicles. This would have benefited the US in the near term by expanding the use of vehicles that burn oil-derived fuels more efficiently. In addition, it would have laid the groundwork for the hydrogen vehicles of the future by necessitating the refinement of the electronic components that fuel cell vehicles also need.

Providing Incentives to Make Refueling Infrastructure and NGVs Available Simultaneously

Natural gas providers in the 1990s struggled with the "chicken and egg" problem of which should come first, fueling stations to service NGVs not yet on the road, or NGVs that users might not be able to refuel easily, because of the absence of fueling infrastructure. The answer gradually became clear. Vehicles and fueling must be provided at the same time. This insight led to the natural gas market's growing strongest in urban fleet applications (such as mass transit and school buses, taxicabs, and refuse and recycling trucks), which generally operate their own fueling stations. In these cases, construction of natural gas fueling stations could be timed to coincide with delivery of NGVs.

This lesson suggests that wholesale construction of hydrogen fueling stations (at a cost of millions of dollars or more) well ahead of the vehicles that will use them is economic folly. What makes more sense is building natural gas fueling stations to serve existing NGVs, and designing them with enough space to accommodate hydrogen fuel dispensers and steam reforming and gas condensing equipment as needed. A government program offering grants or tax credits to the builders of natural gas fueling stations designed to serve as platforms for hydrogen production and distribution in the future would provide much greater public benefit at much lower cost than any of the major hydrogen highway initiatives under development today.

The Second Policy Objective: Promoting Export of Natural Gas Vehicle Technology to Help Meet the Huge Market Demand Developing in China, India, and Other Parts of Asia

There is tremendous export potential for alternative-fuel technologies to the developing nations of the world, whose NGV programs must often make do with the most rudimentary and outdated equipment. The opportunities for marketing heavy-duty NGVs, such as buses, refuse collectors, and delivery trucks, are especially promising in China and India, given those nations' concerns about the health impacts of polluting diesel vehicles.

One need look only as far away as Canada to find examples of how government policies can help to establish leadership in the export market for NGVs. Cummins Westport and Dynetek Industries (mentioned earlier in this report), which have been selling their engine and fuel storage systems in the US for years, recently made major inroads into the Asian market as well.

A major goal of US transportation energy policy should be to promote the export of heavy-duty natural gas engines, fuel storage, and related drive train components. Success in the international marketplace could provide the payoff the US NGV industry has been working so hard to attain. It would also allow these manufacturers to increase production, thereby reducing prices for vehicles and components sold both in the US and abroad.

Strengthening Federal Technology Export Programs

Some US Department of State and Commerce programs focusing on technology export are already under way. The American embassies in Beijing and New Delhi have been working hard to track technologies and support the efforts of US companies that send representatives to China and India seeking new business. The US Agency for International Development sponsors many technology exchange programs between the US and countries in Asia. This work is important, but it needs to be greatly strengthened to support the growing markets for NGVs in Asia.

The insufficiency of current efforts is readily apparent from a review of exports of automotive parts overall, of which NGV components make up only a very small part. According to a study by automotive industry analysts in China published in April 2004, the US exported $268 million in auto parts to China in 2003, making it a distant seventh among leading exporters of these products. In contrast, Germany, the leading exporter, shipped $3.1 billion in parts, while automotive exports from second-place Japan were valued at $2.9 billion. US exports also fell below the $350 million exported by fourth-ranking Canada, even though Canada's industry is very small compared to that of the US.[75]

Making Technology Export a Core Component of US Energy Policy

In the current structure, the NGV industry is only one of many industries seeking business opportunities abroad, and a small one at that. What is missing is the incorporation of technology export as a key component of US energy policy. This would raise the importance of the industry in the technology export circles in which it must operate. The US Department of Energy took one focused step in this direction by establishing the International Clean Cities Program in 1995, which aims to promote collaboration between alternative-fuel programs in the US and their counterparts in selected countries. International Clean Cities currently operates an Asian program in India and Bangladesh but not in China.

Expanding Research Support for Exporters of NGV Technologies

An integrated energy and technology export program should include focused R&D support for NGV companies wishing to market their products overseas. This would be a major change from programs initiated in the 1990s that had a strictly US focus: Department of Energy grants made through the Clean Cities Program for the marketing of NGVs in US cities, and several Environmental Protection Agency and Department of Transportation programs that had the same objective of deploying NGVs in the US, mainly to meet domestic air quality goals.

A new paradigm would make the export of NGV technologies to China, India, and other nations a vital strategy for reducing dependence on insecure oil imports worldwide and promoting the growth of a viable NGV industry in the US. Success in the international arena would increase sales in the US and encourage the development of better and cheaper technologies. This, in turn, would lead to greater oil displacement and improved air quality in the US. Perhaps most important, it would accelerate the pace at which the US travels on the road to hydrogen.

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[75]A. Webb, "U.S. Suppliers Miss Boat in China," *Automotive News*, April 12, 2004.

The Third Policy Objective: Taking the Final Step Toward Sustainable Transportation by Developing Renewable Energy Sources

Expanded use of NGVs in the coming years can mean a great deal in addressing today's air pollution challenges, reducing reliance on oil in transportation, developing the materials and systems associated with a gas rather than a liquid fuel, and establishing a refueling infrastructure that will enable hydrogen-powered vehicles to be refined and commercialized. Yet natural gas, like oil, is a fossil fuel and is ultimately depletable. Both fuels are likely to run out before the end of the century.

While natural gas can serve as the best initial source of hydrogen for fuel cell vehicles, a fuel cycle that can serve our world for centuries rather than decades requires that hydrogen be made from water—a fully renewable resource—and that the energy used to extract it come not from the burning of fossil fuels (which would consume more energy than it created) but from renewable energy sources, such as wind, photovoltaic cells, hydropower, geothermal steam, etc. Ever since the establishment of the US Department of Energy in 1970, the development of renewable energy sources has been a key mission. However, funding for renewables has been a much lower priority ($12 billion from 1978 to 1999) compared to innovations in oil and coal ($15 billion) and nuclear power ($26 billion).

Over the next 20 years, an all-out R&D program, funded by the Department of Energy, will be vital to commercializing renewable energy technologies and encouraging the construction of distributed renewable energy generation facilities across the country. Disbursed renewable energy capacity will enable the US to take the final step toward truly sustainable transportation.

About the Author

James S. Cannon is an internationally recognized researcher, author, analyst, and speaker on energy development, environmental protection, and related public policy issues. Long associated with INFORM as a staff member and then as senior consultant, he is the author or co-author of eight previous INFORM transportation reports. Recent studies include *Greening Garbage Trucks: New Technologies for Cleaner Air* (2003), the first comprehensive look at the innovative deployment of cleaner-fuel technologies in the refuse industry; *Bus Futures: New Technologies for Cleaner Cities* (2000), an examination of the cost, performance, and latest innovations in fuels and engine technology in the US bus industry; *Gearing Up for Hydrogen: America's Road to Sustainable Transportation* (1998), a survey of commercially available technologies for powering electric vehicles more efficiently with hydrogen fuel cells; and *China at the Crossroads: Energy, Transportation and the 21st Century* (1998), Mr. Cannon's first examination of China's explosive vehicle growth. Earlier publications include *Spotlight on New York: A Decade of Innovation in Alternative Transportation Fuels* (1997); *Harnessing Hydrogen: The Key to Sustainable Transportation* (1995); *Paving the Way to Natural Gas Vehicles* (1993); and *Drive for Clean Air* (1989).

Between 1975 and 1987, Mr. Cannon authored six INFORM reports on pollution and energy issues: *A Clear View: Guide to Industrial Pollution Control* (INFORM's first report, 1976); *Energy Futures: Industry and the New Technologies*, INFORM's 600-page examination of alternative energy sources (1984); *Acid Rain and Energy: A Challenge for New Jersey* (1984); and *Controlling Acid Rain: A New View of Responsibility* (1987). Mr. Cannon also prepared two INFORM studies of coal conversion options in New York and New Jersey.

Mr. Cannon is currently president of Energy Futures, an energy and environmental research organization in Boulder, Colorado, serving other nonprofit organizations, government agencies, and private industry clients. Energy Futures publishes two international periodicals, the quarterly *Clean Fuels and Electric Vehicles Report* and the bimonthly *Hybrid Vehicles*. Major long-term consulting assignments have included serving as director of the Governor's New Mexico State Energy Policy Project during an eight-year assignment as energy policy analyst for the state of New Mexico and a six-year consulting relationship with the US Congressional Office of Technology Assessment.

Mr. Cannon received an A.B. degree in chemistry from Princeton University, and an M.S. degree in biochemistry from the University of Pennsylvania.

Publications and Membership

Related Publications

Greening Garbage Trucks: New Technologies for Cleaner Air
Deborah Gordon *et al.* (2003, 106 pp., $35)

Bus Futures: New Technologies for Cleaner Cities
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Driving Clean Transportation — LEV II: A Policy That Works (A Case Study of New York State)
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INFORM's authoritative new report, *The Transportation Boom in Asia*, does more than help clarify the dimensions of the challenge faced by a world addicted to oil. It also highlights the role that India and China are playing in embracing natural gas vehicle technologies. This is giving the US a unique opportunity to strengthen its domestic natural gas vehicle industry through a technology export program that can help these eager Asian nations put natural gas to use in moving toward a sustainable future. Finally, INFORM's report shows energy and transportation planners how the use of natural gas-fueled vehicles can bring the world closer to the widespread commercialization of pollution-free hydrogen-powered vehicles, which promise to provide the ultimate solution to oil dependence in transportation.

Dr. Noel Brown
President, Friends of the United Nations
Former Director, UN Environment Programme, Regional Office of North America

***The Transportation Boom in Asia: Crisis and Opportunity for the United States* will greatly increase our understanding of the interconnections between the transportation challenges of Asia and the United States. It succinctly outlines the urgent need to develop alternatives to today's petroleum-fueled vehicles and provides a necessary road map to a future freed from the economic, health, environmental, and foreign policy costs of today's oil economy.**

Rich Kassel
Director, Natural Resources Defense Council, National Vehicles & Fuels Project

INFORM's carefully researched report documents the consequences of depending on imported oil for our vital transportation infrastructure. It clearly tells us that we must immediately focus on available solutions, like natural gas vehicles, to avoid the coming crisis.

David R. Demers
Chief Executive Officer, Westport Innovations, Inc.

INFORM's report on transportation in Asia is thorough and visionary—what we have come to expect. Author James Cannon has shown clearly that Asia's transportation choices have huge ramifications for the US and the world. This new report identifies a shift to clean fuel vehicles—ultimately to pollution-free hydrogen fuel cell technology—that will be one essential way to address the massive problems identified. The same level of analysis will also be needed to define the urban design, public transportation, bio-fuels, and vehicle efficiency dimensions of a total viable Asian transportation strategy.

Chris Flavin
President, The Worldwatch Institute

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