CHAPTER 3

Toward a Policy Agenda for Climate Change: Changing Technologies and Fuels and the Changing Value of Energy

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The business as usual case for global affairs suggests that some very disturbing trends are apparent today and could lead to significant changes by 2050. By then, the global population will grow by around 40 percent. The number of megacities will grow considerably. The number of vehicles in the world will increase from 700 million to 2 billion. The global demand for energy will increase between two- and threefold, and energy security will become an increasingly significant issue, with the cost of energy remaining high. These trends will be particularly marked in the developing world.

One of the greatest challenges posed by the current trends is to address the increasing buildup in the atmosphere of carbon dioxide (CO_2) and other greenhouse gases (GHGs) associated with increased use of fossil fuels as the world's primary energy source. CO_2 and other GHG emissions have been implicated, almost without doubt, as a major factor in global climate change.

In 2004, policy analysts proposed a "wedge and slices" approach to addressing the need to reduce CO_2 emissions (Browne, 2004; Pacala and Socolow, 2004). In essence, this approach involved reducing the seemingly inexorable growth of emissions to retain emissions in 2050 at 2000 levels. This would involve taking 7 gigatonnes (Gte) of carbon out of the atmosphere. Estimates showed that, by breaking this into seven or more slices of up to 1 Gte each, the problem becomes manageable. The good news is that technologies available today are capable of making sizeable reductions in

carbon emitted into the atmosphere. For example, it has been estimated that, on a global basis, the universal introduction of hybrid electric vehicles (HEVs) powered by biofuels alone would contribute a 1 Gte reduction.

Another practical example of a technology that will lead to reduced CO_2 emissions is the proposed first power station to be fueled by hydrogen derived from natural gas. The CO_2 captured during hydrogen production will be reinjected into an oil reservoir, where it will be stored safely and also used to increase oil recovery. This is a significant step forward in developing "carbon free" energy technologies and will reduce the CO_2 emitted into the atmosphere from this 350 megawatt (MW) power plant by 90 percent. Nonetheless, hydrogen alone is not the universal panacea to the world's global climate change threat. The energy and environmental costs of a hydrogen economy will remain high until there are significant technical breakthroughs in fuel cells and hydrogen production, transportation, and storage.

History teaches us that improved technical performance leads to increased consumer expectation. If the world is to fully address the challenge of climate change through the stabilization of GHG concentrations in the atmosphere, it will also need to embrace demand management. To achieve this, the public must believe that reduced demand will not lead to a loss of lifestyle. Moreover, government policies must be developed that reward a sustainable level of energy demand. Technology alone will not be sufficient.

This chapter discusses global societal trends and future energy challenges that, on a business as usual basis, indicate a major increase in CO_2 and other GHG emissions by midcentury. It then discusses transport energy policy trends and technology trends in transportation offering alternative energy futures that could significantly reduce the contribution of transportation emissions to climate change.

Global Societal Trends

The United Nations (UN) forecasts under its medium case scenario that the world's population will rise from 6.5 billion today to 9.1 billion in 2050 (UN, 2004). Today 95 percent of all population growth occurs in the developing world, where a widespread pattern of increased urbanization complicates the problems, including that of energy demand. For example, in China between 2005 and 2030, the UN forecasts that the urban proportion of the population will rise from 36 to 60 percent (UN, 2004). This translates to 10 million new urban dwellers per year or about 27,400 per day for the next 25 years. Figure 3-1 shows the projected growth in urban and rural populations in China.

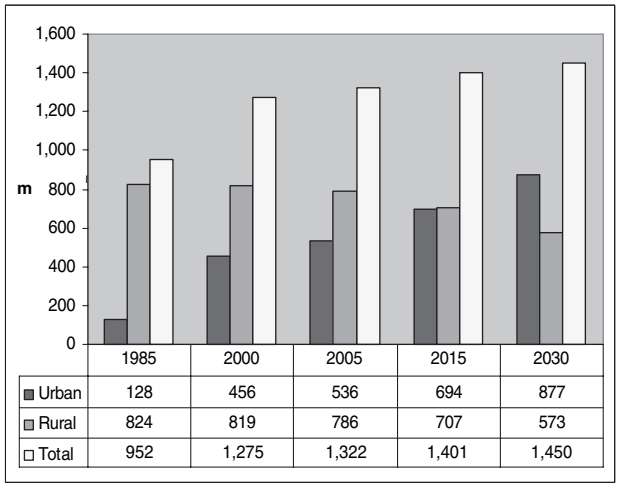
Worldwide, the UN forecasts that by 2015 there will be at least 368 cities with populations of more than 1 million (Prahalad, 2005). The growth of megacities, or urban agglomerations of more than 10 million inhabitants,

China is undergoing a transformation that many western nations experienced in the mid to late nineteenth century during the industrial revolution. The result is a large-scale urbanization, driven mainly by the policy of economic growth.

Forecast Population Change 2005–2030

Overall: +10%
Rural: –27%
Urban: +64%

10 million new urban dwellers per year



	1985	2000	2005	2015	2030
Urban	128	456	536	694	877
Rural	824	819	786	707	573
Total	952	1,275	1,322	1,401	1,450

FIGURE 3-1. China: Urban/rural population trend. *Source:* UN Department of Economic & Social Affairs.

has gone from five in 1975 to 14 in 1995 and is projected to reach 26 by 2015 (Times Atlas, 2000). Most of these megacities are in the developing world.

The trend toward urbanization is accompanied by economic development and the increased earnings potential of urban dwellers. Again using a Chinese example, it is understood that the per capita income ratio between urban and rural incomes is in excess of 3.5. A frequent demonstration of newfound wealth is in personal transportation, leading to more and often bigger cars in cities, despite the traffic jams and the 2.5 billion gallons of fuel that are wasted by them as they sit stalled in traffic every year (Glenn, 2005).

Most energy use in the world today is obtained from the burning of fossil fuels. While fossil fuels are far from running out, they are a finite resource and, increasingly, confined to remote locations or in areas of political sensitivity. This is especially true for petroleum, virtually the sole transportation fuel used in the world today. There is also a distinct regional imbalance between consumption and reserves, as shown in Figure 3-2.

It is reasonable to forecast that a huge increase in energy demand in all sectors will occur as developing countries pursue their aspirations for economic development, leading to growing personal affluence to be enjoyed by a rapidly growing urban population. Figure 3-3 shows the tripling of world oil consumption predicted by the International Energy Agency between 1971 and 2030 (IEA, 2004).

During the past century, the developed world has increasingly taken access to virtually unlimited supplies of energy for granted. Despite the

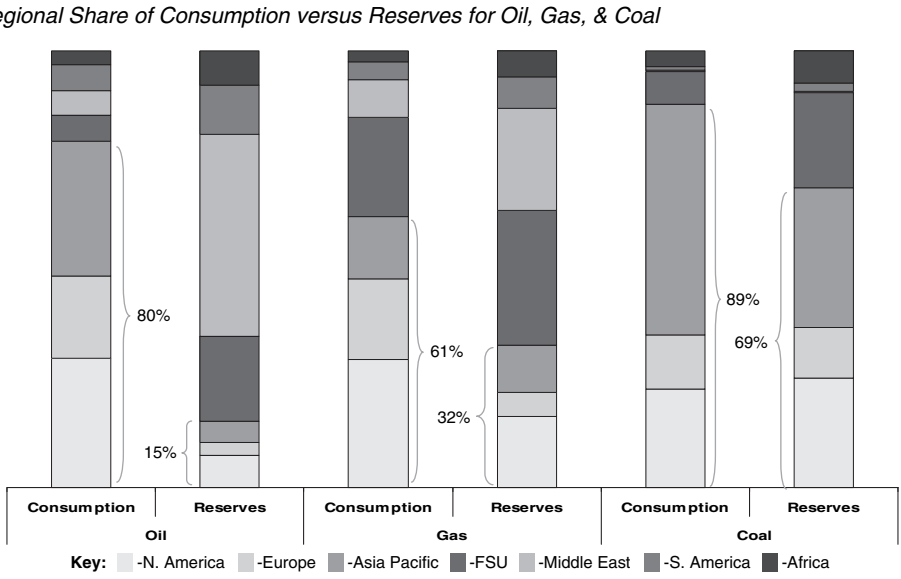


FIGURE 3-2. Growing dislocation of supply and demand. *Source:* BP Data, IEA WEO 2004. *Note:* Oil reserve figures do not include unconventional reserves estimates.

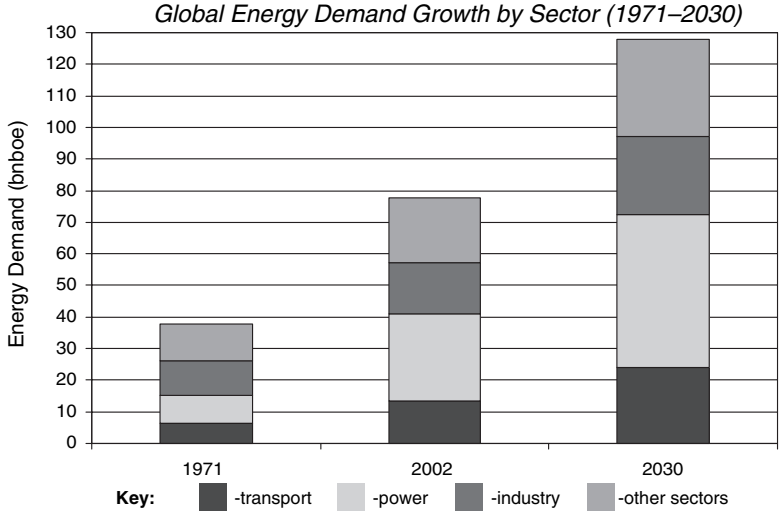


FIGURE 3-3. Rapid demand growth projected for all sectors. *Source:* IEA WEO 2004. *Notes:* 1. Power includes heat generated at power plants. 2. Other sectors include residential, agricultural, and service.

TABLE 3-1. Per Capita Energy Demand

	Primary Energy (million toe equivalent)	*Population (million)*	*Per capita usage (toe/cap)*
OECD—Europe	1,849.8	530.6	3.49
USA	2,331.6	293.6	7.94
Japan	514.6	127.6	4.03
Brazil	187.7	179.1	1.05
Russia	668.6	144.1	4.64
India	375.8	1,086.6	0.35
China	1,386.2	1,300.1	1.07

Sources: Primary energy from BP, 2005. Population from Population Reference Bureau, 2004.

burgeoning growth in energy consumption in the developing world, an imbalance between the developed and the less-developed worlds continues to exist. The imbalance of per capita energy demand between selected countries is shown in Table 3-1.

Future Energy Challenges

Figure 3-4 shows how the energy demand of the developing world may reasonably be expected to increase as those countries achieve higher GDP per capita. The interesting question is by what degree, for example, will they follow a European, an Asia Pacific, or an American trajectory? China has declared an aspiration to increase GDP by a factor of four, while only increasing energy demand by a factor of two.

The World Business Council for Sustainable Development (WBCSD) has forecast that if the UN goal to eliminate extreme poverty is to be met, global energy demand will increase over the period 2000 to 2050 by a factor of two to three, with the greater demand associated with the greater reduction in poverty (WBCSD, 2004).

Future transportation energy demand will be driven by an increasing expectation of the developing world for the access and mobility that the developed world takes for granted. Figure 3-5 illustrates global energy supply and demand in 2002 based on work by the IEA. It shows that in 2002 transportation accounted for 27 percent of world energy demand, met almost entirely by oil (IEA, 2004).

Separately, the WBCSD Sustainable Mobility Project (SMP) forecast that the total global vehicle stock will increase from 683 million vehicles in 2000 to 2.0 billion vehicles in 2050. As shown in Figure 3-6, the proportion of vehicles in the developing world will increase from 21 percent (146.1 million vehicles) to 61 percent (1,216.9 million vehicles) during the period. This is an 833 percent increase in the developing nations outside the

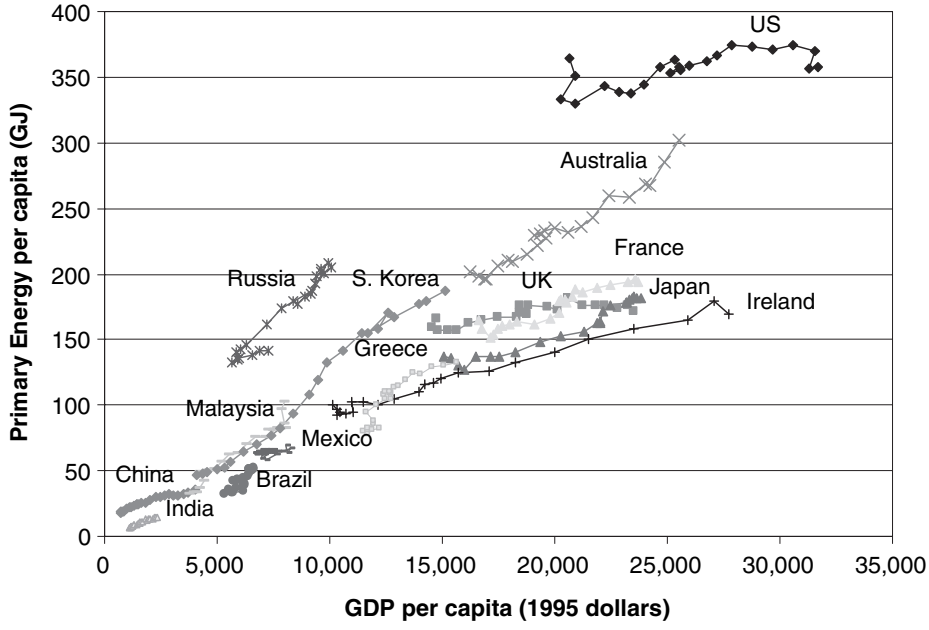


FIGURE 3-4. Energy use grows as a function of GDP.

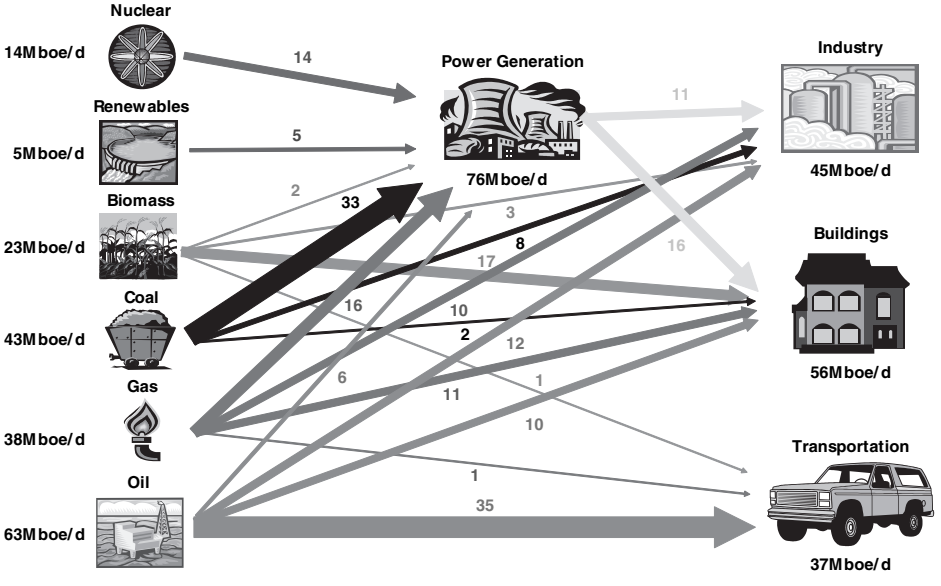


FIGURE 3-5. Global energy supply and demand (2002). *Source:* World Energy Outlook 2004.

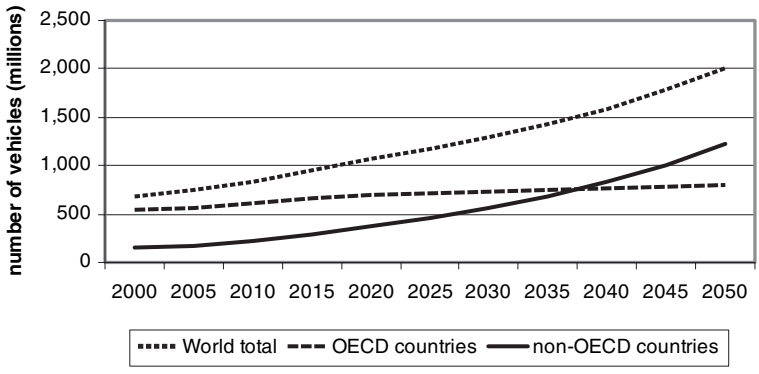


FIGURE 3-6. Forecast global vehicle stocks. *Source:* WBCSD SMP 2004.

Organization of Economic Cooperation and Development (OECD), compared with a 147 percent increase in OECD countries (WBCSD-SMP, 2004). This shift in the demand for vehicles toward developing countries raises some fairly significant questions regarding where vehicles will be made, the energy that will fuel them, and the policies and technologies that will be adopted in their manufacture.

Transportation Energy Policy Trends

Automotive exhausts, including emissions affecting local air quality (LAQ) and GHG emissions, have health impacts and costs. Most countries have already introduced lead-free gasoline, and many are currently in the process of greatly reducing the sulfur content in transportation fuels, especially diesel.

These actions have greatly improved LAQ in urban areas, but there is still much work to be done on the wider health impacts and climate change effects of transportation pollution. Gluskoter quotes Shafik in using Kuznet's curve to suggest that, on a historical basis, through the phases of economic development, air quality can be expected to worsen before it improves (Gluskoter, 1997). One might reasonably suppose that the same could apply to GHG emissions.

Europe is taking a lead in reducing GHG emissions as part of a program to address climate change issues; actions include the creation of the EU Emissions Trading Scheme. This is not an easy task. On a personal basis people have difficulty in making a link between their individual actions and the global climate change consequences. As a result, it will be difficult for the auto manufacturers, despite good intent, to keep to their voluntary GHG reduction targets. This is especially true where there is a public appetite for

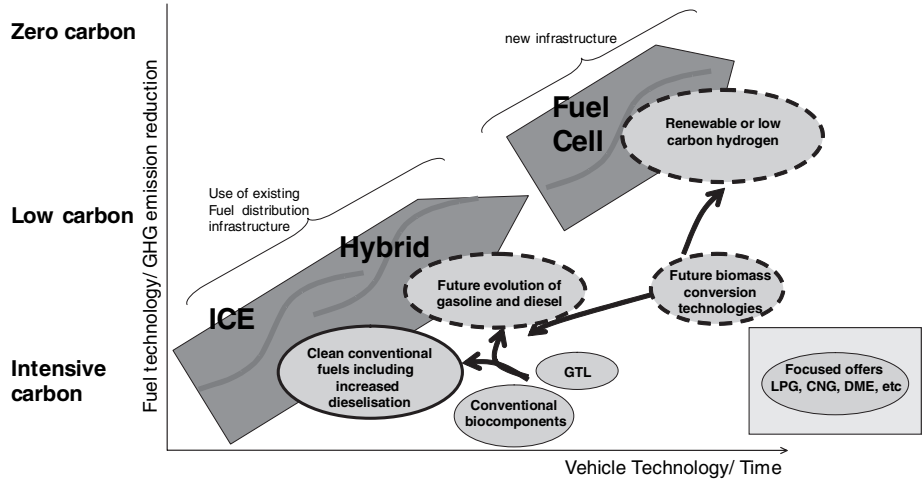


FIGURE 3-7. Future fuels pathway.

ever larger, more powerful, and more sophisticated vehicles without much policy incentive to restrict such indulgence by a relatively affluent population.

Public attitudes can be changed, however. An example has been the growth in dieselization in Europe. For many years in most European countries, especially France, diesel was cheaper than gasoline. In some countries, including the United Kingdom, legislation has been introduced that penalizes high CO_2 emitting cars, especially those that are provided as an element of an employee's remuneration package (DVLA, 2005; SMMT, 2005). Together, these measures have led to technology developments in both the mass and luxury car markets and also in fuels that make diesel cars an attractive option. Indeed, diesel cars now have approximately 50 percent of the light-duty vehicle market, and diesel is being imported to meet the shortfall in supply from European refineries.

BP has developed a future fuels pathway toward a lower CO_2 world, summarized in Figure 3-7. On the engine front, this shows the move from internal combustion engines to hybrid electric and fuel cell drivetrains. On the fuels side the path moves through dieselization to conventional biocomponents, to gas (or coal) to liquids, and on to advanced biomass conversion technologies and, perhaps in the long term, hydrogen.

In the short term, cleaner fuels that go some way to address LAQ problems and begin to make an impact on GHG emissions make those who have

TABLE 3-2. Energy Supply and Urban Planning

WBCSD Goals	*Security of Supply*	*Urban Planning*
GHG Emissions	Energy efficiency	Total energy approach
Local Air Quality	Alternative fuels	Total energy approach
Safety		Improved safety
Noise	Alternative fuels	General planning
Congestion	Modal shifts	Modal shifts
Social Equity	Modal shifts	Central to planning
Maintain Opportunity	Manage supply/demand balance	Opportunity to maintain/improve

the resources and political willpower to use them feel a little better. But it merely scratches the surface of the problems just outlined for the developing world.

For many countries, addressing climate change falls very low on their list of priorities. Innovative leadership is needed to create programs to reduce GHG emissions. By way of example, the issues that are of concern to China are security of energy supply and urban planning for their rapidly urbanizing population. In Table 3-2 these two policy drivers are mapped onto the WBCSD-SMP goals (2004). By addressing these drivers through strong policies, the wider issues such as global climate change and social equity are also met.

Technology Trends in Transportation

A variety of opportunities exist to address energy challenges in the transportation sector. They include use of clean burning, renewable fuels; implementation of vehicle fuel economy improvements; and consumer support of alternative transportation approaches such as walking and bicycling.

One example of an alternative fuel is ethanol produced from sugar cane. In Brazil the cost of cane-derived ethanol is approximately $35 per barrel of oil equivalent (boe). When oil prices exceed $40 per barrel, there is clearly a commercial market for Brazilian ethanol; recently this has been reflected in sharply increased prices for sugar on the international commodity exchanges. Other tropical countries may see the opportunity to establish cost effective domestic, renewable energy industries as well. Hopefully policy decisions that are taken in this regard will be taken for the right reasons, reflect truly sustainable values, and not jeopardize water supplies or essential food production.

Conventional biofuels have the disadvantage that they are not readily fungible in significant proportions with fossil fuels and thus may require

costly, segregated facilities for storage and distribution. Moreover, at higher concentrations, they are unsuitable for much of the current vehicle fleet. Research is being conducted to address this problem through the use of advanced biofuels that are compatible for blending with conventional oil-derived fuels in any proportion and require no new infrastructure or engine technology. Indeed, the goal is to create biofuel substitutes with no discernable differences from fossil fuels.

Naturally there is a concern that in solving one problem we do not create another. In-depth analyses of potential biofuel production suggest that there is possibly a constrained land capacity to meet more than 20 percent of the demand for transportation fuel on a global basis. Such analysis makes allowance for land to maintain food production, water requirements, and land quality.

The fossil fuel that is often forgotten as a potential transportation fuel but is available in relative abundance, is coal. The rise in oil prices begins to make coal-to-liquids technologies attractive. In Shanxi province in China, there is extensive research on coal to methanol technology and the development of associated technologies that will be required to realize the benefits. This is an interesting example of bucking convention to make use of what is available locally.

Turning from the fuels to the vehicles that burn them, the advent of hybrid electric vehicles (HEVs) in the automotive market in recent years has generally improved the potential fuel economy of vehicles. The modular design of HEV powertrains enables several generations of development from the same platform. It is envisaged that HEVs will become progressively more electrified as new models are introduced over time. If forecast advances in battery technology are realized, the plug-in HEV with a 150-kilometer all-electric range will be available for city use in the relatively near future. This will have significant additional benefits in improving urban air quality and noise. With good planning and optimized electricity generation, it can also lead to more efficient use of energy and reduced overall GHG emissions.

The advent of HEV technology raises the possibility of all-electric vehicles for the mass market. What if a far more efficiently electrified society that optimizes the supply and demand balance in a way that includes supplying transportation needs could be developed? If electricity can be generated, stored, and transmitted cleanly and efficiently, there will be significant benefits in terms of GHG and LAQ emission reductions. There will also be other benefits—for example, a much quieter environment. The sources of electrical energy are many and can be chosen to suit the circumstances of the location. Coal, gas, liquid hydrocarbons, hydrogen, wind, solar photovoltaic, and thermal can all be used in the right circumstances and combinations. A challenge for the future is to take a holistic view that looks to a sustainable future, reflecting the various and diverse interests of the many relevant stakeholders.

Development of HEV technology by major automakers is one example of the successful effort by private companies, including oil companies, in promoting more efficient technology that can lead to reduced CO_2 emissions. This effort will be of little value, however, if the consumer does not also make a positive contribution in reducing demand. National, regional, and local governments have roles to play in promoting GHG reduction programs. They can formulate and implement policy that stimulates reduced consumer demand for energy. In the transportation field this can take many forms, including preferential taxation for low energy vehicles and more efficient fuels and lubricants, the provision of attractively routed and priced reliable public transport, the creation of private vehicle exclusion zones, and the provision of cycle paths and safe walkways for pedestrians. Encouraging people to walk and cycle will also have long-term benefits in terms of physical and mental health that can be translated into financial benefits and a general sense of public wellbeing. Provided they are implemented in a thoughtful and holistic way, actions to positively influence consumer behavior will contribute to all of the SMP goals: lower LAQ and GHG emissions, greater safety and social equity, reduced congestion and noise, and expanding mobility access.

Conclusion

There are three potential solutions to the stark energy challenges facing the world today:

- Increase the supply of energy by promoting technological developments, with an increasing emphasis on unconventional fossil fuel derivatives, renewable energy resources, and possibly nuclear power.
- Decrease demand through the widespread use of energy efficiency technologies coupled with changes in personal behavior, recognizing that the latter are perceived to be difficult to implement politically.
- A combination of the two, perhaps permitting the most effective progress toward the common goal of reducing GHG emissions. However, we must guard against the propensity for both sides of the equation to assume that the other is providing all the answers.

Analysis of the trends now underway suggests that the value that society puts on energy is going to change. Economists will argue that the marketplace will establish the price of energy, but this does not always account for uncertainty. Generally, uncertainty is not something that the public at large enjoys experiencing. In a world where energy security achieves greater prominence, it is quite conceivable that consumers will be prepared to pay more for assured "home-grown" access to energy.

For some the current trends are alarming; for others they open up all sorts of new opportunities. No longer will there be a "one size fits all"

approach; what's right on the U.S. West Coast won't necessarily be right in the Midwest, let alone in China or India. Security of supply is becoming of increasing importance in energy discussions, and the result has been a diversity of response to this challenge.

For the optimists the changing value that will be associated with energy will unleash a raft of technologies that are waiting in the wings, and there will be others behind them. But to bring these forward, politicians and bureaucrats will need to set goal-based policies, as opposed to prescriptive route-based policies. Global and regional suppliers, whether of vehicles or the energy to power them, will need to produce products that are adaptable to the various markets that they aim to serve.

In meeting these changing and varied demands, Henry Ford's adage regarding the Model T car—"You can have any color you like as long as it's black"—just won't be good enough!

Author's Note

The opinions expressed in this paper are personal and do not necessarily represent BP's position, policy, or strategy.

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