Jonathan Takahashi
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GETTING STARTED

People want to move. It's that simple. Personal mobility has numerous advantages, giving us flexibility in terms of where we live, where we work, whom we interact with, and what we choose to do with our free time. The efficient movement of goods and people fosters economic growth by enabling a networking of resources and industry. Thus, growing communities are challenged to provide for the immediate transportation needs and desires of its citizens in a manner that is conducive to growth in the long run. Growth is intimately tied to energy use and impacts on the environment, and ignorance of these factors leads to consequences that can function as roadblocks in the future. Specifically, transportation growth introduces new dangers in the form of air, water, and noise pollution, safety problems, reduction of urban space, and national security concerns due to oil importation. The challenge of sustainable development is faced by all nations and cities, but nowhere else is it as pressing as in developing Asia, whose nations must deal with high proportion of the world's population and unsurpassed rates of economic expansion.

This exercise aims to involve participants in some of the practical and ethical decisions that go into the process of shaping the transportation futures of developing countries. While attempting to raise awareness regarding the impending challenges facing all of developing East and Southeast Asia, this exercise will focus on the two largest nations in this group, China and India, with comparisons to the industrialized nations of Japan and the United States. China and India are the second and fifth largest contributors to world carbon emissions, respectively, and they are home to 38% percent of the world's population[1]. South Korea will serve as a kind of "intermediate" example in terms of development. In the last couple of decades, South Korea has developed quickly in terms of industry, urbanization, and transportation, but is still considered part of the developing, un-industrialized group of Asian nations. Later comparisons will bring in other nations as models for future development. Participants will have the opportunity to combine data trends, statistics, policy suggestions, and comparison models to create qualitative scenarios possibilities for the future of China and India. Optional "Exploration Questions" throughout the exercise are meant to stimulate thinking and discussion as participants look at information and ideas.

A CLOSER LOOK

In recent decades, developing Asian nations have shown a steady growth in both population and in economic activity. Following a revolution in agricultural efficiency in the 1960s, increased industrialization and urbanization driven by international trade and export economics has created a large range of environmental challenges for everyone involved, whether they be city planners, government officials, transnational corporations, environmental interest organizations or just the average citizen who is trying to keep up with the rapid change occurring. For the sake of the environment, it is imperative that growth is harnessed to develop cities and nations in a sustainable fashion, avoiding courses of action that lead to large, messy, unmanageable systems.

There is no question that transportation needs must be met for growth to continue. The question concerns how these needs are met, and there is no clear answer for everyone. Sustainable urban planning must account for multiple driving forces, integrating them to produce an effective and desirable outcome. A good solution must address specific economic priorities, cultural priorities, and environmental priorities. Industrialized nations around the world have embraced various patterns of development, but the most powerful component in the largest transportation systems has been the automobile[2]. The automobile has become a symbol of personal status and freedom, and, as the dominant mode of transportation in the United States, the richest country in the world, it has become the object of desire for all developing nations.

However, automobile use has its share of consequences: congestion, air pollution, and space requirements strain the health of people and the natural environment. The issue of global climate change has shown that the impacts of automobile use extend even beyond the clouds of smog that hover over metropolises around the world, suggesting a “carrying capacity” for automobiles regarding the long-term health of life on Earth. It will not be possible for developing nations to adopt the American way of life, since the economic, cultural, and environmental circumstances are fundamentally different. Bangkok, Thailand, is an example of a city whose rapid motorization has had dire repercussions: bumper-to-bumper traffic congestion produces pollution that causes thousands of premature deaths and millions of pollution-related sicknesses each year[3]. Asian nations must manage the increasing demand for personal transportation in dense megacities that do not have the infrastructure or flexibility to accommodate American-like automobile usage in an effort to avoid the undesirable stage of development that Thailand is currently experiencing.

Increasing income provides developing Asian nations with more options in how they use it, and their choice in this matter will largely determine what impact their economic growth will have on the environment. Although current trends point to a globalization of consumption patterns and increased private automobile use, the ownership of automobiles in most developing nations is still far below the level in industrialized countries. There is time and opportunity for effective planning and policy implementation to significantly shape future patterns of transportation use. Planning and policy action is by no means simple or straightforward, however. The movement of human beings belongs to a category of basic activities that include the securing of shelter, eating, sleeping, and talking; deciding how people will move must account for cultural differences and tendencies, and this leads inevitably to issues of equity and ethics in an increasingly global decision-making community.

INVESTIGATING THE DATA: DRIVING FORCES

Population Growth

In the first quarter projections for this century, population growth, and the increased industrialization and urbanization that it brings, are all expected to continue to increase in developing Asian countries. Below is a table of recent growth and projections for the near future:

Population Growth	

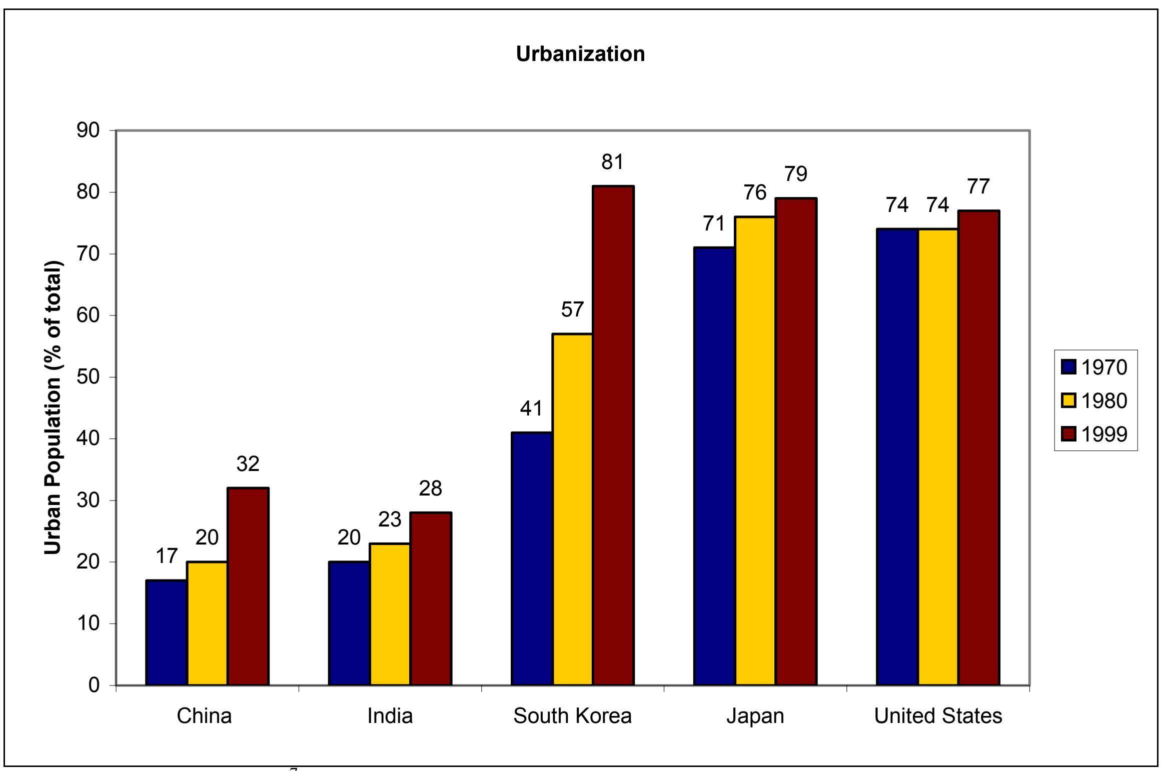
	Population (thousands)			Average Annual Population Change (%)
	1950	2000	2025	1995-00
China	554,760	1,277,558	1,480,412	0.9
India	357,561	1,013,662	1,330,449	1.6
South Korea	20,357	46,844	52,533	0.8
Japan	83,625	126,714	121,150	0.2
United States	157,813	278,357	325,573	0.8

Source: World Resources Institute 2001 (United Nations Population Division)[4]

Exploration Question: *Notice that the percent annual change average for China and the United States is about the same. How many more people per year does this really mean if we extrapolate this rate over the next couple of years? Compare this to the populations of cities that you are familiar with.*

Expanding Urbanization

Overall, Asia's urban population is expected to increase from 360 million in 1990 to over a billion in 2020. By 2015, the urban population percentage is expected to increase to about 48 percent in East Asia and 46 percent in South Asia[5]. Much of this urban growth will be manifest in the formation of megacities (cities with more than 8 million inhabitants), with an expected 23 of 36 world megacities located in Asia in 2015[6].



Source: World Bank 2001[7]

Economic Growth

Given the large populations of China and India and their current level of economic activity, the room for further economic growth is enormous. Whereas the economies of highly industrialized nations such as the United States, Japan, and those in Western Europe have begun to stabilize at high levels of Gross National Income (GNI), developing Asian nations are still much lower in terms of per capita GNI. Steady rates of increase imply that this gap may be narrowed in the near future.

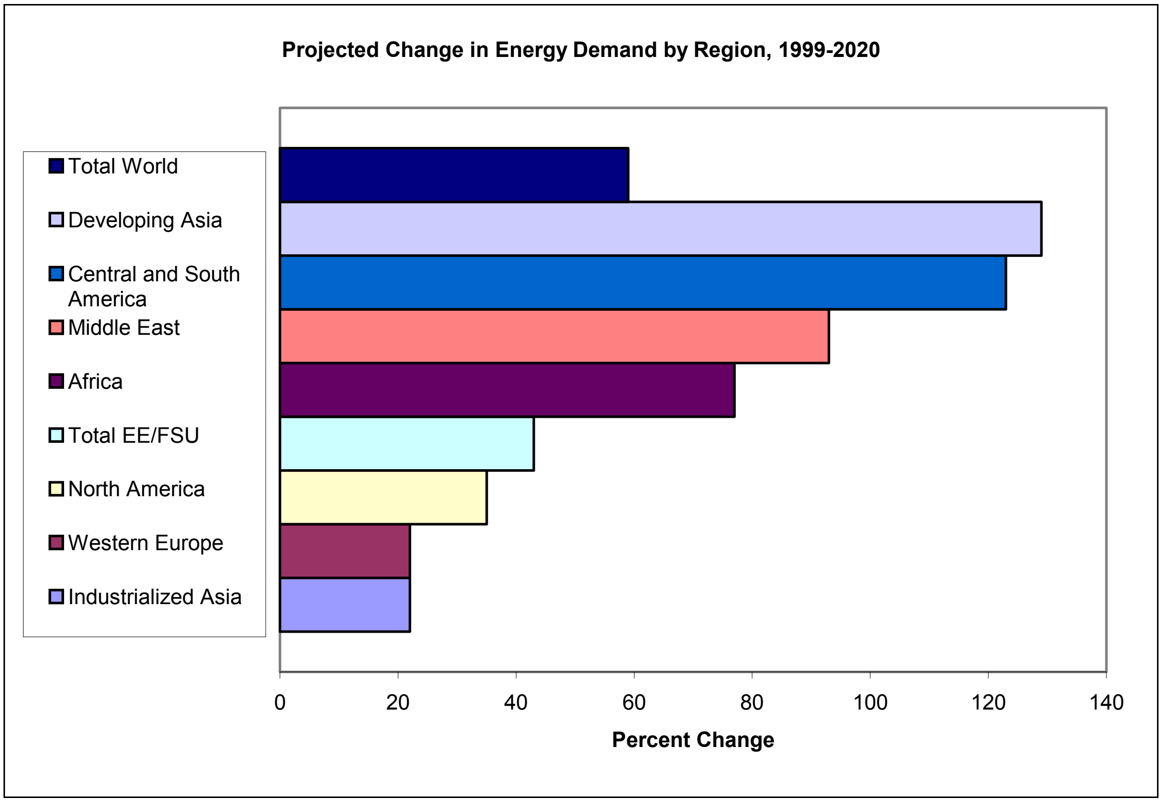
Economic Growth	GNI(1999)		GDP
	total $ billions	per capita $	% growth per capita 1998-99
China	4,452	3,550	6.1
India	2,226	2,230	4.6
South Korea	728	15,530	9.7
Japan	3,186	25,170	0.1
United States	8,878	31,910	2.4
Source: World Bank 2001[7] ($ using PPP method)			

Exploration Question: *Although there are no realistic reasons to expect such a scenario in the near future, what would the total GNI for China and India be if their per capita GNI matched Korea's? Japan's?*

A key consideration when discussing the impact of transportation on the financial future of developing nations is the distribution of wealth. If the use of growing income follows the current pattern of material consumption in industrialized nations by going toward private automobile purchases, for example, developing nations may face a deepening income inequity. On the other hand, more broad-based growth will enable these nations to reduce poverty and vulnerability of the poor to environmental dangers.

Energy Demand

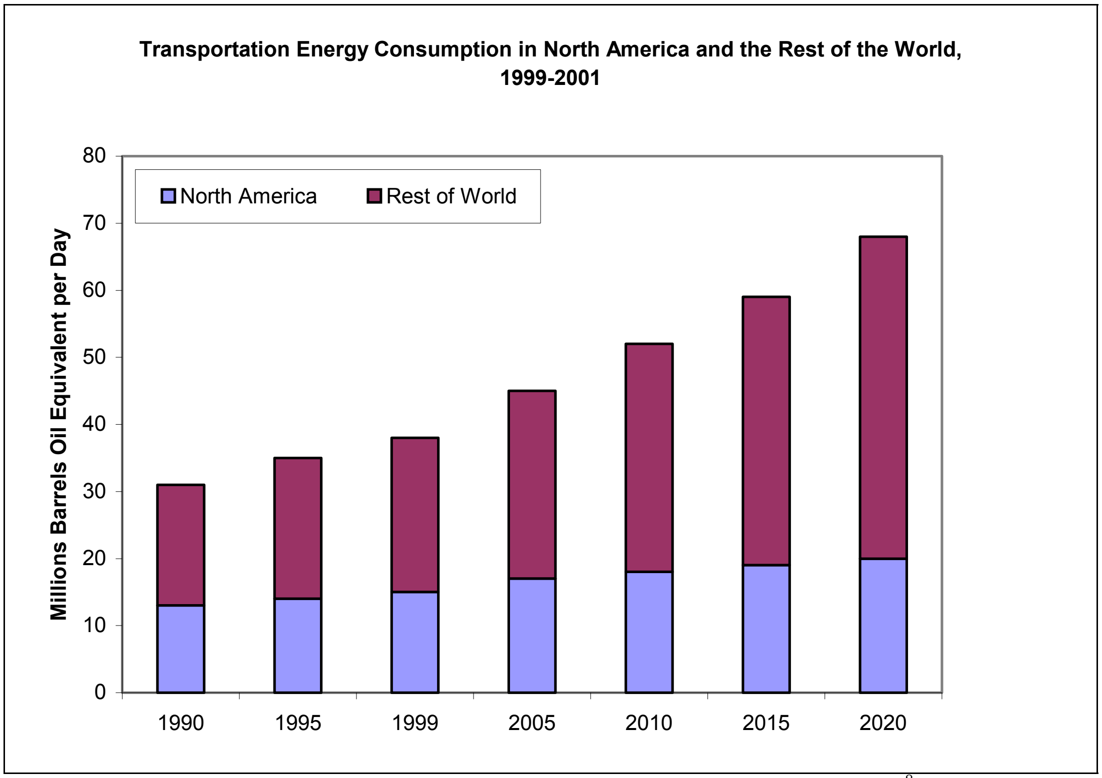
As nations develop and their economies grow, so too does the consumption of resources. Projections of energy use for developing countries show a steady increase in overall usage, with the currently small transportation sector becoming a much greater factor in the energy consumption distribution. While an increase in energy demand is projected for all regions of the world, the greatest increase is forecast for developing Asia.



Source: Energy Information Administration (EIA), International Energy Outlook 2001[8]

Transportation Energy Demand

Currently, the amount of energy consumed in the transportation sector on a global scale is dominated by the United States. This is expected to change over the next 20 years, however, as the economies of developing nations expand rapidly.



Source: Energy Information Administration (EIA), International Energy Outlook 2001[8].

Worldwide, transportation accounts for ¼ of total energy consumption, with motor vehicles claiming 80% of this amount[6]. However, energy consumption in the transportation sector as a percentage of total energy consumption is still quite low in developing Asian countries.

Energy Consumption by Sector

		Energy Consumption, 1997 (%total)	
	Transportation	Industry	Residential
China	8.8	42.5	36.8
India	11.7	22.8	54.1
South Korea	23.2	44.9	8.5
Japan	27	39.8	14.1
United States	39.5	25	17.3

Source: World Resources Institute (WRI), World Resources 2000-2001[4].

Exploration Question: *If we envision the development of China and India as a progression toward consumption distributions of existing industrial nations, what seems to be the direction in terms of energy allocation? What factors are involved in this process?*

Energy Consumption

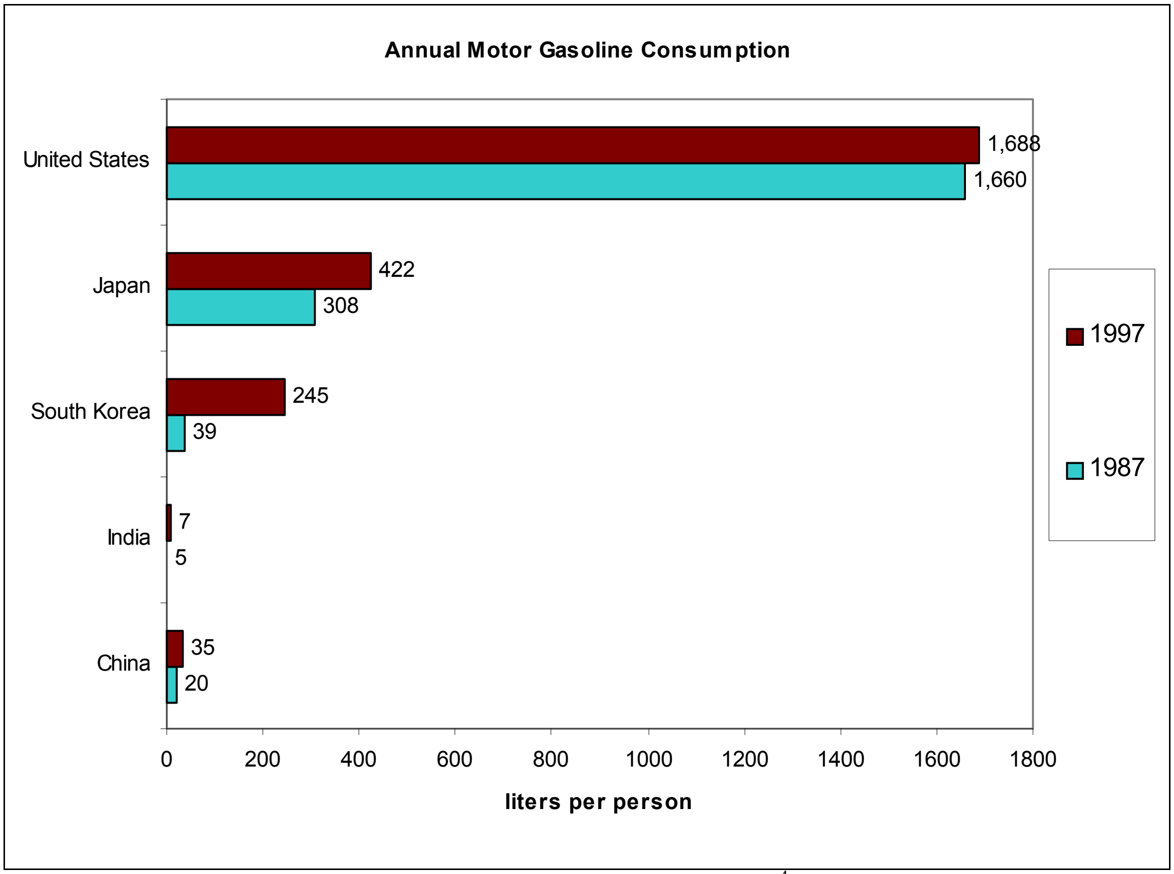
	Total Energy Consumption (1000 MTOE) 1997	Percent Change Since 1987	Per Capita (kg oil equivalent) 1997	Transportation Total (1000 MTOE) 1997	Transportation Per Capita (kg oil equivalent) 1997
China	1,098,931	42	883	96,706	78
India	461,032	45	477	53,941	56
South Korea	176,351	166	3,856	40,913	895
Japan	514,898	37	4,085	139,022	1,103
United States	2,162,191	16	7,956	854,065	3,143

Source: World Resources Institute (WRI) 2000-2001[4].

Having established the relationship between growth and transportation energy consumption, we must consider the source of energy. As long as oil remains relatively inexpensive and cheap, the expected means of powering growing transportation demands is gasoline.

The International Energy Agency's *World Energy Outlook 2000* suggests that China and India's primary oil demand will increase at 4.4% and 4.5% per year in the next 20 years, respectively. This accounts for a third of incremental oil demand in non-OECD countries. The IEA translates this increase into a rise from 35% to 38% of China's total oil demand being used for transportation in 2020, and a rise from 47% to 55% for India.

Oil use in the transportation sector is represented for the most part in gasoline consumption. The amount fossil fuels such as gasoline consumed has a direct influence on the amount of pollutants released into the atmosphere; we shall see how this relates to carbon dioxide (CO_2) emissions.



Source: World Resources Institute (WRI), World Resources 2000-2001[4].

Exploration Question: *What are the assumptions that go into a projection for transportation fuel demand?*

Demand for Mobility

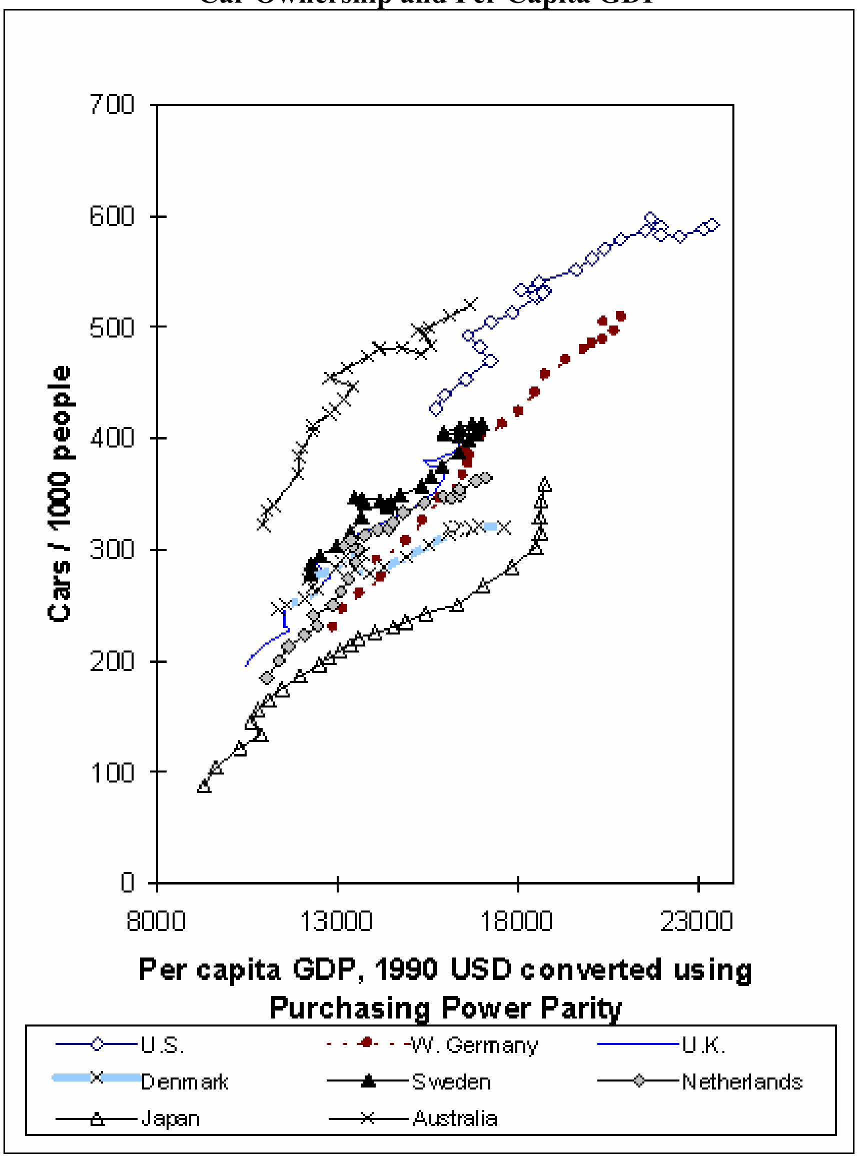
Transportation demand can be met with a variety of methods, and each of these methods has its own share of environmental consequences. The dominant means for addressing transportation demand in developing countries, however, has been personal motorization. A prime example of high economic growth and an increase in motorization can be seen in the case of South Korea. Current levels of motorization in developing Asia are low, but they increasing: the number of cars in East Asia, increased 14-fold from 1975-1993, more than seven times the global average rate of increase[5]. The number of vehicles in China has been growing at an average annual rate of almost 13 percent for the last 30 years, and India's fleet has been growing at more than 7 percent per year [6]. Still, levels of motorization and car travel do not compare with the levels in the United States.

Motorization	Motor Vehicles per 1,000 people		Road Traffic million vehicle kilometers	
	1990	1999	1990	1999
China	5	8	..	..
India	4	8	..	..
South Korea	79	238	30,464	67,266
Japan	469	560	628,581	746,054
United States	758	760	2,527,441	2,536,555

Source: World Bank 2001[7].

A recent study noted a historical link between per capita GDP and automobile ownership in industrialized nations.

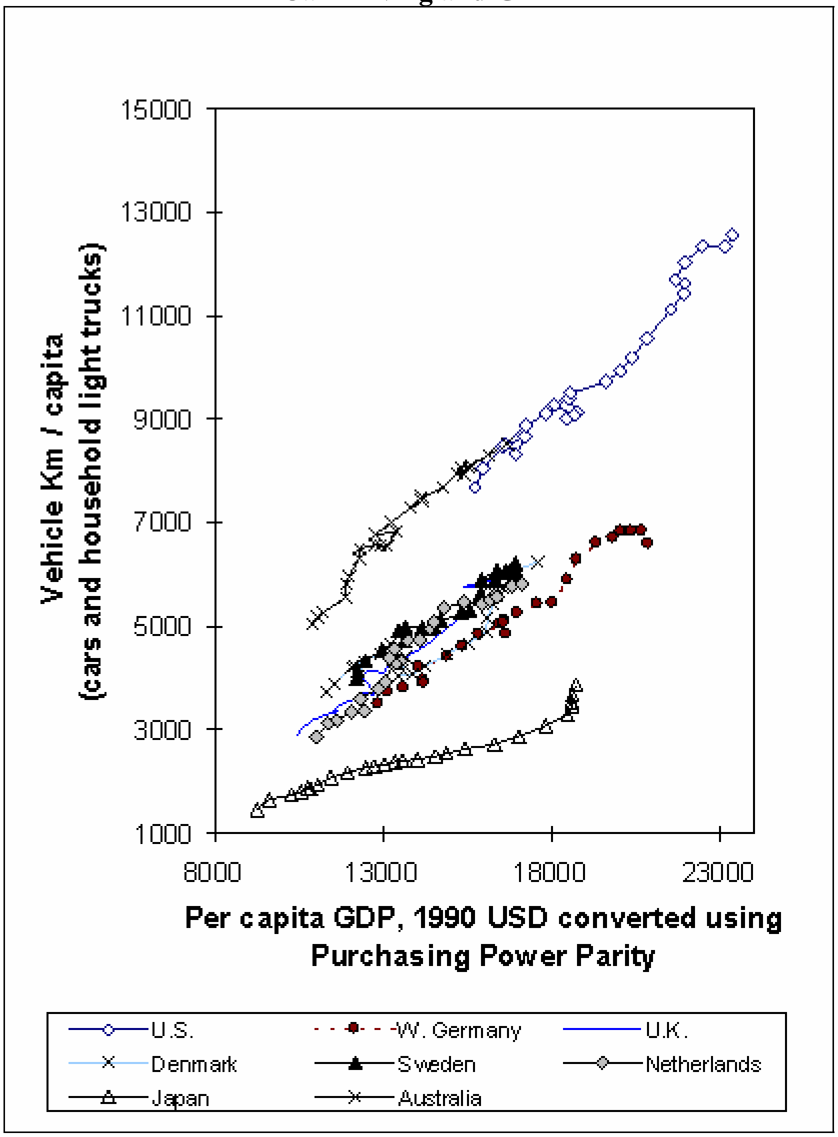
Car Ownership and Per Capita GDP



Source: Schipper, et al. "Rapid Motorization in the Largest Countries in Asia: Implication for Oil Carbon Dioxide, and Trasnportation." [9]

For these same industrialized nations, the study also found a nearly linear relationship between the amount of travel and per capita GDP.

Car Driving and GDP



Source: Schipper, et al. "Rapid Motorization in the Largest Countries in Asia: Implication for Oil Carbon Dioxide, and Trasnportation." [9]

It is apparent, then, that motorization and car use have been directly linked to the wealth of industrialized nations as they have developed over time. This leads us to some important questions: *Will this be the same for developing nations? Are all nations aspiring to attain the economic standards set by the industrialized nations intractably tied to this development track?*

Mobility Impacts on Climate Change

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From the climate change perspective, the principal means toward a desirable future outcome is controlling emissions of greenhouse gases. For the burning of fossil fuels in the form of gasoline, this means decreasing the levels of CO_2 coming out a vehicle's tailpipe. However, most current policy objectives focus not on CO_2 emissions but on issues of air pollution, safety, and congestion, which, unlike CO_2, have immediate, tangible feedbacks on the local population. Locally affective pollutants such as particulates, CO, NO_x, and SO_2 have been drastically reduced through the implementation of emissions standards and technology application throughout the industrialized world, and are beginning to be addressed in developing nations. CO_2, on the other hand, cannot be reduced through similar emissions technologies, since it is an unavoidable product of the internal combustion engine.

Current trends have seen an increase in transport sector CO_2 on par with economic growth, paralleling the trends for automobile ownership and travel. As the second graph shows, the highest rates of growth have been in developing Asia and China.

Figure 1 Per capita CO_2 emissions from the transport sector (tons C

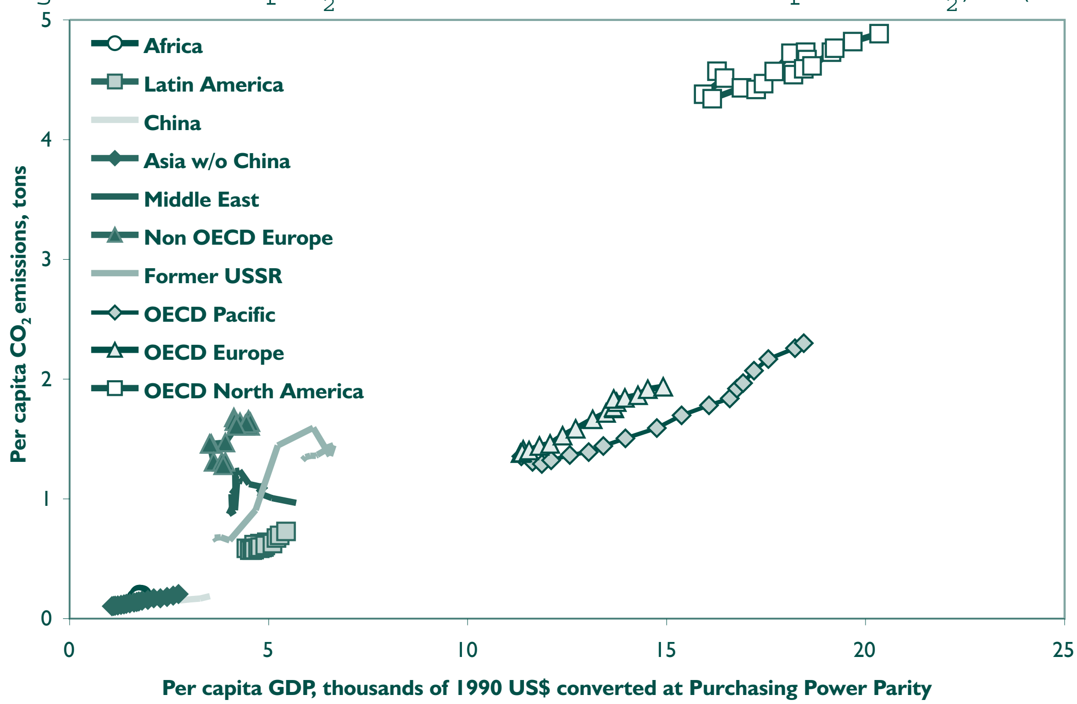
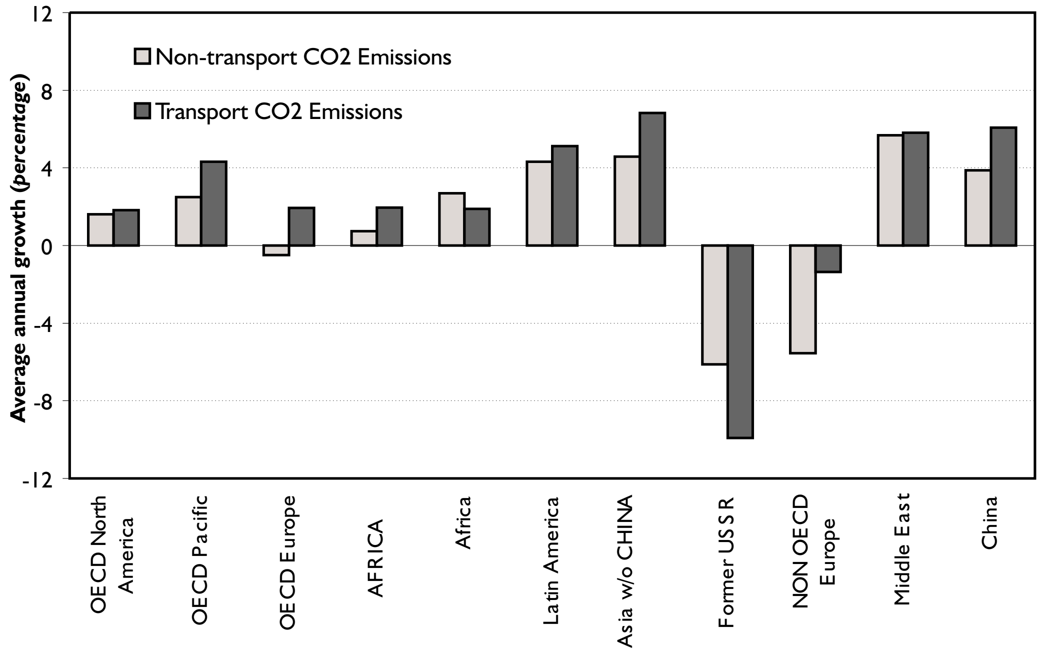
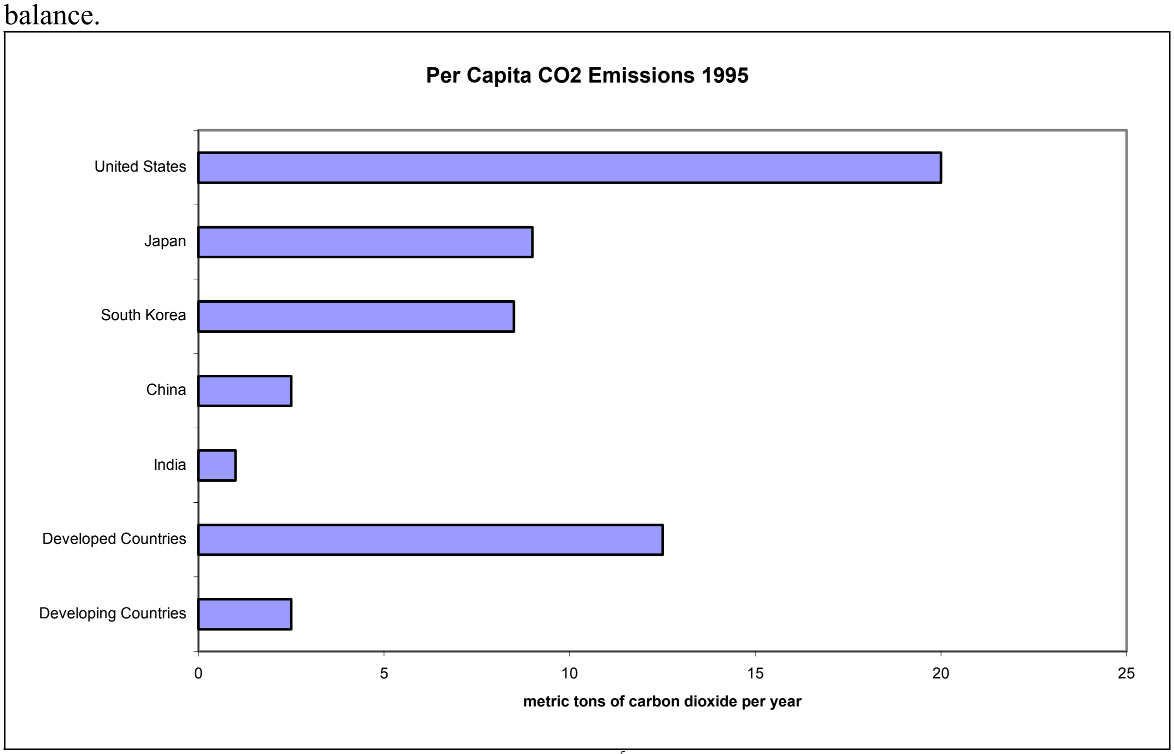


Figure 2 Growth in the emissions from the transport sector an
economy, 1990-97



Source: Schipper, et al. "Flexing the Link between Transport and Greenhouse Gas Emissions."[10]

When discussing reductions in CO_2, it is also helpful to have a picture of the overall global balance.



Source: World Resrouces Institute (WRI), World Resources 1998-1999[5]

The authors of "Flexing the Link . . ." [10] examine the increase in CO_2 in terms of change in four factors: *Activity, Structure, energy Intensity*, and *Carbon Factor*. In terms of *Activity*, growth in the overall travel in passenger-kilometers and freight-kilometers has been steadily increasing, on par with income levels. In terms of *Structure*, the modal mix has shifted toward cars, light trucks, and air, and toward trucks for freight. Energy *Intensity,* the amount of energy consumed per passenger or ton-kilometer, has actually decreased in many cases, but this has not been enough to offset the changes in activity or structure. Finally, *Carbon Factor* refers to the amount of carbon released per unit energy for a particular fuel. This has remained the same, since petroleum-based fuels still dominate the market.

Strategies for developing a sustainable transportation system with an eye toward controlling CO_2 emissions must take into account the nature of the driving force behind the increase in transport activity and the subsequent rise in CO_2 emissions. Data indicates an irrefutable tie between activity and economic growth; *if activity is the force behind growth, how can you address the problem?* This is the dilemma that confronts policymakers today, and the solution requires addressing issues regarding *Structure, Intensity, Carbon Factor*, and even *Activity* directly. (SEE APPENDIX A)

Moving Toward Policy Solutions

The Current State of Policy in China and India: case study on Shanghai and Delhi[12,13]

Current policies in China and India have been targeted at addressing the related local problems of air pollution and traffic congestion. Congestion in major cities such as Shanghai, China and Delhi, India, results from the lack of suitable infrastructure and a high population density, combined with a mix of pedestrians, bicycles, scooters, buses, cars, and motorcycles. Such a combination has created an environment that is chaotic and dangerous.

Transportation has become the principal source of air pollution in major cities; in India's capital city of Delhi, the incidence of respiratory diseases due to air pollution is about 12 times the national average. While India's GDP has increased by a factor of 2.5 over the last two decades, vehicular pollution has increased by a factor of eight[11].

To reduce air pollution, India's Supreme Court approved the following strategies for improving air quality in 1998:

- Augment public transport,
- Reduce Vehicle emissions by setting standards for fuels and auto emissions,
- Establish inspection and maintenance of in-use vehicles, and
- Use clean alternative fuels.

Specific directives include introducing more buses that use compressed natural gas (CNG), cleaning up existing taxi and bus fleets, providing financial incentives for alternative fuel vehicles (AFVs), and installing CNG refueling stations. While enforcement has been weak, the Supreme Court has strengthened local initiatives by steering them toward sustainability. China has implemented similar initiatives to clean up emissions.

In Shanghai, vehicle growth is being retrained through capping registration of all new cars in trucks, mopeds, scooters, and motorcycles, while using a monthly auction system for new vehicle registrations.

On the other hand, vehicle growth has been stimulated by China's commitment to the establishment of an auto industry as a "pillar industry." Although the debate over the government's promotion of the auto industry with regard to economic growth still continues, originally small, inefficient companies have combined and formed joint ventures with international automakers. Following China's accession to the World Trade Organization, increased availability of consumer credit, higher quality cars, and lower tariffs all imply a future increase in private vehicle ownership.

Efforts in both India and China are being made to expand public transit. In Delhi, buses serve about half of all travel demand, but this share has been decreasing even as the number of buses has increased. Increasing privatization of bus service has expanded the fleet, but buses are still overcrowded and poorly maintained. Most riders are too poor to pay even subsidized fares. Chartered buses provide point-to-point service and have been claiming a larger share of overall bus transportation. These buses serve wealthiest 15 percent of the population and are directly competing with private automobile use. Shanghai has invested heavily in transportation infrastructure, and plans to build railways and elevated busways in addition to expanding roads. Delhi is building a multi-modal rapid transit system, integrating rail and busways.

In Shanghai, urban planning efforts are focused on reducing population density by building satellite cities, relocating industry and housing to create a multicentralized metropolis. Details on such an "urban village" planning system will be discussed later, and can be referenced in Kenworthy and Newman's book, Sustainability and Cities[2].

Exploration Question: *How do these efforts fit in with the demand schematic outlined in Appendix A? What are their possible strengths and weaknesses?*

Looking Toward the Future: Policy Options and Scenarios

Although China and India have started to implement promising policies, the story is far from over. Introducing additional measures to meet air quality and public safety objectives as well as CO_2 emissions goals remains a complicated and difficult process. Let's look at factors for consideration when formulating transportation strategies that will work for these countries.

First, we must see communities establish goals to limit the deleterious impacts that increased mobility will have on the population and the environment. This is the sustainability approach; each policy is carefully examined in the context of its long-term effects.

One way to affect transportation activity is through urban planning efforts, as in Shanghai. This is a structural approach: the second-order demand is satisfied by putting more weight on proximity as a means of access. The creation of "urban villages" involves the construction of high-density living spaces with a variety of land-use activities. By providing basic needs within walking and bicycling distance, the need for personal automobiles is diminished. In addition, urban sprawl, a driving force behind auto use around the world, is managed and directed toward satellite cities.

Another approach is to attempt to restrain growth in vehicle use. Policy initiatives can be classified here as either *demand*-oriented or *supply*-oriented. Demand-oriented policies increase the cost of owning personal vehicles to reflect the actual cost they have in infrastructure investment and damage to the environment. Parking fees, fuel taxes, registration fees, and drivers license taxes are examples of such policies. The hope is that people will switch to other modes of transportation because driving is just too expensive.

Supply-oriented policies increase the quality and quantity of alternative modes of transportation. A large part of the supply approach involves improvements in infrastructure: sidewalks are widened and improved, lanes are dedicated to bicycles and buses, and efficient railways carry passengers and freight. A key component of quality is the integration of public transportation. Not only must investments in busways and railways occur, but they must also be co-planned to connect well at points easily accessible to bicyclists and pedestrians.

Some specific initiatives that attempt to curtail car ownership and use include car-free zones and car-sharing. Car traffic would be banned during peak travel periods in strategic areas such as shopping districts, promoting other modes of short-distance travel. Car sharing has recently become popular in Europe; members pay a yearly fee plus a charge per hour of use and kilometer traveled. Such organizations allow a larger number of members to have on-demand travel with fewer cars on the road.

Yet another approach is the "technical fix," where the emphasis is not necessarily on reducing car usage, but on regulating automobile technologies with air pollution and energy efficiency in mind. The first wave of technological innovations is aimed at reducing local air pollution while still using internal combustion engines. These include cleaner-burning engines, eliminating leaded gasoline, exhaust treatment (i.e. catalytic converters), and cleaner-burning fuels such as CNG and liquid petroleum gas (LPG). Right now, efforts to promote CNG vehicles is limited to buses, since more widespread non-gasoline motor fuel use will require greater infrastructure investment in fueling stations, etc. It should be noted that cleaner-burning gas vehicles improve local pollution levels but have little effect on greenhouse gas emissions, since most diesel engine conversions lack efficiency and CO_2 is still being produced in combustion.

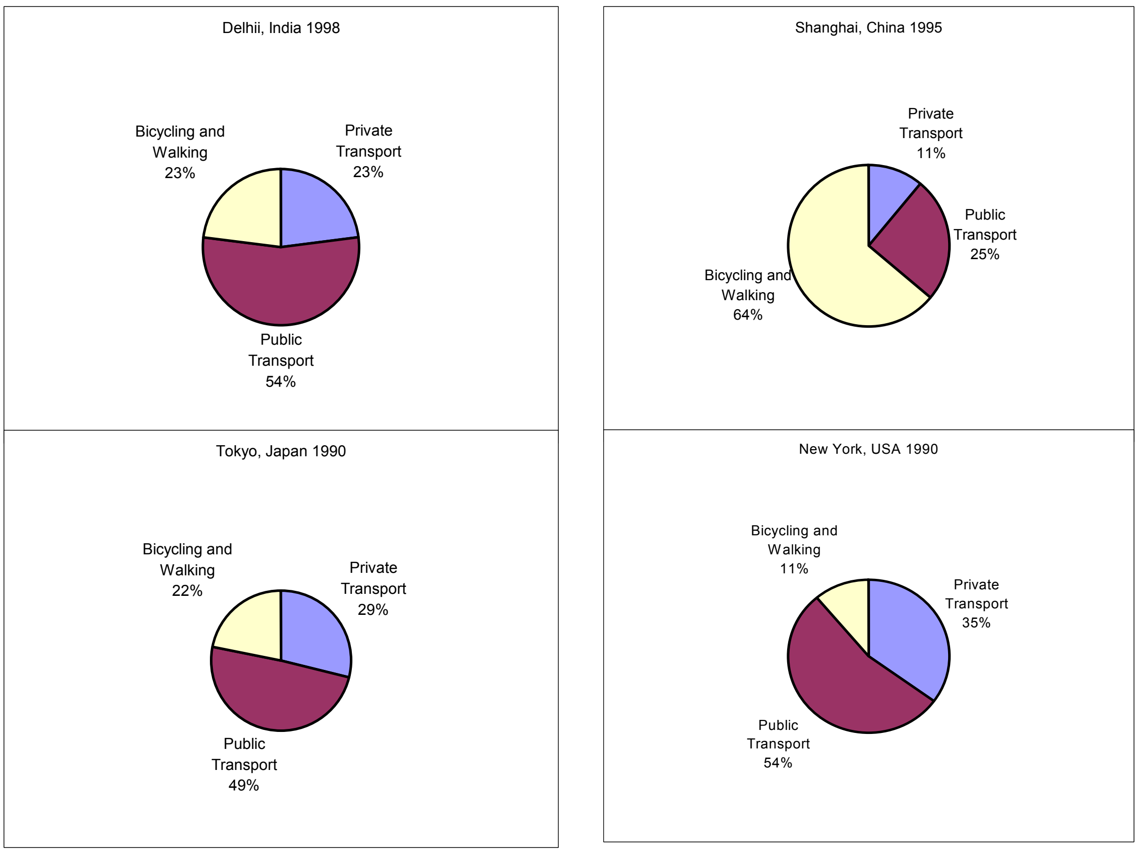
The second wave of technological innovations is aimed at increasing the energy efficiency of internal combustion engines. Vehicles in China and India are not efficient by international standards, and adoption of current technology would make a substantial difference. Current cars in developing nations are typically much smaller and less powerful than cars in the United States. Cars in the United States have applied greater engine efficiency toward greater power and larger vehicle weight, rather than fuel economy[14]. Promoting the use of modern minicars, such as those being developed in Japan, would avoid the adoption of American standards, which are unsuitable to the dense urban zones in developing countries.

The third wave of technological innovations involves the transition from internal combustion engines to electric drive propulsion technology. These innovations, which include fuel cells, batteries, and hybrid systems, would improve energy efficiency by 50 percent or more while substantially decreasing local air pollutants and greenhouse gas emissions. Automakers around the world are currently developing such technologies at increasingly lower cost, making this a feasible way to "leapfrog" developing countries. Such a "leapfrog" maneuver would skip the prolonged, gradual improvement process in efficiency and emissions experienced in industrialized nations.

An important factor in making decisions for the near-term transportation futures of developing nations is the fact that most citizens are simply too poor to afford personal automobiles, much less sophisticated, modern machines that will be efficient and clean (compare GNI per capita levels above). Even mass transit can be too expensive for the poorest people; for them, walking and bicycling offer the only possible way to get from place to place. A shift toward highpowered, high-speed personal mobility threatens to widen the gap between the haves and the have-nots, with city designs increasingly tailored for a smaller percentage of the population.

The existing modal splits in personal mobility for Shanghai and Delhi paint a picture distinctly different from the typical American paradigm. (In this comparison, one should remember that Delhi, India's third largest city, has higher motor vehicle per capita levels than anywhere else in India. Also, consider that New York has some of the highest public transportation use in the United States.)

Modal Split by Number of Total Trips



Source: "Transportation Scenarios for Shanghai, China and Delhi, India." Pew Center on Global Climate Change, 2001.[12,13]

If our eye is turned toward minimizing the impacts on global climate change from the emissions of greenhouse gases, we can look at the fuel intensities and greenhouse gas intensities for various technologies and modes of travel. Data is an average of figures calculated for Delhi and Shanghai. Notice that electric vehicles also have greenhouse gas emissions due to the fuel mix used in producing the electricity at a power plant.

Greenhouse Gas Emissions
CO2-equivalent grams/vehicle kilometer

	Fuel (km/liter)	GHG (g/vehicle-km)
Gasoline Motor Scooter (2-stroke)	35.2	124
Gasoline Motor Scooter (4-stroke)	49.4	74
Electric Motor Scooter	N/A	51*
Gasoline Minicar	24.8	129
Gasoline Car	12.2	318
Diesel Car	17.9	193
CNG Car	N/A	256
Electric Car	N/A	182*
Diesel Bus	3.3	954
CNG Bus	N/A	1045
Fuel Cell Bus (methanol)	N/A	N/A

Source: "Transportation Scenarios for Shanghai, China and Delhi, India." Pew Center on Global Climate Change, 2001.[12,13]
*For battery electric vehicles, the electricity generating mix for calculating GHG emissions is as follows: Delhi, 70% coal, 15% hydroelectric, 10%natural gas, and 5% petroleum and biomass; Shanghai, 78% coal, 15% hydroelectric, 4% oil, 2% nuclear, and 1% natural gas.

INTEGRATING INFORMATION WITH SCENARIO TOOLS

Now that the background information has been established, and some of the current policy direction and possible future directions have been described, it is time to try make sense of the situation firsthand. Let's try to integrate what we have learned and explore alternative futures using scenarios (SEE APPENDIX B).

Participants should divide into small groups (no more than 3 or 4), and, develop a qualitative set of scenarios for mobility development in China, India, and the United States during the next 20 years. Groups can either work on China or India alone, or both countries simultaneously, depending on class size. All groups should develop "minor" scenarios for the United States that serve as a reference/comparison. Things to consider while developing these scenarios include:

1. What are the overall goals of your polices? Try to be as specific as possible.

2. Which trends and statistics are most compelling in their implications for the future?

3. What specific policies in China and India would support you goals? What new policies would be necessary?

4. Is your plan structured with greenhouse gas reduction in mind? If so, consider how it addresses areas of *Activity, Structure, energy Intensity, and Carbon Factor.* Also consider the method of addressing demand outlined in APPENDIX A.

5. Where, when, and how do new technologies contribute to your plan?

6. Do your plans follow the models of any newly industrialized Asian nations? If so, which ones?

DISCUSSION

Come back and discuss your individual group plans with the class. Try and convince other groups that your plan is a good one by explaining the reasoning behind your choices. Through compromise and cooperation, work toward some agreement as to what direction China and India need to take in the near future. Eventually, lead discussion to the following questions:

1. All policy decisions have an ethical basis: they justify their action through some idea of what is good for the affected people. What are the underlying value assumptions behind the policy choices you deem effective?

2. Are these values universal? To what degree might you be able to implement these policies in other nations? What does this say about cultural differences?

3. Define the right to personal mobility in human values. How important is this? How does it relate to larger issues of inequity?

4. What criteria and standards do we use to make decisions regarding personal freedom?

5. Specifically, compare the circumstances in China and India with those in the United States. How might we justify our policies in light of the current state of American national policy?

6. In terms of global impact due to CO_2 emissions, how much difference will the transportation sectors China and India make in the near future? What implications does this have for where global climate policy should be directed to make a real difference?

7. What kind of role should foreign countries and international investors play in shaping the transportation futures of developing nations?