from about 25 percent of all demand in 1972 to more than 48 percent during 1979; and this situation occurred despite a 5 percent reduction in gasoline consumption during 1979.

If the economy of this nation is to thrive, we must begin at once to alter past patterns of wasteful use of energy in every sector of our society. We must realign and reassess our national priorities in such a way as to ensure continued economic prosperity, while, at the same time, providing the best possible life-style for our people. This will not be an easy task but, with clearly defined goals, it can be achieved.

Chief among these goals must be a reduction in our dependence on foreign oil. This can be achieved in two ways--both of which are necessary if we are to survive as an independent, strong nation.

First, we must increase production of all our domestic energy resources, including domestic oil and gas, shale oil, synthetic fuels from coal, solar energy, and nuclear power. Although this is feasible, it will require time—at least several decades—to bring these resources onstream, as well as billions of dollars in capital investment.

Second, we must conserve, and conservation is the underlying reason for this conference. In some circles, this implies rigors, hardships, and doing without. It is particularly frightening in the transportation sector—the sector that now consumes the majority of our petroleum resources—because it means limiting what we have come to know as the freedom of mobility. Our whole life-style has been built on easy mobility. We define our worlds by where we can travel. The thought of shrinking those worlds is frightening in a very basic psychological way. Yet, conservation is our greatest energy-consumption priority.

Our challenge in transportation is to find ways of maintaining the same mobility for both persons and goods and carrying out the same activity with a reduced amount of oil and, ultimately, without any oil. To achieve this goal, we will need to understand the user's needs in a way that we never have before. All too often we have addressed almost all of our attention to the technology of mobility. It is time to concentrate on why the user needs and values mobility and to be creative in looking for a variety of ways in which we can either change those values or meet mobility needs in a more energy-efficient manner, particularly in emergency situations.

Recently, politicians, planners, and academicians have proposed several methods for curtailing the transportation sector's oil consumption. I will briefly outline several of these approaches.

One of the best-known solutions to oil conservation is the legislation that requires improved gasoline consumption of the notorious automotive "gas guzzler". The average U.S. automobile is extremely inefficient; it converts only 15 percent of the energy in gasoline into usable power. The U.S. Department of Energy (DOE) has estimated that each incremental improvement of 1 mile/gal in the fuel economy of all automobiles would save about 400 000 bbl/day of oil.

Another method of reducing petroleum consumption is to develop engines that can replace the inefficient internal combustion engine as well as gasoline substitutes from coal, oil shale, and biomass. DOE has been working with private industry to develop gas turbine, Stirling, and other improved types of engines as well as motors that can use alternate fuels. But these technologies are still in the research stage, and, since it takes an average of 20-25 years to go from the laboratory to commercial production, they will not reach the marketplace until the 1990s at the earliest—after the energy problem has already reached crisis proportions. The same is true of electric automobiles, whose proponents say will replace the second automobile now owned by 35 percent of U.S. households. One government forecast estimates that, by the year 2000, 10-15 million electric automobiles could be on the road. General Motors does not forecast a much larger market share than this estimate during the remainder of this century. Its recent announcement of a nickel-zinc battery design breakthrough projected commercial introduction of an electric automobile in 1985, with a projected market share of less than 10 percent by 1990. But the ultimate energy saving projected for these vehicles is surprisingly low—only about 300 000 bbl/day of oil, or 2 percent of current consumption, according to one study. Another option for personal mobility is public transportation and other ridesharing modes—an option that can play a significant role in energy conservation.

When we speak of public transportation, we traditionally think of buses, trains, or trolleys. But I believe our concept must broaden to a more generic term, that is, high-occupancy travel, as we attempt to find alternate solutions for the single-occupant vehicle, particularly in suburban areas. Are you aware that carpools and vanpools have been found to be the most energy-efficient form of journey-to-work transportation? They provide the door-to-door convenience of an automobile and can provide badly needed additional capacity to the public transportation system at peak hours. Taxipools and jitneys, if carefully used, can provide energy-efficient local circulation for shopping, recreation, and other desirable discretionary trips.

A key to improved energy-efficient mobility is a much-increased range of services and options: rail, bus, vanpool, taxi feeder, local jitney, and private automobile. Each mode serves the trip length, type, and density that are most cost- and energy-efficient for that particular mode. The automobile will remain our most useful vehicle. However, it will simply be used more efficiently.

Several petroleum-conservation measures have been described here. We also know that it is imperative to increase conservation through the efficient use of available energy supplies. Conventional wisdom tells us that, in view of rising prices and uncertain supplies, conservation is a good investment. The question is, "How can we do it?" Restrictions, rationing, and regulations are obvious possibilities for the near term. Education, dissemination of information, and financial incentives also are important. But the real challenge is to develop energy contingency plans in a manner that will permit us to sustain our life-styles, will expand opportunities for individual choice and advancement, and will provide the basis for economic growth. This is our challenge--yours and mine.

Energy-Transportation Overview

Louis J. Gambaccini

With the first oil wells in 1859 came a new source of energy for the United States—one that almost completely replaced coal, firewood, and water for more than a century and became the world's chief source of energy. But oil now is becoming a marginal resource. Although estimates vary, there are approximately 652 billion bbl of proven crude oil reserves in the world today. Until the latter part of the 1970s, petroleum producers were able to augment this supply with 24 billion bbl/year. Now, a situation exists where the world's consumption rate is 42 percent higher than the discovery rate, and depletion runs on the order of 6 billion bbl/year. Although it will continue for some time to supply a major share of the world's energy requirements, oil is expected to reach its peak production by 1990, followed by a precipitous decline for the next 30-40 years.

OPEC members control some 70 percent of the 6.5

billion bbl of oil produced worldwide. In order to stretch revenues from this fixed reserve, OPEC intends to market what amounts to 400 billion bbl of crude oil over the next 30 or more years. For the Middle East, this basic OPEC policy appears to be a wise investment strategy. For the United States, which controls less than 5 percent of the reserve and consumes 30 percent of all petroleum worldwide, the prospect of a chronic limitation on oil could spell economic disaster.

Some oil experts believe that the answer to this energy crisis is to restock the world's reserves by substantially increasing oil exploration. For China, Mexico, and Brazil (which now has the largest offshore operation in the world), big finds have resulted. But, for the United States, the new frontier of offshore drilling on the Outer Continental Shelf, with a few exceptions, has been less than successful. Many companies have abandoned or delayed further exploration.

Energy experts believe that alternatives, such as oil and gas from coal, may become cheaper than finding, developing, and producing new oil and that coal liquefaction and gasification will undoubtedly be the new waves of the future in energy. However, because of the lack of government funding, guarantees, and tax incentives, synfuel plants in the United States are not expected to produce commercial quantities of oil or gas before the mid-1980s. Other energy users are looking to alcohol fuels to extend whatever marginal supplies of high-quality liquid fuels will be available in the United States.

Because of the lead times required to develop and establish any new technology on a commercial scale, our choices are limited, as indicated by the following:

1. Given existing circumstances, oil reserves in the United States are projected to last approximately nine years.
2. If current foreign diplomacy prevails, imported oil from Saudi Arabia will only be able to supply half of our demand in the 1980s (11-12 million bbl/day).
3. Only 7.2 percent of the rest of the nation's energy needs will be met by nuclear power in 1985, compared to previous estimates of 12.7 percent, and synthetic fuels from U.S. coal deposits will not be ready for commercial delivery until after 1985.

Thus, it appears that, throughout this decade at the very least, we will be witnessing a transition to a remix of energy supplies—one where (a) oil and natural gas will supply only 60 percent of our energy needs; (b) synthetics, solar, and other unconventional energy forms will begin to contribute to the total U.S. energy supply; (c) nuclear capacity will increase only slightly; and (d) coal production will reverse its historic decline and represent nearly 30 percent of the total U.S. energy supply by the end of the decade.

The significance of what I have just outlined is that we are living in the last decades of the petroleum era and, in the United States, where petroleum accounts for about 45 percent of our energy base, substantive changes in energy direction and use are required.

The greatest challenge, perhaps, will be in the transportation sector, which is heavily dependent on petroleum. As such, it places an inflexible demand on the highly concentrated and portable energy characteristics found in oil, unlike any other consumer sector in the nation. The private automobile, which consumes 60 percent of the energy devoted to transportation in this country, is the biggest consumer. These vehicles use an amount of fuel nearly equivalent to our foreign oil imports.

Significant issues revolve around the need to greatly reduce automobile use and to place increasing reliance on public transportation. However, it should be stressed that it is the total efficiency of the urban area and of its complete transportation system that counts—not the efficiencies exercised by the individual elements. That is why we rely on transportation solutions that incorporate a family of vehicles—for example, automobiles, vans, small and large buses, rail transportation, and downtown people movers.

In my judgment, great opportunities for petroleum conservation in transportation rest in the proper application of this family of vehicles, with each member used in the most energy-efficient manner. With limited gasoline supplies in the rural and outlying suburban areas, the automobile and the van can be very useful. We can adapt the flexibility of bus services to serve areas of moderate density and to link urban centers not served by rail transit.

These elements of an effective surface transportation system can produce substantial reductions in petroleum consumption in the years ahead, but only if the areas served are gradually reshaped into energy-efficient development clusters. Thus, within the confines of today's urban sprawl, petroleum-efficient patterns must emerge. One prime ingredient is the opportunity for adequate housing near major employment sites. Today, the work trip consumes 44 percent of our gasoline. In well-oriented communities, many walk trips are possible. For example, in a tightly developed downtown area, with housing in adjoining sectors, 70 percent of the trips of one block or more in length are walk trips. This approach should be expanded by cooperative ventures between employers and housing agencies.

Where the walk trip is impractical, the next best energy saver is the multipassenger vehicle for short trips. The opportunity to carry many people on relatively short trips was the trolley's success story early in this century. However, much of the linear or strip development that resulted from the trolley era has disappeared or fallen into disrepair; new commercial development tends to occur in clusters at key intersections. Thus, light rail transit (LRT), a variant to the trolley, is more appropriate to serve these medium-density residential and commercial areas.

More than 80 percent of the housing units that will be occupied in 1990 are already in place. More than 25 percent of these are located in suburban settings where the characteristic pattern of movement in commutation trips is from dispersed settlement areas to similarly dispersed work areas. Such travel patterns are difficult to serve with regular-route bus or rail service. However, these areas are prime candidates for subscription bus service (if the residential trip-ends are reasonably clustered), vanpools, or carpools. However, as time passes and gasoline becomes precious, developers of industrial parks may choose to enhance nearby residential opportunities for their clients.

The question that needs to be addressed now is, "How do we take the energy we do have and develop a new petroleum-efficient transportation system?" The answer must come from pursuing a combination of public transit investments and urban redesign incentives to reduce petroleum consumption by channeling new residential and employment investment to urban areas already furnished with appropriate infrastructure (e.g., sewers, water supplies, governmental services, highway access, and public transportation facilities). This will require joint land use and transportation policies and an irrevocable commitment to public transit facilities. Ideally, the outcome of a joint-development initiatives program will be to concentrate funding in major transit corridors to begin a process of land use reorganization in many areas.

Since World War II, our private investment and land use decisions have undercut much of the potential petroleum efficiencies of our nation's urban centers. The suburban sprawl of the 1950s and 1960s, with its energy-inefficient, single-family residential patterns, along with the continuing relocation of major corporations to the edges of the urbanized United States, has created an automobile-commuting work force of 87 million people and an ever-increasing reliance on the automobile. As a result of this dispersion, our urban centers have lost both business and population, while the public transportation operations that served these urban centers have deteriorated. In short, our urban design efficiencies have been undermined.

In the long run, transportation energy consumption can only be brought under control by formulating an urban redevelopment strategy that stresses modification of out-migration and low-density development patterns. Of

direct relevance to this redevelopment strategy is the expectation that the largest growth in the number of households in the 1980s will occur in central cities. As such, the 1980s will probably offer the last opportunity to implement a cost-effective redevelopment strategy.

One of the most frustrating developments in federal policymaking in the past five years has been its failure to recognize the integral relation among dense urban design, public transportation, and petroleum conservation. Although the gravity of the long-term petroleum scarcity is well understood, the planning required to finance and advance urban redesign moves ahead haltingly. At the same time, the actions required to carry out restored and expanded public transit operations to blend with urban revitalization are financially starved.

Energy-efficient land use changes should be developed now with a guaranteed commitment from government that activity centers will be linked and supported with reliable public transportation. I envision the transportation system of the future as one developing out of the following principles or directives:

1. Public transportation links between major activity centers, as well as circulation and feeder services within these centers, should be guaranteed or given a permanent commitment by government, such as dedicated sources of funding for initial development, operation, and improvements.
2. Pedestrian facilities should be made a prime element of public transportation systems, particularly where they support community-centered public transportation services.
3. System design should include features such as parking facilities and traffic restraints, and economic disincentives should be developed to manage the use of the automobile.
4. Recognizing that the provision of bus services to low-density residential and rural areas is quite costly, paratransit zones should be established immediately with the clear understanding that, in the future, support for vanpooling and carpooling rather than bus services will be offered in these areas.

How, one might ask, can this country finance such a drastic shift in transportation development? Consider that the cost of automobile ownership and operation in 1979 increased by $0.04/mile, and we traveled 1.5 trillion miles in the United States. Thus, the cost of travel by automobile increased by roughly $60 billion in just 12 months—in a year when our total federal outlay for public transportation was less than $4 billion. Any country that can afford to increase its spending on automobile travel by $60 billion in a single year certainly can afford public transit. Securing continuous funding for public transportation and determining the fiscal responsibilities of various levels of government are the primary issues.

The substantial long-term petroleum saving is of great national value; hence, the federal government has the prime responsibility for the major systems that link centers of activity and circulation within these centers. State and local governments are responsive to service needs of residents and commercial interests and, as such, should lead in the funding and development of local and feeder bus systems. Rural areas and free-standing cities need paratransit and the special transit services that are usually provided by county governments.

This suggests the need for financial commitments from all levels of government. To borrow a page from the successful highway program, the federal commitment to public transportation should be the carrot requiring a continuous source of state and local funding of the system. Why not establish binding intergovernmental agreements that mandate state legislative and local policy based on continuing public transportation support as a requirement for federal funds? For example, the limited federal funds available for new rail systems could be awarded only to communities approving new and continuous funding resources for the local matching-fund portion of the project cost and continued operations.

Funding of public transportation should be considered in the larger context--within the framework of a transportation energy-management program. The public has been and continues to be supportive of public transportation programs. Political leaders perceive this and, in the absence of countermoves by special interests, will make commitments to transit programs. But public transportation appears pale when placed against the marketing forces of the automobile society. Thus, if the principal long-term goal is an energy-efficient society, it is the transportation energy-management program that must be understood and nurtured for the public benefit. The question is how to assemble a long-term systems approach that will endure the short-term whims of our political system. I suggest that we start with simple goals, such as reduced oil imports and state aid consumption quotas. Once we are accustomed to this approach, rational long-term objectives for subsets like transportation petroleum-consumption goals for 1985 and 1995 can be established and accepted by the several publics.

The first step in meeting these long-term goals is the continuance and expansion of national programs, higher fuel-economy targets for automobiles (especially after 1985), similar actions for other vehicles, rationing when appropriate, and further technological development of vehicles fueled by other energy sources.

After the projected national targets are deducted from the original goals, missions in transportation petroleum conservation can be assigned to states and to regions within states. This is a most important step if the needed participation of the private sector is to be attained. The transportation community is quite adept at approaching established programs for capital improvements, operational expansions, and marketing of public transportation. Similarly, paratransit is being rapidly developed with substantial private-sector participation. In fact, most of ridesharing's success has hinged on good private-sector participation.

Regions and municipalities can lead in efforts to make existing transportation paths more petroleum-efficient with the development of traffic signals and other traffic management efforts. These can be easily identified, quantified, and implemented.

Park-and-ride programs that are petroleum-efficient are less of a science and more of an art today. But, with petroleum conservation the prime mover in park-and-ride, such programs can be readily produced.

Highway space allocation programs are in their infancy. They operate as a joint venture between the land use management agency—usually local government and a particular road authority, which can be either a local agency or the state highway or transportation department. It works like this: The road authority measures traffic and identifies any remaining space available for additional future traffic during peak periods. The local government or governments traversed by this critical system link agrees to an equitable allocation of this remaining space (i.e., what remains before overcrowding occurs) and, through the appropriate zoning or permit process, assigns such space to vacant or underdeveloped properties, as well as growth assignments to existing developments. Such assignments may carry commitments to use of paratransit and transit in exchange for increased development potential. Routine traffic monitoring and reporting of traffic growth control this release of space allocations to developers. For example, if, in the third year of the program, traffic growth is less than anticipated, the rate of space released to developers can be increased by mutual consent. This actively permits extensive in-filling of development up to the limit of traffic capacity with these benefits:

1. Petroleum conservation through less congestion,
2. Increased employment density with improved opportunities for public transportation, and

3. Firm commitments to the use of paratransit and public transportation from the private sector.

Another intergovernmental joint venture involves local government and the public transit agency—that is, the enactment of a code or ordinance that requires the developer to provide on-site transit improvements, such as shelters, pedestrian paths to bus stops, bus pull-out lanes, and, where needed, bus turnarounds. This is accomplished prior to the issuance of building permits. The transit agency is obliged to identify existing and future services; the local government ascertains facility needs and staging commensurate with the developer's program. These efforts result in improved awareness by all parties of the opportunities for petroleum conservation through public transportation.

Traffic signal programs, park-and-ride, highway space allocation programs, and transit enhancement codes are important elements in any transportation energy-management program. No single mode of transportation and no individual element will do the job. Within the confines of transportation improvements, a system approach is required. Greatly increased public and private cooperation is also necessary for a productive program.

Last, but not least, is the need to cluster development within the confines of today's urban scene. Although formation of clustered development is not the primary mission of transportation planning, clustered development greatly improves the viability of public transportation, increases the number of walk-trips and nontrips (i.e., the elimination of the need for a trip). Recognizing the link between these development and transportation advantages, the Urban Mass Transportation Administration (UMTA) evolved its Joint Development Program. UMTA is to be commended for this absolutely critical program. Expenditures on joint development are in the $50-$100 million range.

For some reason, the petroleum-saving potential of UMTA's Joint Development Program has not been examined. This should be the major thrust in the months ahead because clustered development is the cornerstone of the links among petroleum conservation, transportation, and land use.

In brief, there is no single mode, no simple solution, for substantial petroleum conservation in the near-term future of transportation. A comprehensive transportation energy management program is needed and is needed now. It must be a program with considerable involvement from the private sector. The ultimate focus must be on clustered urban development. This difficult task must be approached with the knowledge of the potential conflict between infringement of the freedom of individual choice versus community benefits and the national need to conserve petroleum.