The Wolf is at the Door

A Common Sense Approach to Sustaining the U.S. and other Advanced Economies After Global Oil Production Peaks

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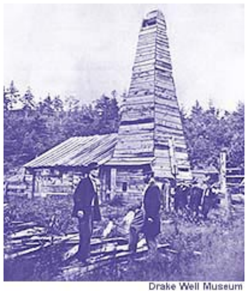
The Age of Oil will soon end. It has been a brief age, only a little over 150 years since the first oil wells started pumping. Oil, the "Black Gold", has given ordinary people a standard of living that was inconceivable two centuries ago. It has done this by making it possible to move goods and people much more cheaply and efficiently than ever before.



Oil made us incredibly mobile. We and our goods go where we want, when we want, without worrying about cost or dangers. In 1873, Jules Verne published Around the World in 80 Days. A sensation at the time, poised halfway between science fiction and reality, Verne depicts Phileas Fogg on a daredevil journey around the world by steamship, railroad, sailboat, and elephant to win a wager of 20,000 pounds and the lady he loves. Today, we go around the world in 80 hours and think nothing of it. Nobody would wager 20 Dollars, let alone 20,000 pounds, on Fogg's ability to make the trip in 80 hours. It certainly wouldn't make the newspapers—perhaps a little light conversation at a dinner party.

Although brief, it has been an exciting Age. Oil has brought a life style that has become precious to us. Because of its value we have fought wars over oil, lost uncounted numbers of tankers at sea, polluted vast stretches of ocean, won and lost many billions of dollars, installed and toppled presidents and prime ministers to keep oil flowing. For Americans, oil has become a part of our lives like air and water.

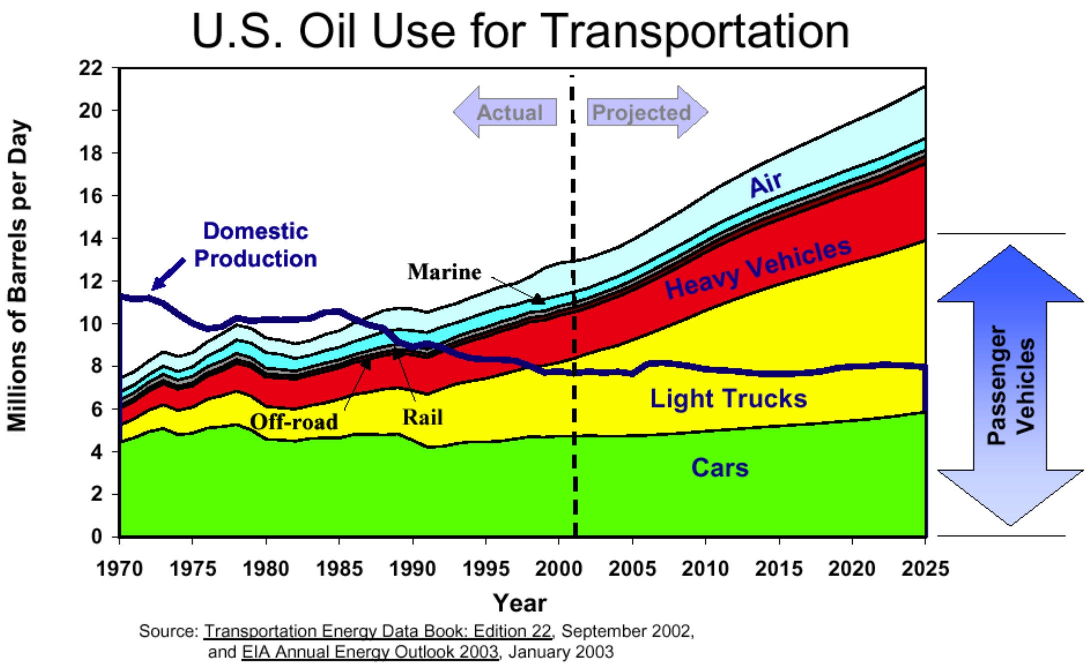
All of this is ending. Within the next decade world oil production will peak and start to decline. Within our children's lifetime, most of the world's oil will be gone. The technology infrastructure developed over this age to take advantage of the concentrated energy in oil will become obsolete and unaffordable to most of us.

The present time is critical. Do we take the path of continued dependence on oil, fight over the last droplets as our mobility and living standards erode, or do we take a path of realistic actions that will allow us to continue to grow and prosper when the oil runs out?

Sadly, the answer is that, right now, we are heading down the first path. There are no real plans for avoiding the inevitable economic decline around the world when world oil production peaks. As oil supplies decline, prices will rapidly rise, making the oil shock of the 1970's look like child's play. World tensions will increase as nations spar over dwindling oil reserves.

Such a future is not inevitable. We can choose to be more efficient in the use of oil, and implement new systems that do not need oil. The technologies to enable large reductions in oil consumption already exist – we need not wait for some future "miracle" technology, such as hydrogen fueled cars, to appear. However, it is critical to begin the transition to the "Age of No Oil", now, and not wait until production begins to drop.

Development of a Transition Strategy
By far the greatest consumer of oil and the most important in its effect on the U.S. and World economy is the transportation sector. Autos, trucks, ships, and airplanes carry the bulk of our goods and passengers. Without oil based fuels, hardly anything would move—even most of the trains are diesel powered today. Accordingly, in analyzing how to maintain our mobility and living standards in the "Age of No Oil" it is necessary to focus on transportation and the actions that can be undertaken to reduce its need for oil. The U.S. currently consumes 20 million barrels of oil per day and the World consumes 80 million barrels per day. The following chart produced by the U.S. government shows U.S. demand for transportation oil almost doubling by 2025 AD.



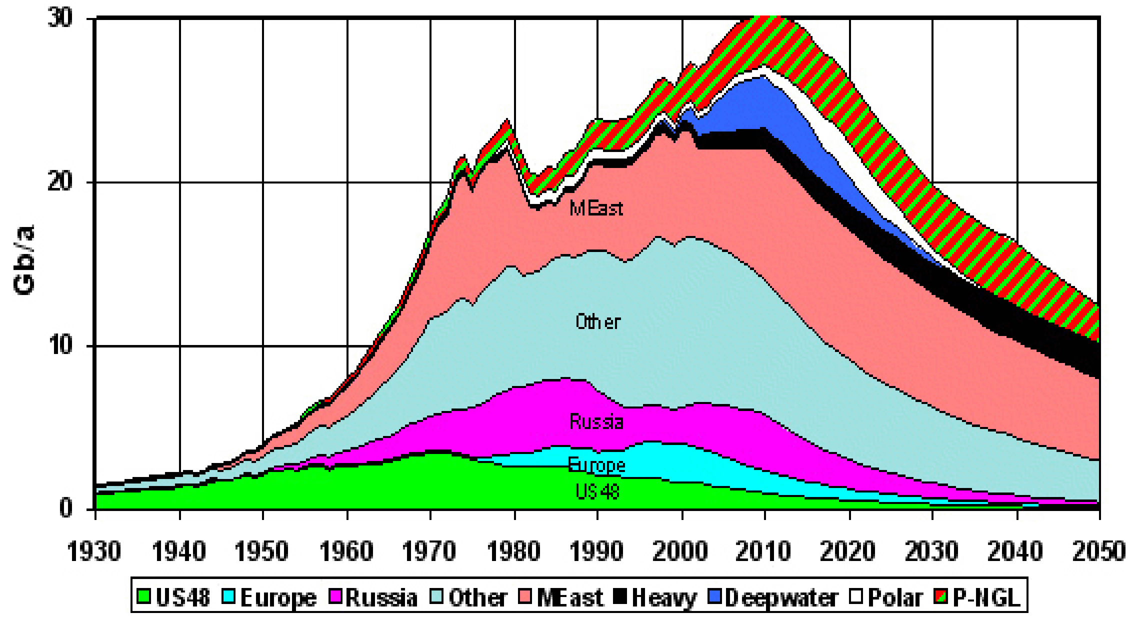
This roughly parallels the GDP growth over the same period, and the total daily U.S. consumption of oil probably would grow to almost 40 million barrels daily and the World to close to 160 million barrels daily, if it could. (Actually, at the rate that China and India are growing, the demand for oil would be well above the 160 million barrels per day.)

Transportation accounts for 2/ 3 of the 20 million barrels of oil our nation uses each day.

The U. S. imports 55% of its oil, expected to grow to 68% by 2025 under the status quo.

Hubbert's Peak within a Decade!
With a daily consumption of 160 million barrels the world's known oil reserves of 1 Trillion barrels would be gone within 16 years. In fact, the world's oil consumption will never reach 160 million barrels per day. Most experts expect that the world will reach Hubbert's Peak about 10 years from now.[a.] At that point, world oil production will peak and then start to steadily decline. Oil prices will then rapidly and steeply escalate as demand exceeds supply causing a very strong drag on the U.S. and World economy.

Regular Oil & Natural Gas Liquids
2003 Base Case Scenario



How the End of the Age of Oil Will Affect the U.S. and the World
The U.S. presently spends about 700 Million dollars per day on petroleum products, or about 300 Billion dollars annually (3% of GDP). When prices start to rise, the effect will be catastrophic. A tripling in the price of oil would rise in value to 10% of GDP at present consumption levels. In 2025, at 40 million barrels daily, 70% of which would come from imports, the U.S. trade deficit at $100 per barrel would be 4 Billion Dollars each day from imported oil purchases alone. This amounts to 1.5 Trillion Dollars per year. Even at a fraction of such a trade deficit, the U.S. economy would collapse.

If the U.S. is to maintain strong GDP growth and be economically secure, it will have to drastically reduce its oil consumption and turn to efficient and practical alternatives. Otherwise, in about 10 years, the U.S. will be hit with rapidly rising oil prices that will derail the U.S. economy.

Oil is vitally important to the United States. We need it to transport our people and goods on the roads and in the air, to provide energy for growing and processing food, to heat our homes and workplaces, to make plastics, drugs, and other vital materials, to generate electric power at peak demand periods, and to arm and fuel a strong military.

Because transport accounts for most—approximately 2/3—of U.S. oil consumption, to make major reductions in oil usage, it will be necessary to find ways to move people and goods that do not depend on oil. In the remainder of this article we examine the alternatives to oil for transport.

In the area of transport, for example, in a single year, each American travels by car about 15,000 miles on average, commuting to work, shopping at the mall, going to restaurants and theaters, taking vacations, visiting friends and relatives, and carrying out all of the activities of normal modern society. Each of us also depends on the transport of tons of material for thousands of miles to bring us food, clothes, fuel, TV sets, refrigerators, furniture and all of the many other necessities of life. On average, each American requires 4000 ton miles of truck transport per year to maintain his or her standard of living.

The per capita consumption of oil in the U.S. is currently 25 barrels per year and growing. If the 6 Billion people now in the World consumed oil at the same rate the world's oil known reserves of 1 trillion barrels would be gone in only 6 years. It is not possible to have a precise value for the ultimate total recoverable oil in the world, since it depends on future potential discoveries and improvements in extraction methods. However, projections suggest about 2 Trillion barrels. Increasing the standard of living for the deprived billions of people in the world will require practical alternatives to oil—it is simply not possible to lift up the World's poor and destitute to anything remotely approaching U.S. living standards and still depend on oil. In fact, it will be impossible to even maintain current U.S. living standards if we fail to move away from oil.

Long-Term Transport Options for the Economy

What are the long-term transport options when the oil starts to run out? Four have been identified by the energy policy community:

1. Conservation
2. Synthetic Fuels
3. Hydrogen
4. New Modes of Transport: Non-Oil Options

Conservation

Conservation of transport fuels, e.g. higher fuel mileage, just stretches out the decline in oil.

There are physical limits to how much conservation can do—at most, miles per gallon could only double. People who talk of 100 miles per gallon are dreaming. 50 mpg is more realistic. Moreover, while the U.S. could impose conservation measures for itself, there is no guarantee that other Nation's would follow suit.

Synthetic Fuels

A major effort was undertaken by the U.S. government during the 1970's to develop synthetic fuels, i.e. gasoline, diesel, and syngas (CH_4) from indigenous U.S. coal, lignite, and shale resources. While technically possible it was found that the cost of the product was excessive and there were too many environmental health problems, including large CO2 emissions that would accelerate global warming, to be an economically and environmentally acceptable route to energy independence at that time. While synfuels are a real option as one element of a transport system to meet U.S. needs as oil supplies decline, their role can be minimized by incorporating modes of transport that do not use carbon based fuels.

Hydrogen Cars: A Pipe Dream?

Hydrogen has been proposed as an ideal fuel for transport, when used in fuel cells. It is non-polluting, with water as the exhaust. The hydrogen fuel cell generates electricity at high efficiency for electric drive automobiles and trucks. However, free hydrogen does not exist in nature, but must be produced using energy from some other source. In fact, since there are always losses in any real process, it actually takes more energy to produce the hydrogen than it will provide for a car or truck. Typically only about 80% of the input energy used to produce hydrogen is available as energy input to the fuel cell.

At present, hydrogen is primarily produced by the steam reforming of natural gas. However, this is not a practical option for the long term, since natural gas resources are also limited, and will run out in the same time frame as oil. The practical long term options for the large scale production of hydrogen are synthesis from coal, or electrolysis of water using nuclear or renewable (e.g., wind, solar) power.

To generate the hydrogen equivalent of the 5 billion barrels of oil that we now use for transport per year would require an additional annual production of 1 Billion tons of coal (if we did it by a *synfuel* process). We now produce about 1 Billion tons of coal per year. This assumes that the use of hydrogen fuel in more efficient cars, e.g., with fuel cells, will enable a factor of 2 reduction in transport energy usage as compared to present practice. It also assumes that the vehicle miles and other transport usage remains at present levels, instead of the almost two fold increase that is predicted by 2025 A.D. If the U.S. economy and population is to grow, transport demand will increase, so that these coal and electricity requirements for switching to hydrogen fuel should be regarded as lower limits that is virtually certain to rise considerably.

To generate the hydrogen equivalent to 5 Billion Barrels by electricity would require an additional 6 Trillion KWH of electricity annually. We now generate about 3.5 Trillion KWH of electricity annually. To generate the hydrogen equivalent to 5 Billion Barrels by electricity would require an additional 6 Trillion KWH, or building new capacity equal to 1.5 times what we now possess. This cannot be coal fired power plants, since that would require even more coal than the 1 Billion Tons for direct synthesis of hydrogen. It would have to be nuclear, solar, wind, hydropower, or geothermal. The capital cost would be enormous—about 5 Trillion dollars or an amount equal to one-half of current annual U.S. GDP.

The safety problems of hydrogen cars and trucks would be immense. Imagine tens of thousands of mini-"Hindenburgs" on the highways each year. Would people ever manage to get to work, dodging all those burning cars? To store the equivalent of 10 gallons of gasoline, you need a pressure vessel 1 meter in diameter holding 5000 psi H_2. Assuming a steel pressure vessel with an operating stress of 30,000 psi (which is quite high), the pressure vessel would weigh 1 ton, almost as much as the rest of the car.

Liquid hydrogen has been demonstrated as an automotive fuel; however, the cryogenic equipment is complex and requires careful handling and maintenance. It is doubtful that it would be acceptable from a safety viewpoint. Metal hydrides, e.g. iron-titanium and magnesium hydride, have been proposed for automotive applications. Hydrogen can be safely evolved from the metal hydride. However, to hold useful quantities of hydrogen, very heavy beds of metal hydride would be needed. In the car, the heating and cooling hardware needed to allow the hydrogen to be desorbed and absorbed in the metal hydride bed would be complex and difficult.

Besides the production problem and the storage problem, hydrogen cars also have a fuel distribution problem. To be effective for transport, cars and trucks require that there be a large network of many convenient fueling stations, so that drivers do not have to drive long distances to be refueled, and that wherever they go they can easily find fuel. Even if the production and storage problems could be solved, setting up an effective network of hydrogen fueling stations would be extremely expensive and take a long time. Such a network would have to be in place before drivers will switch to hydrogen cars—otherwise, they would be severely hampered in their ability to readily drive to their various destinations.

The National Academy of Sciences has recently published a study on hydrogen fuel cars. It concludes that the goal of mass production of hydrogen cars is "unrealistically aggressive" and that over the next 25 years, the effects of hydrogen cars on oil imports and global-warming gas emissions "are likely to be minor". The report also addresses another potential problem for hydrogen cars, that "power from fuel cells is much more costly than power from gasoline engines."

These problems suggest that it is very unlikely that hydrogen cars and trucks will be able to be a significant element in meeting future transport needs as the availability of oil declines and its cost increases.

New Modes of Transport: Non-Oil Options

The most probable and the most efficient use of capital solution is an evolutionary mix of near and mid-term non-oil modes of land transport to replace current oil fueled modes. These modes of transport would complement conservation by using electricity and liquid fuels generated from nuclear, coal and other sources of electricity (biomass refineries, windmills, solar cells, etc.):

We envision the following evolutionary scenarios based on our assessment of known energy/transport technology development ventures that have been initiated:

- Personal transport motor vehicles by evolving non-oil options: hybrid (electric and internal combustion engines), electric (rechargeable batteries), methanol fuel from coal and biomass, and hydrogen from coal
- Non-transport work machines, (construction, farm, drilling, etc.): methanol gasoline and diesel fuel from coal, biomass and hydrogen enriched fuels
- Personal commute: continued construction of electrified light rail to serve metropolitan area commuter corridors and/to Maglev
- Personal long-distance carriers: Synthetic Diesel and Jet Fuel from Coal and Electrification of Rail and/to Maglev
- Commercial Rail Cargo Carrier: Electrification of Rail and/to Maglev
- Commercial Highway Motor Cargo Carrier: Synthetic Diesel from coal and Electrified Rail and/to Maglev
- Commercial Air Cargo Carrier: Synthetic Jet-Fuel from Coal and Shale and Maglev

Maglev

Magnetic levitated transporters (Maglev), moving efficiently, without friction, on electrified guideways meets the need for an economic and practical mid- and long-term replacement for much of U.S. petroleum demand. Maglev is chosen because it is much more adaptable and capable than rail, much faster, and much cheaper.[b.] Because of the necessary time required for testing, certification and implementation development and testing, an interstate Maglev system needs to become a U.S. national development priority. It is probably the best and most reliable technology available to help ensure continuation of the U.S. economy and standard of living.

Maglev is not a futuristic, pie in the sky technology. First generation commercial type Maglev passenger vehicles have been operating for years on demonstration guideway systems in Japan and Germany, and a commercial Maglev route has recently begun operation in Shanghai, China. Hundreds of thousands of passengers have ridden on Japanese and German Maglev, with cumulative running distance of hundreds of thousands of kilometers.

These 1st generation Maglev Systems have operated safely and reliably at speeds up to 350 mph in Japan and 285 mph in Germany. By way of comparison, the fastest high speed steel-wheel-on-rail train, the French TGV, only reaches 180 mph. The Maglev vehicles can operate either as single units, carrying approximately 100 passengers, or coupled together to form multi-vehicle sets (up to 5 vehicle sets operate in the Japanese Maglev System.)

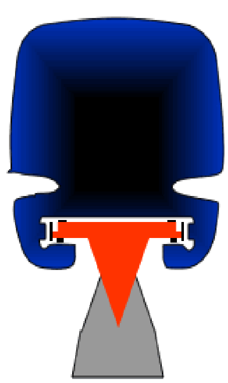
In contrast, high speed rail requires very heavy locomotives at each end of the train-set in order to operate safely, and to be economic it must use a large number of rail cars in each train set with a capacity on the order of 500 to 1000 passengers. Because Maglev vehicles can operate as single units or coupled vehicle sets, they have great flexibility in meeting widely varying load demands as compared to high speed rail trains. Moreover, since single Maglev vehicle operation is economically practical, service can be much more frequent and convenient than is possible using high speed rail.

The Japanese and German Maglev systems utilize different Maglev levitation approaches. The Japanese system, which is based on the Maglev inventions of Powell and Danby in the 1960's and 70's, has superconducting magnets on the vehicles and a set of normal temperature aluminum loops along the guideway. As the vehicles move along the guideway, the magnetic fields from its superconducting magnets induce currents in the aluminum loops in the guideway.

In the Japanese vehicles, the magnetic interaction between superconducting loops and the currents in the guideway loops causes it to levitate 4 inches above the guideway. The levitation is automatic and inherent, and always acts as long as the vehicle is moving along the guideway. Moreover, the levitation is inherently strongly stable. Any external force, such as winds, that act to displace the vehicle from its equilibrium levitated position is automatically countered by a magnetic force that acts to restore the vehicle to its equilibrium position.

The superconducting magnets on the Japanese vehicles consume no power, except for a small amount to maintain them at low temperature, moreover, the I^2R (current squared times resistance) losses associated with the induced currents in the aluminum guideway loops are also small, so that Maglev vehicles are essentially frictionless, except for air drag.

In the German Maglev system called Transrapid conventional electromagnets on the vehicle are used instead of the superconducting magnets used in the Japanese system. The Transrapid electromagnets are positioned beneath iron rails on each side of the guideway beam. The upwards attractive magnetic force between the electromagnets and the iron rails levitate the vehicle.



Cross Sectional Drawing of Transrapid

In contrast to the Japanese Maglev vehicles the Transrapid vehicles have a much smaller clearance between the vehicles and the guideway, e.g. 3/8 of an inch compared to 4 inches. Moreover, unlike the Japanese system in which the levitation is inherently stable, in the Transrapid system, the levitation is inherently unstable, and the high speed vehicles are only prevented from contacting the guideway by continuously adjusting the current in the vehicle electromagnets on a time scale of 1/1000th of a second. In addition the Transrapid electromagnets require a substantial amount of electric power to maintain their magnetic field, as compared to the Japanese superconducting magnets which require no power input other than a small amount to maintain them at cryogenic temperatures.

The first commercial Transrapid System, a 20 mile link between the center of Shanghai and its airport, is now operating. Japan Railways is planning a 300 mile Maglev route between Tokyo and Osaka—60% of the route would be in deep underground tunnels through the mountains in Central Japan—which would carry over 100,000 passengers daily.

Why Maglev Technology should move to 2nd Generation U.S. Maglev Technology
While technically successful, the implementation of the Japanese and German Maglev systems has been held back by 3 factors:

1. High capital cost of their guideways
2. Focus on passenger only service
3. Inability to switch onto or off from guideways at high speeds

These factors can be overcome by developing an advanced 2nd generation Maglev system. After all, while the DC-3 was a very successful 1st generation passenger airplane, air travel today would be tiny compared to its present size, if airplane technology had not progressed beyond the DC-3. The Maglev-2000 program in the United States, which is described next, is a 2nd generation system that can overcome these factors as well as be technically practical and economically attractive.

Guideway Cost
First, consider the issue of guideway cost. The capital cost of the Japanese and German guideways is on the order of 40 million dollars per mile (2 way service). At 30,000 passengers per day (a relatively high traffic load) and 10 cents per passenger mile, the payback period is 40 years, without including operating costs. This is far too long to compete in capital investment markets. While transport systems have been heavily subsidized by governments in the past, in the current climate, large subsidies are very unlikely.

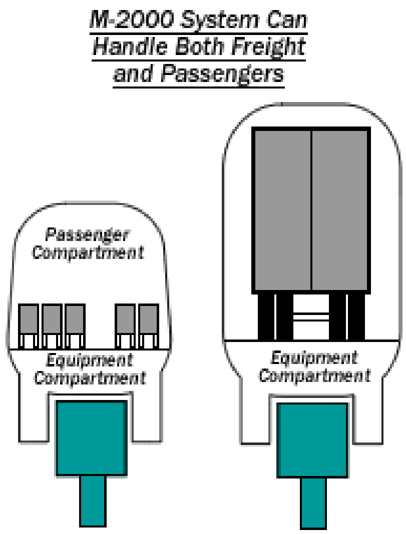
The high cost of the German Transrapid System appears to be inherent in the design, because the guideway must be built to extremely tight tolerances to accommodate the very small 3/8 inch clearance. Even the normal temperature changes in the ambient environment pose tolerance problems and require sophisticated and progressive construction techniques.

The high cost of the Japanese Maglev guideway, on the other hand, does not appear to be inherent. Their guideway is a U-shaped concrete trough that encloses the Maglev vehicle. It uses a large amount of concrete and *re-bar*, and requires expensive field construction.

In contrast, the 2nd Generation M-2000 guideway system being developed in the U.S., uses a narrow concrete box-beam on which the Maglev vehicle rides. The M-2000 beams can be prefabricated at much lower costs in a factory and shipped to the Maglev site, along with the prefabricated piers for the beams and quickly assembled to form the final guideway with a minimum of field construction work. A prototype M-2000 beam has been fabricated to validate construction technique and cost. The M-2000 guideway cost is only 15 million dollars per mile (2 way service) as projected in independent studies by 2 different U.S. engineering firms. At 15 million dollars per mile, the payback period—not including operating costs—would decrease from 40 years down to 15 years at 30,000 passengers per day at 10 cents per passenger mile.

A Technology Designed for the U.S. Market
Second, consider the issue of what market the Maglev system will serve. In the U.S., there are only a few intercity routes with high passenger traffic, the market addressed by the Japanese and German Maglev systems. The U.S. intercity truck market, however, is much greater than the air passenger market, e.g. over 300 Billion dollars annually, as compared to only 60 Billion Dollars for air passengers. Moreover, the truck traffic is very concentrated. Many Interstate highways carry over 15,000 trucks daily with an average haul distance of over 400 miles.

Long-distance transport of trucks by Maglev would be very attractive for shipping companies. A shipper could pick up a trailer load, drive it a few miles to the nearest Maglev station, from which it would be transported hundreds of miles to the station nearest its final destination. There the trailer would be picked up by a second tractor and driven a few miles to its destination. The shipping company could deliver goods much more quickly—e.g., produce could cross the U.S. in a few hours—greatly reduce wear and tear on his tractor/trailer fleet, save money, and allow its drivers to have better working conditions, less fatigue, and less disruption to life. Perishables would be much fresher and costly spoilage would be reduced.



Current intercity trucking costs are on the order of 25 to 30 cents per ton-mile. Assuming a daily load of 3000 trucks (1/5th of the approximately 15,000 trucks moving each day on an Interstate highway), an average load of 30 tons (60,000 pounds), and 20 cents per ton mile charge to the shipper, the Maglev system would have a yearly revenue of $6.6 million dollars for a guideway cost of 15 million dollars per mile. This corresponds to a payback period of only a bit more than 2 years not including operating costs. The revenue from the 3000 trucks is thus equivalent to 180,000 passengers per day at 10 cents per passenger mile. With such short payback times, private investment would be eager to fund the construction of Maglev routes.

Additional revenues would come from passengers, since the M-2000 system is designed to be dual usage, capable of carrying passenger vehicles as well as vehicles holding trucks and cargo. Loading and unloading trailers would be quick and simple. For example, trailers can be loaded and unloaded from the “Chunnel” trains that run between England and France in only 90 seconds.

In addition to reducing oil consumption and shipping costs, and making the U.S. economy more efficient long distance transport of trucks by Maglev would make the highways safer and less congested, reducing accidents and shortening travel times for drivers in the U.S. heavily congested commuter corridors.

High Speed Switching

The third factor addressed by the development of the 2nd generation M-2000 is the switching of Maglev vehicles from one guideway to another. It is very desirable to switch Maglev vehicles off the main high speed guideway to off-line stations for loading and unloading operations. Otherwise the stations must be many miles apart if high average speeds are to be achieved. In both the German and Japanese Maglev systems, movable mechanical switches are required to allow the Maglev vehicle to switch onto or off from a secondary guideway that leads to an off-line station. Because of limits on the length of the movable portion of the guideway, their Maglev vehicles must slow down to about 100 mph before they switch (Even at the lower speed, the movable guideway sections are many feet in length). This penalizes average speed, and prevents the system from having a substantial number of closely spaced convenient stations in higher population density areas.

To solve this problem, the Maglev 2000 system has developed a superconducting magnet configuration on its vehicles that allows them to switch onto or off from the main guideway at full speed—e.g., 300 mph—by electronic switching from one line of speedway loops to another. This enables M-2000 vehicles to perform high speed “skip-stop” service. That is, the M-2000 vehicles can maintain high transit speeds by skipping stations not scheduled for a stop and then electronically switch at full speed onto the guideway leading to the off-line station at which they are scheduled to stop. This allows stations to be closely spaced together in high population density areas, with the riders and cargo embarking the Maglev vehicle that will take the passengers or cargo to the desired station with no intermediate stops.

Status of Maglev Development in the U.S.

The Maglev-2000 system is the only high speed Maglev technology presently under development in the United States. There are several lower speed Maglev systems with tops speeds on the order of 100 mph also being developed in the U.S. for urban passenger transport. These include the AMT (American Maglev Technology) System and the General Atomics (GA) Inductor Track System. The AMT System technology is similar to the HSST Japanese System which has been demonstrated in Japan in the 1980's. It involves conventional electromagnets for levitation, like those in the German Transrapid System. The GA System uses permanent magnets in the vehicle with inductive loops in the guideway. Both are small clearance systems, i.e., less than one inch, and are designed for relatively low speed passenger transport, without the capability to carry heavy trucks and truck type freight.

The Maglev-2000 system is designed so that its guideway can carry both high speed intercity passenger and freight vehicles as well as lower speed passenger vehicles. This enables a single seamless transport system, allowing passenger and freight to travel within an urban/metropolitan area or to another urban/metropolitan area without having to disembark onto a different transport system. Not only does this provide faster, more convenient and more efficient transport, but it also eliminates the need to develop and construct an expensive additional transport system.

Advanced 2nd generation Maglev systems, such as the Maglev-2000 system now being readied for initial testing, require more work to bring them to commercial implementation. However, there are no fundamental technology issues that would prevent their use. As with all previous transport systems, whether airplanes or automobiles, continuing engineering development leads to better performing, lower cost, more efficient devices and systems.

Three Possible Futures When the Oil Runs Out

Not even seers can really predict the future. However, one can foresee, in overall terms, various possible futures based on present knowledge and trends. These futures are not inevitable, and which one turns out to be true will depend on the decisions made in the next few years. As the World's oil begins to run out there are three possible futures, labeled as:

1. Don't Worry—Be Happy
2. Waiting for a Miracle
3. Act Sensibly, Now

Don't Worry—Be Happy

At present, policymakers and the public are on the road to a "Don't Worry…Happy" future. In this future, oil will always be available at a reasonable price and the U.S. and World's economies will grow without hindrance. "Don't worry" believers keep saying that as fast as the old oil fields dry up, new ones will be discovered, so that there will always be 30 years worth of reserves. And a corollary sentiment is often offered that price increases from demand supply imbalances will provide the investment incentives to dig deeper and explore the previously unexplored. *Laissez-faire* economists are especially prone to believe this argument.

The facts are that there are real physical limits to the amount of oil in the Earth. Oil is ever more expensive and difficult to find and recover. New wells are going deeper and dry holes are increasing. Extraction methods are more elaborate and more expensive. Forty years ago, it took the equivalent of one barrel of oil to recover 100 barrels; today, it takes 10 barrel to recover 100 barrels. Most oil experts expect the global production to reach Hubbert's Peak in the next 10 to 20 years—pessimists think 5-10, and optimists 20-25.

In the "Don't Worry" future, however, because we supposedly will never run out of oil, there is no need to conserve oil, raise highway mileage standards, switch to electrified transport and develop technologies that do not burn oil. Price and the market will take care of the problem. Those who propound this future forget the oil price shocks of the 1970's, and the discovery and rapid depletion of the Alaskan north slope.

Once Hubbert's Peak is reached, however, market panic will set in as everybody suddenly realize that the oil really is running out. A horde of expensive and inefficient crash programs will start, ranging from synfuels to more mass transit to new kinds of autos and trucks to whatever. However, because it will take a long time to develop and implement these programs, there will be severe consequences to the U.S. and the World's economies in the meantime. Millions of jobs will be lost, living standards will plummet, and the U.S. annual trade deficit will balloon by hundreds of Billions of Dollars as the cost of imported oil rapidly escalates. The 10 pounds of compressed demand for resources won't fit into the 1 pound bag of available investment capital.

Waiting for a Miracle

The "Waiting for a Miracle" future is not much better. In this future, while policy makers and the public realize that the oil will eventually run out, they are lulled into non-action by a touching belief that some miracle technology will come along to save the day. Many put their faith in the *Hydrogen Economy*, with hydrogen fuel cells powering autos, trucks and homes. However, as pointed out earlier, hydrogen is not free, but must be manufactured from some other energy source, with consequent energy losses in the production process. Moreover, there are real problems of hydrogen safety, storage and distribution that make its use for transport questionable. To appreciate, the problems with hydrogen safety, consider the experience of the Space Shuttle. The shuttle is engineered, serviced and maintained to a degree light years beyond that possible for ordinary autos and trucks, yet hydrogen leaks in it do occur, leading to repairs and launch delays.

Imagine ordinary gasoline service stations pumping high pressure or liquid hydrogen into your car, or your average auto mechanic sniffing out hydrogen leaks. Or imagine that crunched tanks have somehow managed to hold in their high pressure hydrogen and not explode in the totaled cars that one sees in highway crashes. Perhaps a miracle technology will come along and save us when the oil starts to run out—after all, miracles do happen. However it is not prudent to count on miracles—they tend to be rather rare. When the miracle fails to materialize, the result will be the same as the "Don't Worry" future.

Act Sensibly Now

The "Act Sensibly Now" future is the only real choice if we want the U.S. and the World's economies to continue to grow and prosper when the oil begins to run out. In this future, governments start right now to plan and implement a broad mix of actions based on near term options and technologies that can be in place when global oil production starts to decline in the next 10 to 20 years. These actions should not depend on the long-term and uncertain development of new kinds of fuels and energy sources. The development of new fuels and energy sources can be carried on in parallel, but not counted on until proven successful.

The oncoming decline in oil production will affect all national economies. In an ideal world, all nations should cooperate in a coordinated coherent program to minimize the effects of the decline. However, as the Global Warming experience has shown, it is virtually impossible to develop a coordinated World program because of the conflicting and widely different goals, needs, and capabilities of the various nations involved.

Developing a coordinated program on world oil will be even more difficult than achieving a program on global warming. The familiar "Tragedy of the Commons" situation directly applies to the World oil problem. Nations that invest capital to cut their oil consumption are at a competitive disadvantage compared to nations that do not. Nation A, by investing its capital in non-oil technologies causes oil prices to go down, making Nation B, which continues to use oil , able to produce goods more cheaply than A –at least until Hubbert's peak is reached.

If the U.S. is to switch to transport systems that use less oil—or hopefully, none at all—the economic benefits will have to be clear, real, significant, and near term. Public funding is increasingly difficult to obtain, and private investment requires short payback times. Many proposed systems cannot attract either as shown by the recent rejection of plans for high speed rail systems in Florida, California and Texas. New light rail and fast bus systems are also increasingly in trouble; in many cases, the actual cost of a passenger trip is much greater than the paid fare, with taxpayers making up the difference.

Besides economic benefits, there are other factors that can help to persuade the public to support the implementation of non-oil transport systems. These include:

1. Independence from foreign oil
2. Creation of new high-value jobs in design, engineering and manufacturing
3. Reduced congestion on highways
4. Shorter travel times and more convenient service
5. Increased safety when traveling
6. Reduced pollution and global warming

Independence from foreign oil sources strikes a strong chord with Americans. Virtually all agree that we would be more secure if we did not have to import oil. The possibility of supply disruptions and cutoffs would disappear. The U.S. trade deficit would drop dramatically, and we would be less likely to be drawn into war.

The steady decline of high value manufacturing gobs is another very strong concern. The U.S. is rapidly transitioning from being a major world manufacturer to just a consumer with only low value service jobs. The creation and construction of new non-oil transportation industries would provide millions of new high-value jobs for U.S. workers in design, engineering, manufacturing, and construction.

Less congestion and greater safety on the highways appeal very strongly to all Americans. The mean round trip commuting time to work is over 1 hour, and rapidly growing congestion not only increases travel time, but also increases the accident rate. Sharing congested highways with high speed trucks is a scary experience. In truck-car collisions, the truck usually wins, with almost all of the fatalities occurring to those in the automobile. With 5 fatalities occurring an hour on U.S. highways, driving has become a leading U.S. public health problem.[b] Pollution and global warming, while not the top priority for most Americans, are viewed as important issues, and the switch to non-oil transport would garner important support from concerned citizens.

What are the common sense near-term steps that we can undertake to reduce the oil used in transport? There are three:[c]

1. Increase mpg standards for autos and trucks
2. Expand Mass Transit/Light Rail
3. Start Construction of a National Maglev Network for High Speed Truck and Passenger transport.

Implementing these three steps can produce large savings in oil consumption and significant economic benefits. The accompany table shows the dollar outlays, traffic, and oil consumption, for the principal oil users in the U.S. transport system. The various data are taken from the U.S. Statistical Abstracts and the US Department of Transportation reference document "The Changing Face of Transportation" which projects transportation demand to 2025 AD.

The transport outlays and oil consumption for the "Don't Worry" future are calculated assuming that the current costs and oil usage rates per passenger mile and ton mile for autos, trucks, and airplanes are the same in 2025 as those projected by the Department of Transportation in their 2000 AD report. In this future, U.S. annual oil consumption increases form approximately 7 Billion barrels in 2000 AD to over 12 Billion barrels in 2025 AD, while the combined annual transport outlays for autos and SUV's, intercity trucks, and airplanes increase form approximately 1200 Billion dollars to almost $2100 Billion, in constant 2000 Dollars.

In the "Act Sensibly" future, with the same total passenger and intercity truck traffic as in the "Don't Worry" future U.S. annual oil consumption in 2025 AD is cut from 12.6 Billion barrels down to only 4.2 Billion barrels—a factor of approximate 3—, and the combined annual transport outlays for autos & SUV's, intercity trucks, and airplanes is cut from 2080 Billion dollars down to 935 Billion. This does not include the costs associated with the additional mass transit, light rail, and Maglev systems, which would add approximately 600 Billion dollars annually to the U.S. transport outlays. The net transport savings to the U.S. would then be [2080 less (935 + 500)] or about 500 Billion dollars annually.

The cost and oil savings for the "Act Sensibly" future are based on the following assumptions, which, while are estimates, appear achievable.

1. The average 22 mpg for autos in 2000 AD increases to 44 mpg in 2025 AD. SUV's increase to 36 mpg from the present 18 mpg. Trucks increase form 5.6 mpg to 11.6 mpg (U.S. Statistical Abstracts for 2002, Table 1082)
2. 2/3 of intercity trucks tone-miles witch to Maglev, at 10 cents per ton-mile
3. 1/2 of air passengers demand switches to Maglev at 10 cents per passenger mile.
4. 1/2 of highway passenger miles continue to use autos and SUV's; 1/4 switches to mass transit and light rail at 15 cents per passenger mile; 1/4 switches to Maglev at 10 cents.

The economic and oil savings illustrated above are indicative of the benefits that can result from taking actions that will mitigate and compensate for the oncoming decline in world oil production. Determining more precisely what are the best actions to take, and what benefits will result, requires further study in greater detail.

U.S. Transport: Present and Future

Sources: U.S. Statistical Abstract and *The Changing Face of Transportation*, U.S. DOT BTS 00-007

	2000 AD	2025 AD	
Category		***Don't Worry* Future**[1]	***Act Sensibly* Future**
Auto/SUV Passenger Miles (Trillions/yr)	5.0	8.4	4.2[2]
Intercity Truck Ton Miles (Trillions/yr)	1.0	2.1	0.7[3]
Private Auto/SUV Outlays [(Billions Dollars/yr (2000$)]	800	1350	675[2]
Intercity Truck Outlays [Billions Dollars/yr (2000$)]	320	610	200[3]
Air Passenger Outlays [Billion Dollars/yr (2000$)]	70	120	60[4]
Total Outlays	**1190**	**2080**	**935**[5]
Oil Consumption (Billion Barrels/yr)	**2000 AD**	**2025-AD**	
Auto/SUV	3.0	5.0	1.3[1]
Trucks	0.9	1.7	0.3
Air	0.5	0.9	0.4
Other Transport	0.4	0.6	0.6
Total Transport Oil	**4.8**	**8.3**	**2.6**
Total Non-Transport Oil	**2.4**	**4.3**[6]	**1.6**[6]
Total Oil	**7.2**	**12.6**	**4.2**

Notes:

1. Oil use for autos, SUV's, trucks and airplanes assumes 2000AD mpg performance; usage is linearly proportional to traffic.
2. Assumes that for the Act Sensibly future, 1/2 of the projected 2025 AD highway passenger traffic will be handled by autos & SUVs, while 1/2 will be handled by increases in mass transit & light rail systems, plus Maglev. Also assumes that 2000AD mpg for autos & SUVs will be improved from current 22 and 18 mpg values to 44 and 36 mpg (factor of 2)
3. Assumes that 2/3 of projected 2025AD intercity truck miles will be transported by Maglev. Also assumes 2000AD 5.8 mpg for trucks will be improved to 11.6 mpg (factor of 2)
4. Assumes 1/2 of air passengers will travel by Maglev
5. Transport Outlays do not include expenditures on Mass Transit and Maglev (See Text for discussion)
6. Non-transport oil is presently used for manufacturing (process heat, feed stocks), home heating, power generation, etc. "Don't Worry" future assumes that non-transport oil grows 80% from 2000AD to 2025AD, the same rate as the projected growth in GDP. The "Act Sensibly" future assumes that 2025 AD usage is 2/3 of the 2000 AD value, through substitution of electricity for process and home heating, better insulation; elimination of oil fired power plants, etc.

The Hour has Arrived

If the U.S. is to have a 2nd generation National Maglev System available for implementation when oil supplies begin to decline in the near future, it must begin funding engineering development with a commitment to provide about $20 Billion per year for 20 years (~25,000 miles at $15 million per mile for 20 years). This investment will be paid back manyfold by the large annual savings in the cost of transport and a large reduction in the highway fatalities and injuries (as much as 1/2) that will flow from the National Maglev System

All agree that the U.S. standard of living and economic security is dependent on our ability to move goods and people. Economic studies show that the U.S. highway and airway systems make a vital and critical contribution to the U.S economy and standard of living. These systems which include the automobile and the diesel powered freight carrier fleet together with jet aircraft at present are nearly 100% dependent on petroleum. It is very clear that the Nation's future economic health will require new modes of transport that do not depend on oil. Electrification of the Nation's transport system by creating a 2nd generation interstate Maglev system is a practical, common sense approach to sustaining the U.S. standard of living after the end of the age of oil.

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[a]. Global oil production will probably reach a peak sometime during this decade. After the peak, the world's production of crude oil will fall, never to rise again. The world will not run out of energy, but developing alternative energy sources on a large scale will take at least 10 years. The slowdown in oil production may already be beginning; the current price fluctuations for crude oil and natural gas may be the preamble to a major crisis.

In 1956, the geologist M. King Hubbert predicted that U.S. oil production would peak in the early 1970s.[1] Almost everyone, inside and outside the oil industry, rejected Hubbert's analysis. The controversy raged until 1970, when the U.S. production of crude oil started to fall. Hubbert was right.

Around 1995, several analysts began applying Hubbert's method to world oil production, and most of them estimate that the peak year for world oil will be between 2004 and 2008. These analyses were reported in some of the most widely circulated sources: *Nature, Science,* and *Scientific American.*[2] None of our political leaders seem to be paying attention. If the predictions are correct, there will be enormous effects on the world economy. Even the poorest nations need fuel to run irrigation pumps. The industrialized nations will be bidding against one another for the dwindling oil supply.

b

Total Fatalities in Motor Vehicle Crashes by Type of Crash: 1998

Drivers/occupants killed in single-vehicle crashes	16,671
Drivers/occupants killed in two-vehicle crashes	15,724
Drivers/occupants killed in more than two-vehicle crashes	2,964
Pedestrians killed in single-vehicle crashes	4,795
Bicyclists killed in single-vehicle crashes	737
Pedestrians/bicyclists killed in multiple-vehicle crashes	449
Others/unknown	131
Total	**41,471**

Source: U.S. Department of Transportation, National Highway Traffic Safety Administration, Traffic Safety Facts 1998 (Washington, DC: 1999).