First Chapter of Serialization – A draft soliciting comments

An American Citizen's Guide to an Oil-Free Economy

A How-To Manual for Ending Oil Dependency
With valuable bonus information on Saving Our Economy, Our Planet and Strengthening Our National Security

by Alan S. Drake

Foreword

"Where there is no vision, the people perish" – Proverbs 29:18

A society that does not plan or prepare, that does not consider the consequences of the present and contingencies of the future, a society that lives only for today, the next quarter or the next election is doomed.

Events and a changing reality will, sooner or later, catch up with those that refuse to prepare. Available resources, time and most importantly, wisdom will simply not be at hand to allow us to adapt and recover from foreseeable negative developments - developments that reasonable people would have started to prepare for decades ago.

This "how-to" manual is intended to help Americans effectively and efficiently address a wide variety of problems that now loom darkly on the horizon and which appear to be moving ever closer. It is an action plan to replace inaction.

The various chapters, taken together, will help create a viable, resilient and sustainable oil-free transportation and economic system that can operate in parallel with our existing petroleum based system. We can transfer our economy, bit by bit, to the new, more efficient and oil-free replacement as our present system becomes increasingly more fragile and eventually unsustainable. These plans all rely on mature, proven and economically viable technologies and not the current "Hunt for Miracles" that Secretary of Energy Chu has so aptly described his department's Advanced Projects Research.

As new technologies develop, as they will, and are debugged and scaled up, our plans can be adjusted to incorporate these new solutions. Yet we can make a viable, workable plan with what we have "on the shelf", ready to go today. We need not gamble our future on "Just-in-Time Technology" appearing at *just* the right time and with *just* the right technology. No miracles are required, simply foresight, persistence and hard work.

This manual will show, as two sides of a coin, how we can keep the US economy from sliding into Third World status while dramatically lowering our energy consumption and greenhouse gas emissions. We can divert oil and other consumption that has no lasting value into long lived, productive and energy efficient infrastructure that generates increased high value employment.

An oil-free transportation system can be enthusiastically supported by those who do not acknowledge the gravity or severity of climate change. An oil-free transportation system provides effective and efficient remedies to several critical national problems. However, the creation of an oil-free transportation system is also one of the two most effective ways to control our carbon emissions (the other being conservation & efficiency).

An oil-free transportation system effectively addresses the single greatest strategic threat to the national security of the United States of America — the possibility and indeed probability that "one day" we will no longer be able to import and produce enough oil to keep our economy, our society and eventually our military functioning properly. This threat is discussed further in Appendix B.

As a secondary benefit, our plan will help save many tens of thousands of American lives and improve the quality of life for the average American.

If our future is to be energy constrained, as it appears likely today, there is no better legacy to pass along to future generations than a durable, energy efficient transportation system that operates on renewable energy.

If we are to enjoy the many benefits of a stable and resilient society and ensure the same for the generations to come, we must prepare for the future. Our best hope is a clear vision of the critical problems before us, to devise a set of practical solutions to those problems and to take resolute action to implement effective remedies.

This manual is the first step in formulating the practical solutions we need.

In Aesop's fable, the Ant worked to prepare for the coming winter while the Grasshopper lived for the day, consuming as much as he could and leaving the future to take care of itself. The grasshopper would react and "do something" when cold weather and food shortages were a reality, but not before. The USA of today is much like the Grasshopper.

Best Hopes,

Alan S. Drake

Chapter #1 – Electrified and Improved Railroads

Overall Strategy – Create an Oil-Free Transportation system that can out-compete our existing oil based system. Electrified and improved oil-free railroads can competitively attract much, and likely most, of today's truck freight traffic under current conditions of $80 per barrel oil and tax subsidized trucking vs. unsubsidized rail. Extant rail freight plus the freight transferred from trucks can be carried faster, cheaper, cleaner, greener, safer, more profitably and largely without oil, while creating an oil-free passenger network.

At deregulation, the rail modal share of fruits and vegetables was just 1%. It has since grown to about 15% today. Transporting a majority of our fresh food ton-miles without oil is a realistic and very worthwhile strategic goal.

A major goal of an electrified and improved rail system is that in the event of an oil supply shock (imagine $200 to $350 per barrel oil coupled with shortages), our oil-free transportation system can quickly expand to transport at least 85% of today's inter-city truck ton-miles. This will allow food and critical materials to be transported oil-free and this shift will reduce the pressure on rationing oil to critical needs.

The more society uses roads, the more expensive and slower road transportation becomes. Highway and road expansion projects show that the marginal cost for increased road capacity is higher, usually far higher, per lane mile or vehicles per hour than the inflation adjusted cost of the original road. And the USA is having increasing difficulty in just maintaining the roads we inherited, much less an ever expanding network.

The opposite is true for rail. Extra capacity on existing right-of-way (ROW) is usually significantly cheaper than the base cost. The more we use rail, with appropriate infrastructure investments, the cheaper and faster transportation by rail becomes. The annual maintenance budget for an expanded rail freight system will be significantly less than for trucking highways.

Building the subsidized Interstate Highway system reduced rail use and shoved railroads into the higher cost, lower volume end of the increasing efficiency with increasing volume curve of rail operations. The. market is now slowly moving back down this virtuous curve as rail expands. This paper advocates a significant push down the curve towards faster and cheaper rail service. Increasing the rail modal share of freight will also significantly reduce highway maintenance for even greater economic savings.

Roads have unrestricted access and need to be sized to meet peak demand. Roads also create their own demand over time, thus we simply cannot build "enough" roads, or buy enough oil to operate on them. Clearly, more roads are simply not the answer.

Trains are scheduled and routed and their demand can be managed with creative dispatching, adequate track capacity and state-of-the-art signaling. These strategies expand rail capacity very cost effectively, reduce transit times and lower unit costs. So greater use of electrified railroads is an essential part of the answer.

Much can be done in six years (see Appendix A), but the horizon I am proposing is twenty years, with some additional "in fill" work for another decade. However, oil emergencies can develop in a matter of days. Therefore, infrastructure investment in oil-free transportation should be "forward leaning" to ensure greater elasticity of transportation supply and rapid expansion in the event of an oil supply shock.

Benefits – Transferring inter-city freight from truck to electrified double stack container rail replaces roughly 20 BTUs of refined diesel with 1 BTU of electricity. This electricity is potentially renewable, and we can easily conserve the less than 2% of total electrical demand required to operate expanded and electrified railroads.

Railroad Double Stack 40' Containers, each roughly equivalent to an "18 wheeler" on the highway

The reasons for the efficiency advantage of electric rail rest on basic physics. Steel rolling on steel has about one-fifth of the friction of rubber on concrete or asphalt and electric motors are almost three times as energy efficient as diesel engines. Electric motors can also serve as generators when braking, converting motion back into electricity. Trains, especially double stack container trains, are more efficient aerodynamically than an equivalent number of trucks since one rail car reduces drag for the following car.

This 20 to 1 replacement ratio, diesel "traded" for renewable electricity (or conservation), has significant economic, energy, environmental, public health & safety and national security benefits. Savings on the order of two million barrels per day or about 11% of current US oil consumption are possible. That 11% performs a critical service – one that will be difficult to reduce in an oil emergency - unless, of course, we can turn to an expanded and electrified railroad system. An electrified rail system that significantly reduces oil consumption before an emergency can also expand quickly to save even more oil during an emergency.

Electrifying existing rail traffic trades 2.5 to 3 BTUs of refined diesel for 1 BTU of electricity and will speed up transit times a bit, 5% to 15% in the European experience. This creates an oil-free transportation backbone that can deliver food and other essential materials regardless of the severity and duration of any future oil shortage. This "new and improved" system can respond quickly to a prolonged oil emergency with proper planning.

Just 3% of Switzerland's transportation energy is used by electrified rail, but the Swiss transport 1/3rd of their freight tonne-km and 1/6th of their passenger-km with that 3%. This success helps explain why the Swiss voted to invest 31 billion Swiss francs over twenty years in improvements to their already excellent rail system. Adjusting for population and currency, an equivalent American investment would be more than $1 trillion. The plan envisioned here will take less money, proportionally, than what the Swiss are investing today.

The People's Republic of China is spending about 9% of their GDP on infrastructure, including electrifying 20,000 km of existing rail lines, building 20,000 km of new rail lines, high speed passenger rail lines plus a couple of New York Cities worth of subways. The United States of America is spending just 2% of our GDP on infrastructure and almost none of that spending will help us adapt to an oil constrained future, or reduce carbon emissions.

The Republic of France, among other goals, wants to electrify "every meter" of French rail and "burn not one drop of oil" by 2025. They also plan to double the low modal share of rail freight by 2022.

Electrifying, expanding capacity, eliminating bottlenecks and speeding up freight rail will significantly lower costs for freight shipments while increasing reliability of delivery. The savings and increased efficiency in Transportation, one of the principal factors of production, will spread throughout the economy and provide support for general economic activity. And it will muffle the impact of an oil supply emergency.

Maintaining an electrified and expanded rail system, once built, will cost much less than maintaining the Interstate Highway System for trucking. Just the Federal share of highway maintenance will be over $50 billion this year.

The savings from reduced highway maintenance and expansion due to fewer trucks can pay for much, or all, of the required rail investment. Trucks and weather are the two main causes of highway maintenance; damage to highways is proportional to the 4^{th} power of the axle weight. One heavy truck does more damage than 5,000 compact cars, and pays far, far less in fuel taxes per mile than those 5,000 cars combined.

The macro-economic advantages of positively and pro-actively transforming one major sector of the economy will help buffer the impact on all other sectors of the economy once world oil exports peak. That peak in world oil exports may have been five years ago in 2005 (the highest to date) or a new peak in world oil exports may be reached in 2030 (the most optimistic projection). A twenty year plan implemented ASAP will be completed in 2031 at the earliest.

Regardless of whether the peak in world oil exports was 5 years ago, or will be 20 years hence, there is precious little time to adequately prepare for a future with less oil available each and every year. Starting today, we could stay “ahead of the curve” for a 2030 peak in world oil exports, but only with dedicated efforts. In the much more likely case that the USA will import less oil every year from this year forward, a maximum effort to build and promote oil-free transportation is clearly necessary.

Significant funds will be invested internally in long lived, energy efficient, productive infrastructure rather than exported to pay for oil. The choice for our future, and our grandchildren’s future is between being saddled with difficult to pay IOUs or enjoying the benefits of a modern, efficient oil-free transportation system “Made in the USA”.

These improvements will also allow more and better passenger service - another oil-free alternative provided by electrified trains. This is an important and politically popular; albeit secondary benefit.

There are significant safety benefits as well. Last year, ten times as many Americans were killed by trucks as by railroads. A reasonable estimate is that this proposal will save 4,000 to 5,000 lives each year.

Compared to Natural Gas Trucks – Natural gas trucks operate off of either compressed or liquefied natural gas. Compressing the gas to 2,500 to 5,000 psi takes a considerable amount of electricity. Liquefaction of natural gas takes even more energy than compression but makes LNG fuel much more dense than CNG (Compressed Natural Gas), although LNG is still less than half as energy dense as diesel.

Inferring from California Air Resource Board (CARB) number, compressing natural gas takes $1/5^{th}$ of the energy in the natural gas. Other data from 1990 suggests that operating and maintaining the compressor would cost $1/6^{th}$ the cost of the natural gas itself. If these data points are confirmed, it should take **less electricity to move an electric train than it would to just compress the natural gas** to move the same freight by NG truck. Add to this the safety and road impacts of trucks, however fueled.

CARB says compressed gas from landfills has a Greenhouse Gas impact of 11.26 gCO2e/MJ and NG from pipelines is 67.70 gCO2e/MJ. Since landfill gas is considered to be zero emissions (it comes from the living environment, not fossils), one can infer that 20% of the 67.70 gCO2e/MJ for CNG is for compression. Given the 20 to 1 gain in diesel fuel to electricity by shifting freight from trucks to electrified trains, it appears that more electricity is consumed in just compressing natural gas than it would take to move freight by electrified train.

Also, natural gas burned in a combined cycle natural gas plant has efficiencies above 50% to 60% at best. Diesel engines in trucks are a bit below 30% efficient.

The better solution is to burn the natural gas to make electricity that drives electric trains and not to power long haul “18 wheelers”.

[The author is seeking more direct data on the energy required to just compress natural gas]

Energy Saved on Energy Invested – is the counterpart to ERoEI (Energy Returned on Energy Invested), a key concept in energy economics and analysis.

A BTU saved is a BTU earned – Benjamin Franklin (*with apologies*)

As noted earlier, transferring freight from trucks to electrified double stack container trains trades roughly 20 BTUs of refined diesel for 1 BTU of electricity. The major components of an electrified railroad have lifespans ranging from 30 years (rail cars) to multiple centuries (tunnels).

Railroad infrastructure is quite durable, and once built will serve society during good times and bad. In fact, much of the railroad infrastructure in use today was built over a century ago. Tunnels and grade improvements save both energy and time and last

for centuries. Bridges last for well over a century and ties and rail typically last 40 years on heavily used lines. When rails are finally scrapped, they can be recycled easily for 1/4th the energy of virgin steel.

The relatively modest energy required to electrify and expand the railroads, the 20 to 1 improvement in energy efficiency and the long life of the infrastructure gives some truly astounding ESoEI numbers. Some rough calculations show ESoEI can approach 1,000 to 1 returns.

As the supply of energy becomes a growing problem, getting close to a 300 to 1 payback, or even a 50 or 20 to 1 return, will become essential economic strategies. By comparison, boiling tar out of sand has about a 4 to 1 ERoEI and corn ethanol has less than 2 to 1 ERoEI return.

In a very real sense, we can bank the relative energy abundance of today for use by future generations, as those 19th century railroad builders did before us.

A rough EsoEI analysis of BNSF's Transcon rail line is in **Appendix E**.

Reliability, Speed and Cost – These are the primary determinants of which mode shippers will select. An informal survey of shippers that could ship by rail but choose to ship by truck, found that reliability was more important than speed, unless the cargo was perishable. "*If we knew that rail would only take one extra day, we would take the savings. But sometimes it can be an extra week and that causes all sorts of problems*". In all cases, rail was cheaper than trucking, often by large amounts.

Thus, bottlenecks and operational decisions that can delay rail shipments for undetermined times are anathema for switching freight away from trucks. And anything that can shorten shipping times and lower costs is good for American business and the general economy.

There are several options available for moving existing truck freight to rail.

In Europe, truckers place both their tractor and trailer on flatbed rail cars and then ride in sleeper cars for their required rest period. And at the next node, they roll off and drive to their destination. This is the least energy efficient choice, but it is the easiest one for truckers to adopt. A reasonable estimate is that a service like this will replace 6 to 8 BTUs of refined diesel with 1 BTU of electricity.

In the United States, long distance double stack containers dominate, and are growing rapidly, because this is the most efficient mode of freight transportation. However, the loading, unloading and sorting of these containers adds some delay. The US also transports truck trailers on flatcars (but without the tractors and drivers) with different drivers and tractors at either end.

Single stack containers can operate on virtually all rail lines, but double stack service is available today only on most, but not all, main lines due to clearance issues. SBB (Swiss Rail) is about to start 160 kph (100 mph) express freight service with single stack containers for high value and perishable goods .

A reasonable conclusion is that "All of the Above" rail solutions will find a viable market niche. Innovative and aggressive railroad management coupled with expanded, improved and electrified railroads will be the carrot and higher oil prices, the stick. This paper advocates electrifying and removing the limitations of rail infrastructure so that "All of the Above" can freely compete in supplying oil-free transportation.

A significant transformation in railroad operations will be required to gain the bulk of current truck freight. Both railroads and shippers have made such transformations before in response to a changing world. Only private management with control of both the track and operations can supply the necessary innovation.

Scheduled freight service that operates of a fixed time table allows for more efficient use of labor, equipment and track capacity. Scheduled service gives shippers much greater reliability, a key in switching customers to rail. The emphasis on scheduled service varies significantly from railroad to railroad. Scheduled service needs to become the industry standard for all but the lowest value cargoes.

Factories and warehouses will need to move back to rail spurs or rail spurs will be built to them (Virginia, Pennsylvania and Maine subsidize such rail spurs). This change will take longer than a decade relying solely on economic forces, but can be accelerated with public policies.

Increased innovation focused on quick and efficient handling of individual containers going in diverse directions will be required. In theory, there are several potential solutions but railroad management will need both innovative operations and the investment to implement them. The new Norfolk Southern yard and CSX yards, both outside Columbus Ohio, the Union Pacific yard outside Chicago and several BNSF yards may be a models for what is needed.

Infrastructure Investments – will pay for themselves within less than the planned twenty years. These investments (perhaps 2.5 AIGs* worth) can be spread over two or more decades, but it would benefit both our economy and our society to front end load them as much as possible.

** An "AIG" is defined as the amount of money required to bail out one insurance company.*

Electrification of Railroads - The USA has 177,000 miles of railroads, with the Department of Defense classifying 32,421 miles as strategic (STRACNET). These

selected rail lines correlate closely, but not exactly, with what are considered “main line” railroads. DoD only selected one of two main lines where two lines run parallel and a few main lines are not considered strategic. 36,000 miles should cover all of the main lines necessary to deliver vital goods and maintain a degree of personal mobility between cities.

The Pareto Principle (also known as the 80/20 rule) suggests that these 36,000 miles of main line railroad should carry 80% of the railroad ton-miles and burn 80% of the fuel used by railroads (there being no oil-free electrified common carrier freight lines in the USA today).

Electrified railroads are common outside the USA. The Trans-Siberian was electrified in 2002, Switzerland is completely electrified and France plans to be 100% electrified by 2025. Electrifying 36,000 miles of US railroads could take as little as six years with “Maximum Commercial Investment”.

An example of “Maximum Commercial Investment” was the effort (till mid-2008) to boil more tar out of the tar sands of northern Alberta. Rationally, we should work at least as hard to electrify our railroads as we do to boil more tar out of more sand.

The details of how quickly we might electrify are discussed in Appendix A. It should be noted that Mr. Murphy might add one, or even two years to the schedule.

Electrified sections of rail generally need to be over 400 miles long to be economically viable and, indeed, the longer, the better. Likewise, there are inherent efficiencies in an all electric railroad versus one operating with a mixture of fuels.

Depending upon future oil prices and the efficiency of running an all-electric rather than mixed fuel railroad, the pace of electrification may slow once the first and most important 36.000 miles of main lines are electrified - or a prolonged oil emergency may compel further acceleration.

The electrified railroad ROWs could also serve as new high voltage transmission corridors. In a number of cases, electric utilities would be willing to invest the capital to get new transmission lines and sell “power at the wire” to the railroads.

http://www.theoildrum.com/node/4301
Another article by the author on this subject

Double Tracking – Consider two-way traffic on a one lane road. For obvious reasons, roads are almost never built this way, but it is the norm for most rail lines.

Two tracks on the ROW, like a two lane road, allows for three to four times the capacity of a single track*, but it does not double costs since the ROW, signals, grade crossings and most other components are already part of the existing single track operation.

Double tracking also speeds shipments since trains traveling in one direction need not wait for trains moving in the opposite direction to clear the track.

Today, about 17,000 miles of main lines are double or triple tracked. Not every mile of main line track needs to be double tracked, but it does need to become the norm. A reasonable estimate, given the goal of supplanting truck freight and increasing passenger rail service - 15,000 miles of additional double track plus other capacity improvements at a cost of less than one AIG (perhaps $75 to $150 billion), almost all of which would be spent in North America.

* The issue of track capacity and average speed is more complex than this. A single track with tightly spaced sidings and CTC controls has over twice the capacity of a single track with few sidings and simple controls, but average speeds are still slow. A double track with many medium speed cross-over switches has significantly more capacity than double track with few cross-overs. A good summary is at:

http://findarticles.com/p/articles/mi_m1215/is_2_206/ai_n13455602/?tag=rel.res5

However, the article's rule of thumb, "Build as a last resort", needs to be altered.

http://online.wsj.com/article/NA_WSJ_PUB:SB120179835382432337.html

Rail over Rail Bridges and Grade Separation – An at-grade crossing between two busy rail lines, East-West and North-South, creates an obvious bottleneck as E-W trains have to clear the junction, with an adequate safety margin, before N-S trains can proceed. Likewise at grade crossings of roads can slow rail traffic and reduce capacity.

A single rail over rail bridge completed in Kansas City in 2000 reduced congestion delays by two hours to half a day for most trains traveling through Kansas City. A very worthwhile investment !

http://findarticles.com/p/articles/mi_m1215/is_9_201/ai_65805832/

CREATE is a $3 billion series of projects in the Chicago area designed to reduce rail congestion in Chicago (West Coast to Chicago transit times can be comparable to cross-Chicago transit times). Much of this improvement will come from six rail over rail bridges (mainly Metra commuter trains over freight rail) and 25 rail/highway grade separations plus a number of other, less dramatic improvements. CREATE II is in the wings and staff have told the author that CREATE III exists, but only over the office coffee pot.

http://www.createprogram.org/

There are quite a few locations where capital is required to reduce congestion and improve speeds with new rail infrastructure, such as Cajon Pass. However, such improvements can have century plus economic lives. Build them today and our great-grandchildren will benefit.

http://en.wikipedia.org/wiki/Cajon_Pass#Rail_transport

Creating grade separation between railroads and roads is often costly and can be time consuming. Some of the highway funds saved by reducing heavy truck traffic should be diverted to reduce the impact of roads and highways on rail operations.

In almost all cases, the railroads were there first and technically, under common law, it is the responsibility of the roads and highways not to interfere with the senior rail operations.

Better Signals and Scheduling, Improved curves and grades – These are often the most effective ways to expand capacity. Railroad signals are a complex and arcane subject, but improving signals has benefits similar to synchronizing traffic signals. The Federal Railroad Administration is currently requiring Positive Train Control on the major freight railroads, and this has the potential to increase speed and expand capacity once implemented and debugged.

Improving "go slow" tight curves and reducing the incline on steep hills with either more excavation or by relocating the line, can significantly speed up a rail line and increase its capacity while reducing operating and maintenance costs. In many cases, curve, grade and signal improvements on a single track will be enough. These basic improvements to the ROW will last for centuries.

Strategic Railcar Reserve – The United States maintains a Strategic Petroleum Reserve in order to respond to sudden and significant oil supply shortfalls. A Strategic Railcar Reserve would serve the same function, allowing railroads and urban rail systems to quickly respond to an oil supply interruption by providing increased oil-free transportation. The type and volume of cars stored in the SRR will require a detailed technical analysis, but the likely options for railroad cars are:

- "Well" cars for double stack containers
- Flat cars designed for carrying truck trailers (roll-on/roll-off)
- Refrigerated Boxcars
- Tank cars for increased ethanol shipments
- Old Amtrak coach cars replaced with newer equipment (perhaps a year or two ahead of schedule) and stored serviceable instead of being scrapped

Unlike the SPR, the SRR would be filled with "Made in the USA" products, some used ("mothballed" before completely worn out) and others newly built. The SRR

will be a better investment than the SPR in several ways. The SRR would not deplete once used liked stored oil, the stockpile can be used more than once. The stockpile of rail cars is useful for oil price spikes without associated shortages, there is no hesitation in using 100% of the stockpile if needed in a crisis and these stored railcars have the potential to save more oil per dollar than the SPR in the event of a prolonged oil shortfall.

It would be best if the track capacity had some excess capacity already built, so extra cars and traffic could be absorbed without a significant increase in congestion and delays. Slow and delayed trains could potentially absorb many of the extra cars from the SRR, which would cut into the value of this proposed emergency response to a national security crisis.

The old Amtrak coaches can also be used for evacuation from disasters, as has been proposed by advocacy organizations such as the National Corridors Initiative (www.nationalcorridors.org), which has put together an outline plan to do exactly that.

Such a strategic reserve need not wait until the railroads are electrified.

Semi-High Speed Rail – The European and Japanese model of High Speed Rail is for passenger service only at around 300 kph (180 mph), although very light cargo like mail and packages can also be shipped on the same tracks. This is the result of specific technical designs on super-elevation (tilt) and radius of curves, grades, axle loadings and more. Regular freight trains simply cannot operate on the same tracks.

There is a "sweet spot" where medium density (e.g. fruits & vegetables, electronics, just-in-time inventory) express freight operating at 90 to 100 mph can operate on the same tracks with passenger service at 110 mph and perhaps 125 mph with changed regulations. SBB (Swiss Rail) will soon be offering 160 kph (100 mph) express freight service on the same tracks with 240 kph (150 mph) passenger service.

The demand for express freight increases with distance while the demand for passenger rail service begins to drop off after 300 miles and is generally a small modal share for trips over 500 miles within the EU and Japan. The energy efficiency of passenger rail also drops significantly when trips are long enough to require rolling hotel beds and restaurants.

Combining these two economic services - long distance express freight with medium distance passenger service - makes a much larger network of semi-High Speed Rail economically viable. On most segments freight can "pay the freight" with higher speed passenger service as a nice supplement. On other segments, passenger trains will dominate the demand for premium rail service and express freight will get a free ride. More detail in Appendix C.

Cost – Good cost estimation is difficult given the variety of issues with the existing infrastructure. However, rail investments can provide superb value for money. An excellent investment example is BNSF double tracked and improved 2,217 miles (Los Angeles to Chicago) for slightly over $2 billion recently. BNSF more than doubled track capacity and now offers 70 mph express container freight service.

A $2 billion investment made BNSF's Transcon line the world's busiest container rail line (the Trans-Siberian is #2). By comparison, $2 billion spent on highway expansion projects would have no national and limited local impact. For example, $2.3 billion is proposed to just rebuild the Milwaukee Zoo interchange and $1.2 billion to add two lanes to the Huey Long Bridge outside New Orleans..

The following are reasonable cost estimates for what is being proposed, given the available information, in 2010 dollars.

- Electrify 36,000 miles of double track railroads - $100 billion or 0.55 AIG
- Double track 15,000 miles of single track, new rail over rail bridges, better signals, improved curves and grades – $75 to $150 billion, 0.4 to 0.8 AIGs
- Grade Separation (a cost that should be borne by highway budgets) could easily absorb $50 to $100 billion, 0.27 to 0.54 AIGs
- Semi-High Speed "3rd track" on existing ROW - 7,000 to 14,000 miles - $140 to $280 billion, 0.77 to 1.54 AIGs
- Strategic Railcar Reserve – perhaps a couple of billion dollars for mothballed used equipment. New equipment, when used is not available, should be an order of magnitude more expensive.
- Improved Intermodal Centers – a very rough estimate to supplant 85% of existing truck traffic would be $50 billion or so. Roughly a quarter of an AIG.

The investments are large, but the benefits far exceed the investment required.

Financing – Railroads are privately owned with the exception of the Alaskan RR, the Northeast Corridor, commuter rail lines, a few short lines and some stretches of ROW. Appendix C covers public railroads. There are a variety of tactics to encourage the privately owned railroads to invest much more.

The railroads are currently lobbying for a 30% Investment Tax Credit. Increase that to 40% and the $142 billion that railroads plan to invest over the next twenty years becomes $236 billion with $94 billion in tax credits. Increase the tax credit to 50%

and $142 billion in private investment creates $284 billion in long lived, energy efficient infrastructure that will benefit future generations.

Another tax credit could be for reduced carbon emissions or reduced oil consumption. Likewise, extra tax credits can be awarded if the rail electrification is powered by new renewable electricity.

Low-cost borrowing with federal loan guarantees or directly from the US Treasury can only increase and accelerate capital investments. Lower interest rates support a longer term perspective by increasing the net present value of long term investments. The improved ROW would be the collateral.

However, additional incentives beyond those just mentioned will be needed to induce the railroads to massively invest in new infrastructure. One possibility (not enough by itself), is for Congress to use the Interstate Commerce Clause and the requirements of National Defense to waive some proportion of property taxes on certain railroad improvements.

This is a zero cost measure since taxes are waived on something that does not yet exist and likely will not exist without suitable inducements. Consider that the competing trucks get their ROW for free, and with no property taxes whatsoever. One suggestion is a 75% waiver of property taxes for specific railroad ROW improvements a period of 40 years if placed in service by December 31st, 2015.

Every month after that date would shorten the 40 year exemption by two months and reduce the exemption by 0.25%. This would encourage the railroads to "front end load" their improvements. Under this plan, in December, 2025, new improvements would get a 45% property tax exemption for 20 years.

Another possibility to increase capital at the railroads would be for the government to buy the right to build a semi-High Speed Rail track on existing ROW, and then operate that track as a Public Belt. A Public Belt is like a toll road in that any licensed rail operator can use it by paying a fee.

Steps should be taken to reduce costs and speed construction wherever it is reasonable to do so. Adding electric wires to an existing century old railroad ROW should not have any significant environmental impacts except possibly aesthetic. NIMBYs should not be given the right to slow electrification on aesthetic grounds and environmental impact statements should reflect the inherently low environmental risks of electrification.

A variety of other incentives need to be considered.

Who Benefits ? Who Pays ? – The manifold benefits of switching from trucking to electrified rail are so much larger than the costs that a "fair" allocation of costs is not

required. It is as if four people could each contribute a quarter and each would walk away with a five dollar bill (a 20 to 1 return). Or one of the four contributes $1 and the others nothing, and they all still walk away with a $5 bill. The "chump" still makes $4.

Warren Buffett (BNSF Railroad is his largest single investment) and Bill Gates (30% of his non-Microsoft stock portfolio is in CN Railroad) are hardly charity cases. Their investments may reflect the same opportunity that I see. However, the market valuation of all seven major North American railroads is just $151 billion, less than one AIG, and just half of the market value of Exxon-Mobil.

The railroads clearly do not have the financial strength and risk appetite to build this proposal, unaided in the time required. They have stated that they can invest a maximum of $142 billion over twenty years in new infrastructure. However, the initiative, innovation and adaptability of good private management is required in order to capture the bulk of current truck traffic.

The national interest is very well served by electrifying, expanding and improving our railroads as quickly as possible. All parties should contribute but the ratios of contribution and direct benefits are subject to negotiation and compromise. A little known potential revenue source is discussed in **Appendix F**.

One historic example is that US Government freight was shipped at half price until after WW II as a quid pro quo for giving the railroads the land to build the Trans-continental railroads in the 19th Century - another major rail project that benefited the entire nation but required government assistance.

We spent a half trillion dollars (2008 adjusted) or 3 AIGs and built 46,876 miles of Interstate Highways under the "National Interstate and Defense Highways Act". The case for, and benefits of electrified and improved railroads are significantly greater than they ever were for Interstate Highways.

Bottom Line Benefits – Modeling **Chapter 1, Electrified Railroads** and **Chapter 2, Urban Rail** of **A American Citizen's Guide to an Oil-Free Economy** plus a major push for renewable energy (ACORE) resulted in the following results in twenty years (vs. the alternative Business as Usual in an oil constrained environment).

GDP +13%
CO_2 -38%
Oil Use -22% (would be lower but higher GDP increases oil demand)
Employment +4% (The US economy looks less like a 3rd World economy)

http://www.millenniuminstitute.net/resources/elibrary/papers/Transportation_MI09.pdf

The increased GDP alone could justify investing over a dozen AIGs over twenty years.

The -38% reduction in CO_2 is close to the -50% reduction called for by notable Climate Scientists and additional doable steps such as conservation could take us to over -50%.

The Millennium Institute modeling strongly suggests that the USA, with Business as Usual, is heading towards an economy characteristic of 3rd World economies. Subsequent events do not contradict the model run in 2007. Halting the slide towards becoming a Third World type economy (characterized by a few rich and most struggling to get by with lower GDP) has very positive social and democratic benefits, as well as economic ones.

Investing in a high efficiency domestic transportation system is an essential step in changing our economic course for the better.

Various people, with different perspectives and priorities, can unite in supporting oil liberation. For example, those that dismiss climate change can enthusiastically support the economic, energy and National Security benefits and accept that reducing carbon emissions "won't hurt".

Oil Liberation is good for what ails us !

Appendix A – Details of Electrifying Our Railroads

John Schumann of LTK Engineering and I developed a schedule for rapidly electrifying US railroads. Our scenario assumed Maximum Commercial Investment, defined as the maximum effort that people driven by the profit motive can sustain on large scale projects. This effort is less than war time efforts since national survival is clearly at stake during a war.

We agreed to five groups. Four would be run by the four major Class I railroads in the USA; Union Pacific, BNSF, Norfolk Southern and CSX. Separate efforts by Kansas City Southern, the US divisions of Canadian National and Canadian Pacific, as well as Class II railroads would comprise the fifth group.

All five groups would make roughly equivalent efforts and each group would create new work teams at the rate of about eight teams per year, per group. This is as fast as possible, within the boundaries of cost control. This would not be a "cost no object" war time-like effort.

Our conclusion is an aggressive but feasible effort for railroad electrification.

Year 1 – 0 (Design, Planning, Mobilization, Materials)
Year 2 – 5 x 500 miles = 2,500 miles
Year 3 – 5 x 1,000 miles = 5,000 miles
Year 4 – 5 x 1,500 miles = 7.500 miles
Year 5 – 5 x 2,000 miles = 10,000 miles
Year 6 – 4.5 x 2,500 miles = 11,250 miles

A total of 36,250 miles would be electrified in six years. The slight slowdown in the sixth year reflects a saturation of lines worth electrifying at Maximum Commercial Investment. The low hanging fruit would have been picked.

Depending upon future oil prices and the efficiency of running an all-electric rather than mixed fuel railroad, the pace of electrification may slow after the main lines are electrified - or a prolonged oil emergency may compel further acceleration.

There are 70,212 miles of heavily used rail lines, including branch lines. This implies that an additional 30,000 to 35,000 miles would be worth electrifying in a high oil price environment, another 2 to 3 years at Maximum Commercial Investment.

Subsequent to our discussions, the author discovered a never implemented 1979 contingency plan for British Rail that envisioned five teams electrifying 250 miles/year as a response to a prolonged oil emergency. This is 50 miles/year/team and we assumed 62.5 miles/year/team. If new teams can still be formed at the rate of 8 teams per year, per group, but they electrify only 50 miles per year, per team, this would add an extra year to the forecast.

Appendix B – Oil Supply Emergencies

The "American Way of Life" is vulnerable to an oil supply emergency that can develop in a number of simple to complex ways. The following are some potential scenarios.

Economic – "One day" the USA may need to pay for its imports with exports. Nations with oil to export may no longer be willing to trade their "black gold" for ever more US Treasury bills from our printing presses. Rather, they may want something more tangible in return. The Chinese are ready and willing to trade goods for oil. In 2009, we exported $1.57 trillion and imported $1.95 trillion, 24% more imports than exports.

Political – "One day" the House of Saud may be replaced by the Islamic Republic of Arabia (perhaps even with a nephew of Osama bin Laden on the Ruling Council). The Islamic Republic of Iran might work with their fellow Islamic Republic and together they could intimidate all the emirates of the Persian Gulf.

If the Islamic Republic of Arabia decided to only export enough oil to buy food, medicine and spare parts, there would be a severe oil supply shortfall world-wide.

There are many other potential political risks. The 1973 Arab Oil Embargo and the 1979 Iranian Revolution are past examples.

The Chinese have been very active in assuring the reliability of their oil imports. Some examples are buying half of an Ugandan oil field, lending Venezuela money that will be paid back in oil over 20 years, over 100,000 Chinese are building infrastructure in Angola, in Iran they are supplying parts and expertise to build subways, develop oil fields and much more. The net result is that in an oil supply emergency, Chinese oil imports will be disrupted less and other nations proportionally more.

Natural Disaster – A Cat 4 or Cat 5 hurricane pushing water up the Houston Ship Channel would not only destroy 40% of our refining capacity but also severely disrupt our oil supply network for many months. There is not enough spare refining capacity in the world to offset the loss of Houston and it would take months for shipping to adjust and bring the USA whatever refined oil products that would be available. If another hurricane hit New Orleans that same year, or even the following year, the effects would be even more catastrophic.

The Strategic Petroleum Reserve is 99% unrefined crude oil, which would be of little help if many refineries are destroyed.

Peak Oil Exports – Peak Oil is the point in time when world oil production peaks and then declines. Peak Oil Exports is when oil being exported (and imported) peaks and then declines. The delta between the two concepts is the oil produced and consumed domestically by oil producers (about half of world production).

Since the USA is the world's largest oil importer, peak oil exports is our primary concern. Domestically, the USA is 40 years past our own oil production peak, with crude oil production now down by half. In fact, Texas can no longer produce enough oil to meet its own internal demand.

Internal oil consumption by the major oil exporters is rising quickly and many of them have chosen to shield their population from world oil prices. Gasoline prices are subsidized to anywhere from 11 cents to $2 per gallon. An example of increasing production coupled with reduced exports is Russia in 2008. Russian oil production rose slightly, stimulated by record oil prices, but Russian oil exports fell due to a 6% increase in domestic demand.

Saudi Arabia is not only using more gasoline and diesel to support their growing economy and population, but they recently announced plans to burn an additional 1 million barrels/day of crude oil to generate electricity by 2020. The Saudis are short of domestic natural gas and electrical demand is currently growing by 8% per year.

The Saudis would rather burn crude oil than imported natural gas to generate electricity.

The US Joint Chiefs of Staff is well aware of this strategic threat, and in JOE2010 state "A severe energy crunch is inevitable without a massive expansion of production" and "By 2012, surplus oil production capacity could entirely disappear, and, as early as 2015, the shortfall in output could reach nearly 10 MBD".

10 million barrels per day is almost one-quarter of total world oil exports. It is difficult to grasp all the implications of an oil shortfall that large. However, the German Army (Bundeswehr) attempted to do so, with disquieting results.

The German Bundeswehr study of the effects of post-Peak Oil Exports was recently leaked.

http://peak-oil.com/download/Peak%20Oil.%20Sicherheitspolitische%20Implikationen%20knapper%20Ressourcen%2011082010.pdf
[in German]

A detailed evaluation of the report :

http://www.energybulletin.net/stories/2010-09-28/review-putting-bundeswehr-report-context

Appendix C – Government Owned Railroads

Government owned railroads that interconnect with interstate lines such as the Long Island RR, the NorthEast Corridor, the former CSX line in South Florida, several commuter rail lines around Boston, Chicago, etc. and Public Belts at ports are a special case. The easiest and best way to finance useful improvements are federal government grants to electrify, add more rolling stock and improve the ROW. Improvements that could be financed with, say, a penny a gallon tax on imported oil. A National Defense and economic measure to reduce oil dependence that benefits everyone.

The Alaskan Railroad is state owned and serves only the state of Alaska. The State of Alaska is flush with oil revenue (no state sales tax or personal income tax and even sends annual checks back to every citizen). Therefore, special provisions by the federal government to assist the Alaskan Railroad are a policy option. The State of Alaska can self finance needed improvements from their own resources.

I would encourage electrification of the Alaskan Railroad (perhaps supported by small hydroelectric dams along the way) and enhanced speed (say 90 to 100 mph passenger service with EMUs) with limited double tracking (enough to allow passing without stopping) between Fairbanks and Anchorage. A spur or two may be worth adding around Anchorage and Fairbanks.

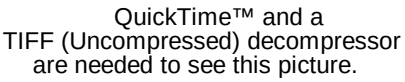
Appendix D – Details on semi-High Speed Rail

As an example, El Paso-San Antonio is unlikely to economically support even two passenger trains/day, but long distance express freight needs this segment to connect California with the South. However, San Antonio-Houston could support over a dozen (best guess 16 to 20) 110 mph electric passenger trains/day if both cities built good Urban Rail systems for inter-city passengers to transfer to. Freight would need to pay for the improvements on the El Paso-San Antonio section, but would get a "free ride" from San Antonio to Houston.

CSX asked for federal funding for rail line improvements from Washington DC to Miami. Grade separation for the entire 1,200 miles. Two 100 mph passenger tracks between DC and Richmond and one 100 mph track south to Miami combined with two regular freight tracks (typically 60 to 70 mph service, maximum 79 mph). The single 100 mph track would use the regular tracks for passing North and South bound traffic. $20 million/mile appears to be appropriate for such improvements to existing rail lines.

http://www.vhsr.com/system/files/CSX+CFP+Submission.pdf

Below is a hypothetical map where building the 3 & 4 track approach might be appropriate. The Northeast Corridor is already built. The fast, oil-free transport of fruits and vegetables from California, Florida and elsewhere could form the economic backbone of this system. The strategic advantages of transporting food without oil are apparent.



A number of other possibilities will apply to other lines outside the semi-HSR network. Today a single bi-directional track rail line may carry a lot of coal, gravel and other high density, low value cargoes along with some general rail freight. The first track could continue in that role (with low super-elevation and high axle loadings that beat up the track), but a second bi-directional track could be added for regular freight, empty coal cars, express freight and Semi-HSR passenger service. The "coal track" could be used for passing.

Double stack container service may require a choice. Double stack container trains can operate slowly and erratically on the "coal track" or the second track can be built for double stack containers with slower passenger (say 79 mph) service and no express freight service.

The high center of gravity of double stack containers limits the super-elevation (tilt) in curves, which also impacts how fast trains can go. Over good terrain and wide curves, 90 to 100 mph passenger service can operate on the same tracks with double stack container trains. In my opinion, a case by case decision will need to be made when 3 tracks are not an economic option.

Appendix E – Energy Saved of Energy Invested – An Example

BNSF double tracked and improved the 2,217 mile "Transcon" rail line from Los Angeles to Chicago. In doing so, they have transformed the Transcon into the world's busiest container rail line and captured a majority of the container market in that corridor, shifting the containers from diesel truck to diesel trains, results in an 8 to 1 savings in diesel. *Below is still a very rough & incomplete draft*

Energy Invested:

The embodied energy is approximately 30 MJ/kg for steel, 2 MJ/kg for concrete and 100 MJ/kg for copper

2,217 x 2 miles of 136 lb/yard rail plus concrete ties every 18 inches, 800 lbs each gives 20.1 billion MJ of energy invested (largely energy from coal). Add (guess) 30% for transportation (by energy efficient rail), welding, switches, bridges and other auxiliary infrastructure for roughly 26 billion MJ of energy invested. Refined diesel has about 34 MJ/l in energy, plus another 6 or so MJ/l for refining and transportation.

Lifespan: Track has an expected lifespan of 40 years, bridges over a century. After 40 years, the ties will be scrapped but the steel will be recycled (except for what is worn off) with a 75% energy savings. So, in 120 years (remember that this is a legacy improvement), 2,219 miles of track may take 50 billion MJ.

50 billion MJ is the energy of 1.25 billion liters of diesel or 2.75 million gallons/year. Offsetting this is the energy saved with much reduced interstate highway maintenance.

Energy Saved: The US uses about 84 million gallons of diesel per day on inter-city trucking. **IF** the Transcon saves $1/30^{th}$ of that amount, 2.75 million gallons/day by diverting freight from truck to rail, it would "pay" for one years energy invested in one day of operation. An ESoEI of 365 to 1.

Currently, the author has been unable to find freight volumes specifically for the Trans-con, as opposed to BNSF in toto.

Appendix F – An Alternative Financing Proposal

Don't tax you ! Don't tax me ! Let's tax that fellow behind the tree !
- Sen. Russell Long

World Trade Organization (WTO) rules allow a nation with a long term structural trade deficit (and the USA certainly qualifies !) to place a unilateral tariff on all "non-essential" imports so long as the proceeds from the tariff are used exclusively to reduce the structural trade deficit and there is no preferential treatment in the application of the tariff.

Oil imports are a major part of the "long term structural trade deficit" of the United States of America. This plan (all chapters) will reduce US oil imports by substantial amounts. Therefore, a substantial fraction of the governmental costs to implement this plan could be financed by a 1% to 2% tariff on a broad range of imports.

The initial reaction from foreign governments may not be positive, but our diplomats can assure them that this new tariff:

1) is according to WTO rules. In fact, this is precisely why this exemption exists.
2) will be effective in reducing US competition for available oil exports, which is very much in the self interest of oil importers and even oil exporters.
3) will be effective in reducing US carbon emissions, which is in everyone's interest.

And furthermore, it is the only politically possible way that the US will do anything meaningful about either oil consumption or Climate Change. Thus, it is in their enlightened self interest to not object to the US financing part of the program with a broad but small tariff on imports. And if the tariff is implemented according to WTO rules, they have no other recourse under international law.