Avoiding global transport crises before oil and gas extraction ceases

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Abstract

Most of our global transport systems rely on oil and its derivatives of bunker fuel, diesel or gasoline. These fuels power the machines of agriculture, the transportation of people and goods along our roads, and the global shipping that moves bulk products from sources to refineries, and then other goods from manufacturers to consumers across the open seas. All these systems are vulnerable to price variations in their fuels and ultimately to the continued pumping of crude oil from the ground. Although estimates vary it has been suggested that the ‘oil peak’ occurred in 2006 and the gas peak will soon arrive (the coal peak is somewhat later). Once we have passed a ‘peak’ the fuel’s production rapidly becomes much more costly as the remaining resource becomes more difficult to extract.

Instead of our global reliance on oil as the preferred fuel for transportation this paper will argue we ought to shift to using electricity instead, and that we ought now to be assuring ourselves of adequate supplies of electricity before we run out of both the transport and productive capacity necessary to build its new supply and distribution infrastructure. And further, we need to invest in a new global ground transport system that does not use oil as its fuel.

We argue that the best options at this time are to (a) capture as much renewable energy as possible and to transmit this electricity by high voltage direct current cables to densely populated regions where there is a wide range of production capacity, and (b) implement a high-capacity transport system which must be able to carry both people and freight that does not rely on oil or gas as its primary fuel but electricity. The freight mode must support the complete logistics chain from raw material supply to the distribution of finished goods, be they minerals, or water, or food stocks.

In other words, before we lose our fuel supplies that presently power our transport systems and indeed our whole life cycle we have to build resilient new infrastructures and so win time to allow our science and technology to create new processes for our survival.

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Introduction

Since the Industrial Revolution began in the UK in the mid 1700s we have become more dependent on fossil fuels to provide our energy needs. First it was coal that superseded manual, wind and water power; and after the late 1800s oil, then gas, became important sources of power partly because oil in particular is very transportable and has a high intrinsic energy output per unit volume. It was recognised that all the primary fuels were non-renewable, that once used they could not be replaced – but we imagined there was an ample supply of all three, given new 'fields' were frequently discovered. Now we find that the recoverable fuel in the new discoveries is outstripped by our continuing and increasing demand. The total system is not sustainable, and moreover, soon there will be no fossil fuels remaining to be exploited.

This paper will discuss the fossil fuels and their main uses followed by a consideration of 'life after the oil peak'. That takes us to a discussion of a new electrical grid and a new transportation system using mainly electricity as its 'fuel'. In passing we will note that developed nations all need to re-develop most of their infrastructures that have been enlarged piecemeal over decades which now exhibit several forms of instability that might only be cured though a redesign and rebuild. We argue that both the electricity and the transport grids require innovative designs that far supersede the capacity of earlier systems so they will be capable of sustaining our future after the ending of the oil and gas supplies. A brief section detailing ball-park cost estimates for these new grids is followed by a discussion section that highlights sociometric issues that will gravely hinder our global progress towards implementation of these new structures; namely, our social and leadership differences across the nations of the globe, our management differences in terms of our inclination to procrastination and corruption, and our difficulties in trusting other people. Notwithstanding the huge technical, political and social difficulties in solving the question of our global survival we conclude that the evident large costs of implementing the new global electrical and transport grids are slight relative to the untold misery of global famine that would occur soon after the breakdown of our oil-fuelled transport systems.

This paper is about pragmatism. We do not deny that there are many good new inventions in laboratories and in demonstration units across the whole energy and transport sectors. But to move these ideas into fully developed and implemented products takes time. Even if these ideas were somehow to be implemented now the present global population would still exhaust the reserves of oil and gas quickly. Further, while the people in the developed world will only incline towards sustainability and frugality slowly and under the duress of regulations, those in the undeveloped world aspire to the 'better' life style perceived of those in the developed world thus in total we will consume still greater volumes of our resources. Further, we have vowed that we must, via the Millennium Goals, lift those in abject poverty into a better world (Annan, 2000)[1]. This latter aspect has a huge resource cost which we must honour –

> … thus the central challenge we face today is to ensure that globalization becomes a positive force for all the world's people, instead of leaving billions of them behind in squalor. Inclusive globalization must be built on the great enabling force of the market, but market forces alone will not achieve it. It requires a broader effort to create a shared future, based upon our common humanity in all its diversity (Annan, 2000:6).

To achieve these goals, of lifting those people in the undeveloped and the developing nations, and to maintain those in the developed world require that we secure our energy and transport security globally using methods not yet widely deployed, but which are practical and which presently exist as fully operational systems. This paper describes two ventures to capture renewable energy and to use its electricity for our future transport needs.

To muse … of a future without oil and gas!

The future should concerns us as the perception of problems within it will creep up on us slowly. We are aware that oil and gas resources are becoming more difficult to extract, and finding new sources is less likely. Also the 'green policies of the people' are against the exploitation of oil shale and schistes as they say the process of 'fracking' is too dangerous to use since its methods demand many chemicals be injected to keep open the fractured strata, and in some instances, these processes will pollute our underground water resources (Waxman et al, 2011). The 'greens' force governments to halt licensing of production and new exploration of these potential fuel sources, just as they forced nuclear power station building programmes to be abandoned. The result will be a global absence of evaluated reserves of non-traditional fuels in the near future.

Consider how disruptive such actions may be.

> This note concerns a 16-hectare field in the Rothamstead farm near Oxford, UK, that has had its winter-sown wheat yield measured since 1843 (the Broadbalk experiment). As a part of an agricultural research institute, the field has had detailed experimentation undertaken on its yields of wheat following different management regimes, and Figure 1 shows how these yields have altered over time. There was a major field management change in 1978 when it was decided to rotate wheat with other crops on some of the research strips. This was mainly as a disincentive to wheat diseases: a fungicide regime was also adopted as well as applying the best of fertilisation regimes. The highest yields occur when the area is crop-rotated and treated with the best organic or inorganic fertilisers producing about 10 tonnes/hectare; second best has no-crop rotation and a regime of inorganic fertiliser and/or organic manure producing about 3 tonnes long-term, which increased to about 5 tonnes with the introduction of higher yielding wheat varieties (see Figure 1 notations); while the worst patch of the field, being always untreated, only yields 1 or 2 tonnes.

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[1] The *Millennium Goals* report. See http://www.un.org/millennium/sg/report/full.htm

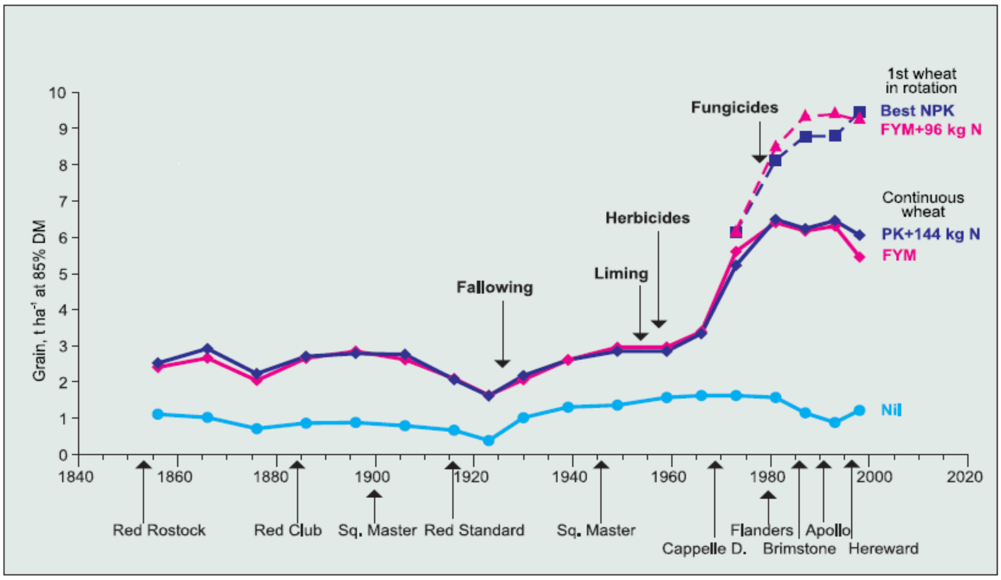

Figure 1: Wheat yields/hectare[2]

Farming regimes now rely on having fuel for the tractors and harvesters, and of course the manufacturing and delivery of fertilisers and herbicides (using gas or oil). At the beginning of the supply chain we rely on there being natural gas, gasoline and diesel fuels to develop the electricity for the pumping and delivery of the crude fuels to the shipping terminal. Then there must be heavy bunker fuel for the large ships who might carry these crudes half-way round the globe consuming 150 – 250 tones of their own fuel per day over a voyage of perhaps four to five weeks (from the Arabian Gulf to say, Rotterdam). Once transhipped to the refinery the crudes are converted to a myriad of products: central to this story are the gasoline, diesel and other fuels, as well as the fertilisers (plus herbicides and pesticides) that will be delivered to the Rothamsted farm.

If there is no oil or gas what then will be the yield of wheat? Some exclaim that we ought not to be using inorganic fertilisers but ought to feed back our bio-mass to the field from which our grains came: this may prevent the high yielding parts of the field from falling below the middle result in Figure 1. But others demand the bio-mass residues after harvest be gathered to be 'efficiently' consumed in other energy-producing systems to create, say, bio-diesel to fuel our transport system. That is laudable, but the wheat yield would then fall to the lowest results shown in Figure 1.

(Source: Wheat yields data and graph from Rothamstead, 2006; otherwise story-line by this author).

Central to this paper, when the oil and gas supplies do run out, we will have no manufacturing of fertilizers and herbicides, nor any fuel to acquire stock grain for planting, or to make deliveries of food grain to end-users. This would suggest a bleak future for mankind if we must succumb to subsistence farming when yields are as low as the worst case at Rothamstead. Essentially urban people will starve, while rural people will be able to follow a poor existence as they always have done. We will not travel, and we will not have any information flows as there will be no Internet; and libraries which are dependent on air-conditioning to maintain the quality of modern paper will see their stock of books become mouldy and fall apart. Quickly we will forget how to do what we used to take for granted, as electrical or fossil fuelled systems will stop and we revert to manual or water/wind power: we will live, earn, eat and die locally.

The current global population of 7 billion will quickly fall to less than 1 billion, the level of early industrialisation circa 1800, and maybe fall to pre-industrial levels of ~ 700,000 (about the 1750s) when we find sustainability difficult to achieve and starvation is the easy alternative. In an attempt to assess 'sustainability' in a supply chain Stonebraker et al (2009) discuss the incremental fragility of each stage of the 'chain' on several factors: this is good work, but they do not discuss the issue broached in this paper – *no oil* means *no transport system*. Of course we may target the vast waste in resources that occur presently in industry, commerce and in households (we throw away uneaten

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[2] See http://www.rothamsted.bbsrc.ac.uk/Research/Centres/home.php

about 1/3rd of the food we purchase), and we may learn to be more frugal. As energy costs increase due to their scarcity we will further consider our use of these resources: for instance, choosing in winter to wear more clothes rather than maintain a high temperature through the whole house; however there is a limit to our individual scavenging. It is undoubtedly true we individually need little in order to survive: to wit, we may observe the millions of people who live in near-desert conditions, or who have been forced to migrate due to natural or ethnic conflicts. But in the 'developed' world we who live in cities do not understand how to survive when the supermarket shelves become empty. As we said above – starvation become the easy alternative.

There are several issues preventing the quick changes desired later in this paper. In wartime development cycles are shortened by ignoring Health & Safety assessments as new processes are tested in use even though those decisions may lead later to high litigation costs as 'class actions' are brought against the State for injuries sustained in action. In peacetime there are long lead times due to

a) Slow breakthroughs of scientific research
b) Difficulties in acquiring development cash-flows
c) Slow take-up of research into pre-commercial pilot plants
d) Procrastination of decision-makers over (a, b and c)
e) Decision confusion 'at the bleeding edge of progress' as no one likes costly 'leading'
f) Incompatibilities due to decision makers betting too late on alternatives
g) Incompatibilities due to governments forcing different implementations to prevent 'enemy' use.
h) The long testing cycle of 'Health and Safety' authorities.

All in all, in peacetime, the progress from a scientific announcement to public use might be 10 to 50 years due to many issues – some reduce costs, others increase efficiencies; and presently we are working through a period of reducing availability of fossil fuels that will increase their prices so decision makers are further confused. Once the oil supply falters we will quickly lose all our transformation capacity and this might be predicted to be in the next 20 years, or even shorter as the International Energy Agency has stated that we passed the 'oil peak' in 2006 (IEA, 2010)[3]. Decision makers have ignored the warnings of scientists about 'peak oil': partly because many forecasts use the metric of 'total energy' that often indicates a secure energy future (using an aggregation of renewable and fossil/nuclear fuels). These forecasts forget that all supply chains demand oil as their main motive power. Without oil we will fail.

This paper advocates we make our supply chain secure using as much electrical motive power as possible to conserve our oil for the beginning and end of the supply chains (the 'first/last mile' transportation where trucks have to be used). Once secure [electricity] supplies are established we will be able again to research and bring on-stream new modes of power supply that at present are laboratory examples or pilot plants far removed from commercial deployment: but first, we must concentrate on our survival.

Users and uses of fossil fuels

Some aspects of 'climate change'

Kunzig & Broecker (2008) refer to the original Keeling Curve that demonstrated that man had accelerated the creation of air-born CO_2 from the late 1950s onwards and discuss many 'solutions' that ought to be investigated collectively and operationalised as mitigation or as adaptation. Hansen et al (2007) reported on historical changes to CO_2 levels, and discussed the potential for man to induce 'flip changes' to all global eco-systems due to the aggregate effects of climate change. Their analysis and similar others (for instance, from the UN or OECD) carry implications for the continuance (or the increase) of air-born pollutants year-on-year into the future. These are the anthropomorphic global

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[3] It is difficult to determine critical points or points of inflexion on curves, especially time series, without considerable data. The data of the IEA changes as major players adjust their 'official' data making the aggregate data set dynamic. The IEA is to be applauded for its vigorous assessment of the critical point of its data – ie 'the peak' in such a timely manner: as illustrated here in Figure 1.

warming (AGW) ‘greenhouse gasses’ which may cause irreversible climate change. The warnings of *The Stern Report* (Stern, 2007) indicated that if we collectively ‘do nothing’ the planet will be in grave danger, but for relatively little cost to our collective GDPs we can all contribute to a better future. In addition, the Intergovernmental Panel on Climate Change (IPCC, 2007) in their report *Climate Change 2007: The Physical Science Basis* assessed current scientific knowledge about the natural and human drivers of climate change. The UN has organized meetings under the United Nations Framework Convention on Climate Change (UNFCCC) at Rio de Janeiro (1992 – *the Earth Summit*), Kyoto (1997), Bali (2007), Copenhagen (2009) and Cancun (2010) in order to obtain voluntary agreements by nations’ heads on reductions in their pollutants. These meetings had only a moderate success mainly due to arguments between the developed and developing nations, the rich and the poor, and who would carry the costs (whereas Stern suggested all should pay little).

Turning to national issues we note that each country has a different primary energy mix based on its percentage use of primary fuels [nuclear, coal, oil, gas, hydro, etc] that contribute to its characteristic carbon footprint. This not constant, but alters over time as new power generating systems are commissioned and older ‘dirty’ systems are decommissioned. For instance, the UK was once heavily dependent on fossil fuels for its electricity generation but now only about 22% of its generation comes from coal (the dirtiest fuel). Even so, electricity generation remains the main source of UK pollution, with road transportation and housing as the next major sources. France at present is almost totally dependent for its electricity on nuclear fuels (84%) plus hydro-electric generation (6%): even the household electrical bills of EDF (Electricité de France) proclaim its ‘green credentials’ noting only 4% of its electricity is generated from coal yielding a pollution loading of ~50 gmCO_2eq/kWh: in contrast, the UK creates 891 gmCO_2eq/kWh from its electrical generation (WNA, 2007). Therefore, in France, the pollution from road transport and housing assume a much greater proportional significance than in the UK, so there is now a somewhat heavy government pressure on the transport sector, though to be fair, such pressure has been exercised since the *Grenelle* of 1968[4].

Each fossil fuel has its own specialised use. Coal is used predominantly to heat boilers to generate the steam that turns generators so creating electricity which then is used as though a primary fuel in many situations. The conversion efficiency of coal to electricity is not perfect, achieving at best 30 - 50%. Over many years the energy conversion efficiency of the steam turbine cycle has been improved by increasing its main pressure, and by raising its operating temperature: the modern units are described as ‘super critical’ following an accurate scientific description of their operational cycle. Even better efficiencies (~55%) may be achieved by new ‘ultra-super-critical’ types, but they will reach the limits of steel technologies. These efficiencies are similar to the best of oil or gas-fired electricity generating stations, though oil produces only 65% the CO_2 of coal burning and gas about 50%, which is a consideration for the goal of global warming green-house gas mitigation.

Electricity is popularly imagined to be a ‘primary’ fuel as “it causes no pollution” so is deemed the fuel of choice for city cars propelled by batteries. But it must not be forgotten, though this fact is often ignored, that the required electricity for charging the batteries would have been made in some CO_2 producing system according to each nation’s pollution profile.

Our fossil fuels

The IEA (2010) describes the main coal use as ‘industry, whereas the use of oil is mainly ‘transport’; and gas is used for heating (ie ‘Industry’) with ‘Other’ being the manufacturing of chemicals for the production of a wide range of outputs from fertilisers to plastics. Table 1 describes the main uses of these fuels where oil is clearly the main global energy source (in terms of millions of tons) – so once its supply falters the global energy demand will be left unfulfilled.

Uses of oil

Crude oil is refined into various oil grades for the transport industry and for heating oil and lubricants – but transport is the largest user. Like natural gas, it may be used as the source to make fertilisers,

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[4] A conference bringing together the government, local authorities, trade unions, business and voluntary sectors to draw up a plan of action of concrete measures to tackle the environmental issue. The name “Grenelle” comes from the first conference which took place in May 1968 in the Rue de Grenelle, Paris

pesticides, plastics and synthetic rubbers, paints and dyes, well as medicines, detergents or food additives. Its derived chemicals find their way into most of our daily consumption.

Table 1: Global use of fossil fuels (% within each mode: 2008)

Oil		***Gas***		***Coal***	
Transport	61.4	Other	48.2	Industry	78.5
Non-energy	16.2	Industry	35.1	Other	16.6
Other	12.9	Non-energy	10.8	Non-energy	10.8
Industry	9.5	Transport	5.9	Transport	0.4
MTOE	3502	MTOE	1313	MTOE	823

Source: IEA, 2010

Notes: 'Other' and 'Non-energy' uses include the manufacturing of a wide range of chemicals for use in further processes such as the making of plastics and fertilisers.

MTOE is million tons of oil equivalents (there are defined conversion factors).

Uses of natural gas

Much of the natural gas is consumed for heating – either as space heating (industrial and domestic); for the heating of water or ovens; or as the heat source for the generation of electricity; and even by pipeline operators delivering gas (and oil) as they need a fuel for pressurizing and pumping their products. However, natural gas is also used as the feed stock for making fertilizers, antifreeze, pharmaceuticals, fabrics as well as creating chemicals like ammonia, methanol, butane, even acetic acid which progress as feedstock for other end-products. It may also be used directly as a vehicle fuel, either directly by substituting for petrol/diesel, or in fuel-cells although it is more polluting than hydrogen that would be the preferred vehicle fuel if it were to be produced cheaply. And, notwithstanding the breakthrough in hydrogen production by Ozalp et al (2010) this is still a laboratory project, and dependant on solar energy.

Uses of coal

Predominantly coal is used in steam-driven turbines used to generate electricity. In this use it is highly polluting as its oxides of oxygen, sulphur and nitrogen are only partially captured, and the exhaust gases also contain many small carbon particles that are carcinogenic. There is considerable research effort expended upon carbon-capturing and sequestration (CCS) but, as yet, there are few commercial examples of such equipment.

We suggest that our present worry about anthropogenic global warming will dissipate once we accept that without oil to fuel our transport requirements much of the global industrial pollution will simply stop. For example, without oils to fuel the extraction of coal from the ground and to transport it to power stations there will be no coal-fired generation, thus no electricity and no production of any sort. Our climate change worries will be over.

Oil and Gas peaks

Hubbert (1956) predicted the demise of the oil industry in the US after 1965 - the year he predicted as its peak output; he went on to predict the global peak as the year 2000. He was remarkably accurate in both cases if one took his upper bound of his forecasts - being 1970 for the US, and 2005 for the global output peak. The International Energy Agency (2010) in Paris has said the global oil peak was in 2006 and the gas peak will be about 2015 – 2020; with the coal peak following much later.

We must now come to terms with its statements, and resolve the differences in oil peak predictions – see Figure 2. The predictions of the IEA are seen as the curves of Logistic [Low, Medium, and High] peaking at about 2006 (their modal prediction has been emphasised herein by the thick dashed line:

author's emphasis). Perhaps simply accepting most of the different curves is all that is required by us, as the far more important question is "what will we do when the oil finally does run out"?

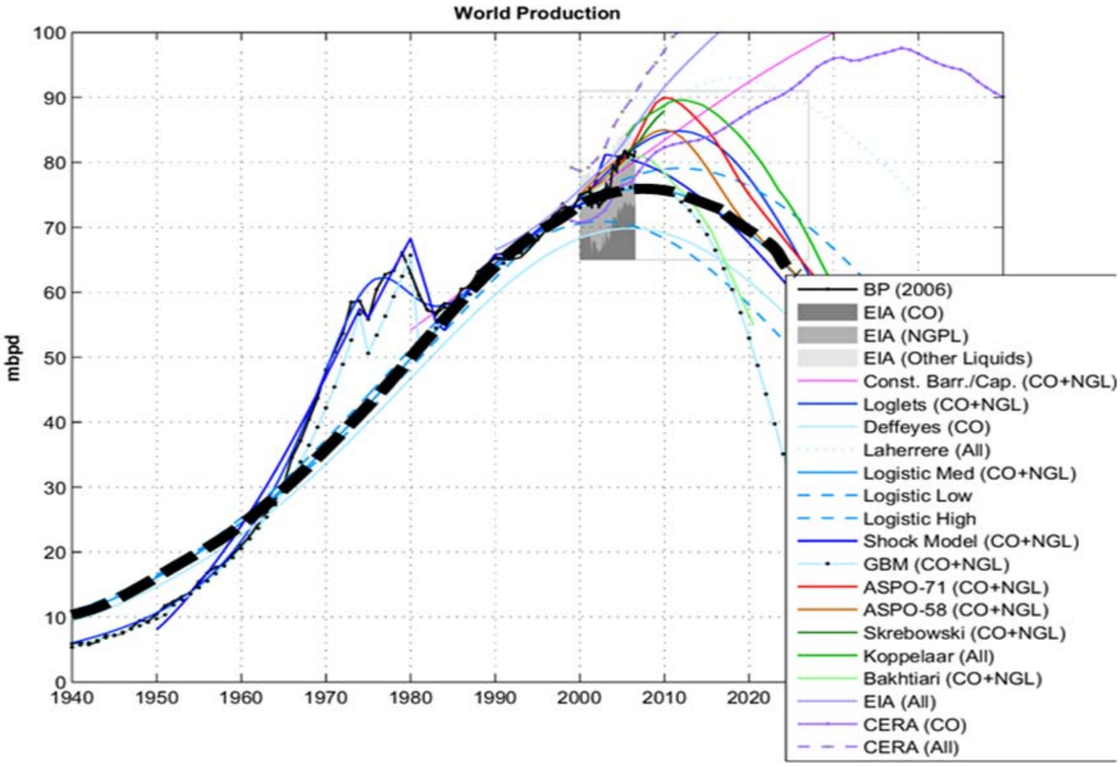

Figure 2: Various predictions of 'peak oil'[5]

The variations in the 'peak' are caused in part by inexact data proffered by the producers – both in terms of quoted extractable reserves and in terms of new traditional-oil discoveries as well as the inexactly predicted supply from unconventional sources like oil sands or shale deposits. Even major oil producers revise their reserves figures, sometimes by large volumes as did Shell in 2004; so it is not surprising that the average person is sceptical of doomsayers, or even of any suggestion of 'past the peak'.

One fact that is inescapable is that fuel prices will rise, probably quite quickly, as reserves are depleted. Oil is easily and cheaply extracted in the early days of any field, but by mid-term flow slows down, and soon extra energy has to be applied to ensure efficient extraction towards the well's end-of-life. This is done by passing into the well high pressure water or gas hoping it flows through the reservoir and so release fuels trapped in the strata. This inflates the 'lifting cost' as the water/oil mix has to be separated prior to shipping. However, as the yield of oil from any field falls that effect contributes to the aggregate fall in yield globally and thus market speculation through supply/demand economics, and because of political manipulations will rapidly inflate consumer prices. Sooner, rather than later, we will have little oil left underground and even the lifting cost will become so prohibitive the producer will cease pumping.

The world has enough resources?

Above we have suggested frequently that we must act now to avert a global disaster that, whilst being presently opaque will surface in a few years time as the oil and gas pumping ceases. But there are widely held views that contradict this thesis.

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[5] Source: http://upload.wikimedia.org/wikipedia/commons/f/f2/PU200611_Fig1.png accessed 16th March 2011.

The United Nations with its many action groups has been unique at data-gathering on many fronts, one being climate change and also the mitigations of the effects of anthropometric global warming (AGW). It has issued many warnings and suggestions that have been taken up by regional governments and in turn by their member states: eventually the people complain about new rules and regulations imposed on them by their own government unknowledgeable of the history of that decision. For example the UN Brundtland Commission (1987) on 'sustainability' concluded that building insulation (ie increasing their energy efficiency) was one of the most applicable solutions to reducing fuel use, thus mitigation of AGW. These ideas are now being drawn into new-build regulations around the world; and some consider that by increasing several diverse efficiencies we will be able to survive (a) climate change issues by capping temperature rise to 2ºC average and (b) eking out our remaining oil and gas reserves.

We see many attempts by the air, maritime and land-transport industry to mitigate the effects of global warming. Accidentally, as it were, the maritime industry reduced its emissions during the financial crisis by reducing the speeds of their vessels so saving fuel (to maintain profitability of the shipper) while not greatly affecting the supply chain as demand was rapidly falling and many firms were reducing their inventory. In general however, as regulations are agreed many years in advance, engine manufacturers have time to instigate R&D and development experimentation ahead of the due dates while suggesting to the gullible public they are advancing engine efficiency to 'save the planet' – but these changes are usually only upon land transport, not ships nor 'planes. Thus the airline and the maritime industries have outlined efficiencies they are going to achieve voluntarily by 2020 (IATA, 2009; IMO, 2009).

Individual manufacturers also show they are 'responsible', such as the luxury yacht builder Paracas Group who say their Paracas 158 is the most efficient boat, ever. It combines solar power with a mini-water turbine to generate electricity as it makes way under sail. These charge lithium-ion batteries which will power the boat in harbour via electric underwater motors, as well as supplying its electrical 'household' needs without often using its diesel motors. Other engineering solutions envisaged by others discuss the deployment of novel sails or even large 'parachutes' to drag a boat along and so reduce the need for oil-burning motors. Yet they miss the long-term point, what will they do after the oil runs out? They cannot create boats that achieve perpetual motion as there is undisputed scientific consensus that perpetual motion would violate either the first law of thermodynamics, the second law of thermodynamics, or both. Their power supplementation is simply … a reduction in the use of diesel fuel: good for the planet, but ultimately still burning a scarce resource.

Even so, another branch of the UN - the well known Intergovernmental Panel on Climate Change (UN/IPCC: SRREN) said recently

> Close to 80 percent of the world's energy supply could be met by renewables by mid-century if backed by the right enabling public policies.
>
> The findings, from over 120 researchers working with the Intergovernmental Panel on Climate Change (IPCC), also indicate that the rising penetration of renewable energies could lead to cumulative greenhouse gas savings equivalent to 220 to 560 Gigatonnes of carbon dioxide ($GtC0_{2eq}$) between 2010 and 2050 (from their Press Release 9th May, 2011)

And also

> … the report shows that it is not the availability of the resource, but the public policies that will either expand or constrain renewable energy development over the coming decades. Developing countries have an important stake in this future—this is where most of the 1.4 billion people without access to electricity live yet also where some of the best conditions exist for renewable energy deployment.

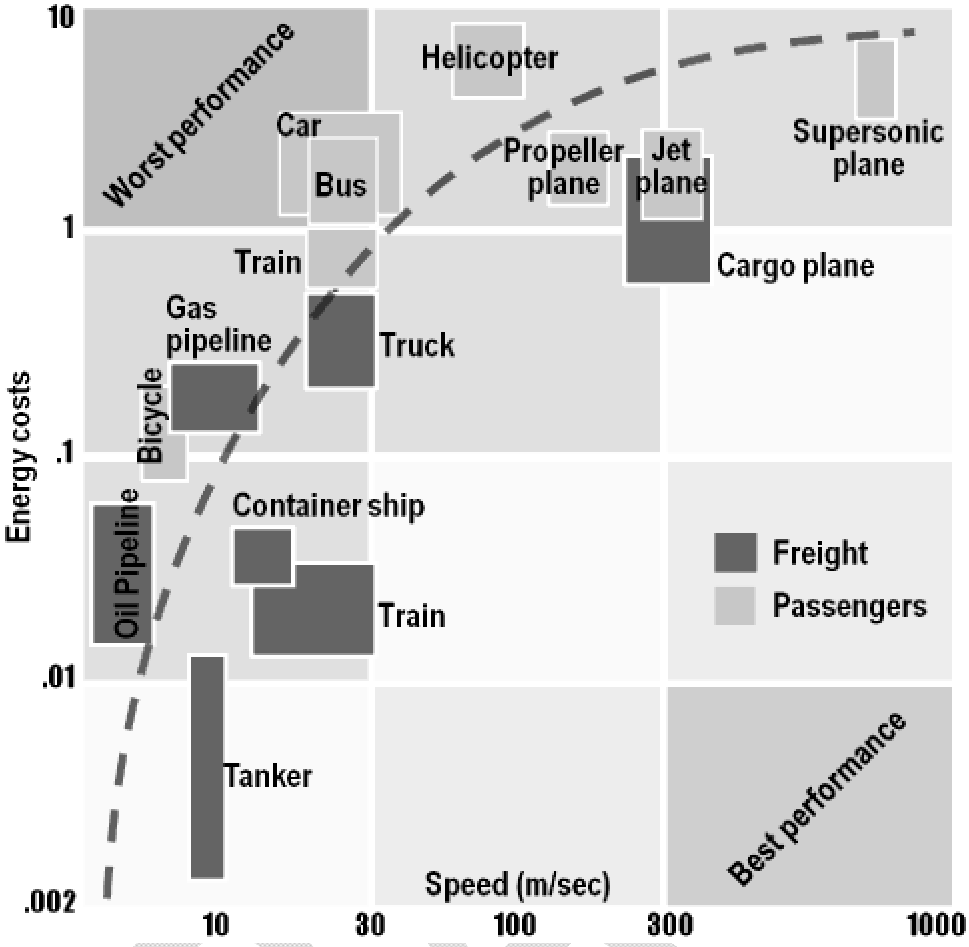
Clearly this panel with its study of 160 simulations were confident that renewables could aid the globe with respect to climate change mitigation – *but* they did not mention the cessation of oil/gas supplies.

A good example of 'ecological growth' might be Brazil where for some while it has co-manufactured sugar from cane, and from its vegetable waste manufactured ethanol highly efficiently. All of the nation's cars are able to run on either petrol (gasoline) or ethanol, or a mixture of both. Other nations, with the support of the IPCC invested in ethanol production using arable land used for growing food grains and changed to growing maize for ethanol production. Happily this 1st generation bio-diesel or ethanol is being phased out as it is both costly, and it may not be in aggregate a reducer of global CO_2. Sadly the US is still subsidising its production while others look to new oily plants that may be grown on non-crop land. Yesuf (2007) says that many rural famers will not grow these crops for a variety of reasons – they are highly risk averse, believing the no one will pay them to harvest crops that they perceive to be of no use – they are not for food, and grown on useless land, so how can the crop be useful? Further to this argument is the belief that there could be enough bio-supply to satisfy our global needs for bio-fuel production or to use in combined heat & power systems. We doubt this assertion, as few systems are fully effective in collecting 100% of any kind of rubbish. And, as there will be many competitions for a limited volume of bio-waste, it is highly likely that the fuel/heat generating systems will not work well in practice as many systems are still at the laboratory stage.

Procrastination is not an option

It has been argued that American research engineers were at the global vanguard with respect to maglev systems in the 1980s into the 1990s (Lever, 1999). However into the 1990s the US maglev projects were not developed for many reasons, one of which was fund diversion due to 'earmarking'. This is the process whereby local State lawmakers divert Federal funds for their personal projects rather than allowing, in this case, fully funded research into the potential of maglev. This ensured that deserving research projects were never developed into pilot projects for pre-commercial evaluation since as little as 50% may have been made available for research and it simply is not possible to make a reasonable 'return on investment' when one begins so badly hampered financially. 'Earmarking' has severely hindered US first-mover advantages across many sectors, not only maglev; and it is only now in the [new] Obama Administration that the practice is being resisted. However we doubt this, as his $410 billion spending bill of March 2009 contained 8,570 earmarks for specific projects – hopefully the earmarks were aligned to alleviating the financial crisis (Economist, 2009).

A graph by Chapman (1989) displayed in Rodrigue et al (2009) is displayed here as Figure 4. It shows a neat comparison of transport modes against their energy/speed trade-off. It is of considerable importance to note that in this paper we suggest the decommissioning of most of these modalities except perhaps for pipelines (oil and gas) for as long as they remain commercially viable. All the others will be subsumed under our revised trio of 'last mile mode' trucks or battery cars, electric rail and maglev. The average speed of our proposed system will be high, and the energy cost will be low (given the required electricity will be generated by renewables) – though they have a capital and operational cost. We will in fact move the average curve depicted in Figure 4 towards the 'best performance' hoped for by Chapman.



Source: Source: adapted from J.D. Chapman (1989) *Geography and Energy: Commercial Energy Systems and National Policies*, New York: Longman Scientific & Technical.
Shown in http://people.hofstra.edu/geotrans/eng/ch8en/conc8en/energymode.html Accessed April 4th, 2011

Figure 4: Comparative energy/speed trade-off by transport mode.

We suggest our anxiety about the oil peak and other aspects (such as the pollution that may come from hydrofracking of potential oil/gas formations) is basically a distraction away from the deeper consideration of how to avoid a future catastrophe when we do not have access to any oil or gas supplies. We argue herein that the present worry about global warming is [almost] irrelevant as the global climate warming due to pollution emissions will cease when the oil/gas runs out. This is notwithstanding the availability of coal and its potential use as a fuel for electricity generation (producing much CO_2 unless captured and sequestered: not yet a commercial operation), or as a source of feedstock chemicals (again producing CO_2 as an unwanted pollutant…). We will have no transport system (as this mostly requires oil as a fuel) and no industry, so atmospheric pollution will cease.

A typical response is seen in the US where a Congressional Report commissioned in 2009 with a mix of authors (climate scientists, businessmen and politicians) was met with outright hostility by politicians on its publication stated Kaufman (2011) -

> Joe L Barton. Republican of Texas, who has been leading the charge against further regulating carbon emissions, swiftly dismissed the council's findings in an interview. "I see nothing substantive in this report that adds to the knowledge base necessary to make an informed decision about what steps — if any — should be taken to address climate change,"

Also -

> "This is the classic problem — the divide between scientific reality and political courage," said Paul W. Bledsoe, a senior adviser who has worked in Congress and with the White House on these issues. "The

> scientific organizations are reluctant to advocate detailed policy prescriptions, while political actors are tentative about the scientific realities."

Even so, this report *America's Climate Choices*[6], which was written by Americans for America (in contrast to the UN/IPCC publications that are global in scope) does not address the depletion of oil and gas sources, but competently concentrates on the predicted effects of climate change thus advocates mitigation or adaptation, rather than outlining a revolution of thought and action.

Over the previous 150 years we have extracted more and more coal, oil and gas from our natural reservoirs and we have now used over half of all existing oil supplies (IEA, 2010). Critics of 'peak oil' say we will (a) discover much more oil from oil sands, etc; and (b) learn how to make oil from our own vegetable rubbish (bio-mass or other sources). Both aspects are true to some extent, but in the case of (a) our increasing global demand outstrips discoveries, and owners of existing oil fields must heed their EROEI ratio (energy return on energy investment) because once the EROEI falls towards unity the oil production is no longer a net energy source. Logically, extraction will cease when EROEI = 1.0 and this will occur before the oil field is physically exhausted. As for (b) – making oil – most of the suggested processes are pre-commercial at best, and some are found only in laboratories. Some processes are already in commercial use – namely bio-ethanol production which has caused some concern as it diverts land-use away from food supply as governments offer subsidies to 'fuel farmers'.

The International Energy Agency found

> Conventional bio-fuel production requires about 1% of all arable land and yields about 1% of global transportation fuels. If 100% of the global fuel requirements for the world were derived from conventional bio-fuels, the land requirement would reach 1.4 gigahectares, an amount equivalent to all of the world's arable land… competition between bio-fuel production and food production would appear inevitable (IEA, 2006: 289).

The *Economist*[7] notes that William Cline of the Peterson Institute for International Economics in Washington, DC suggests at least 4% of the world's grain is used to make ethanol for fuel. Most of this is doing little good for the environment, and stopping subsidies for such fuels would boost the supply of grain for feeding people on a scale similar to the fall that the past three decades of warming have provided. The *Economist* continues … easily achievable improvements in roads and markets can increase the availability of food a lot, even if farm yields stop rising.

King (2010) has attempted to expand the measurement of EROEI: it is usually computed at the well-head source rather than tracing its costs through the supply chain. He does this by computing the Energy Intensity ratio (EIR) for oil, gas, coal and even electricity: he finds it is an easily computed index. He notes also that EROEI is usually computed for official statistics only each 5 years, a period too long considering the volatility of modern fuel markets. But there is also a difficulty in introducing the energy efficiencies of renewables to the equations -

> …. in the long term, the development of renewable energy technologies is a race to install them with the high EROI of past and current fossil energy resources before fossil resources are depleted to lower EROI. It is also likely insufficient to have energy resources with EROI just greater than unity, and researchers to date have given very little attention to the minimum EROI that may be required for a modern complex society. For example, debates about whether or not corn-based ethanol has EROI > 1 rarely discuss how or when it is supposed to compete with petroleum and gasoline characterized by EROI and EIR many multiples higher (King, 2010:17).

Further -

> It is important to guide future research to understand the meaning of crossover values of EIR and EROI from renewable and fossil alternatives as the use of more land for capturing renewable energy flows has a similar negative effect on long run economic growth as the depletion of fossil resources. Thus, a need exists to calculate the trends of EROI and EIR for renewable energy technologies starting in the lab and continuing through commercialization. These early assessments will teach us better how to measure the pace of innovation in energy technologies. However, the lack of specific renewable energy prices or sector energy input data presents a difficulty for long term tracking. Future research should be directed at deriving methods and data for effectively comparing EROI of fossil and renewable technologies, on equal

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[6] Available at http://www.nap.edu/catalog/12781.html

[7] *The Economist*: Climate Change and Crops: Hindering harvests. May 5th, 2011

> footing, and over time. In this way, we can measure the innovation, or lack thereof, of both fossil and renewable energy systems (King, 2010:17).

Hall et al (2010) have derived a 'theory of minimum EROEI'. They say that it must be obvious that '… for any being or system to survive or grow it must gain substantially more energy than it uses in obtaining that energy'. Rather worrying, they calculate the EROEI for both oil and for corn-based ethanol is about 3:1 at the well-head/farm-gate. Since most bio-fuels have EROEI's of less than 3:1 they must be subsidized by fossil fuels to be useful! They suggest -

> While it is possible to imagine that one might use a great deal of fuel with an EROEI $_{\text{minimum}}$ of 1.1 : 1 [but] to pay for the use of one barrel by the consumption of many others, we believe it more appropriate to include the cost of using the fuel in the fuel itself. Thus we introduce the concept of "extended EROEI" which includes not just the energy of getting [ie lifting] the fuel, but also of transporting and using it. This process approximately triples the EROEI required to use the fuel once obtained from the ground, since twice as much energy is consumed in the process of using the fuel than is in the fuel itself at its point of use (Hall et al, 2010:45).

They conclude

> … of course the minimum of a 3:1 "extended EROEI" that we calculate here is only a bare minimum for civilization. It would allow only for energy to run transportation or related systems, but would leave little discretionary surplus for all the things we value about civilization: art, medicine, education and so on; i.e. things that use energy but do not contribute directly to getting more energy or other resources (Hall et al, 2010:45).

Both Hall and King support arguments expressed elsewhere – that discussions about energy are unclear, pressurised by lobbyists, and over-emphasised by oil producers or others determined to continue 'business as usual'; and that the conventional measurement of EROEI underestimates the true requirements of society. These arguments are clearly observed in high-level climate change discussions where negotiators are unwilling to concede changes leading to reductions in their national emitted pollutants.

It is important that we recognise that innovation decision horizons are long and procrastination levels are high with respect to decision-making by government Ministers or venture capitalists who may offer finance to develop ideas (Fischer, 1999; O'Donoghue & Rabin, 1999). Time thus passes as we squabble about irrelevancies. We ought to concentrate on global electrical energy security and a new ground-based transportation system before our fuels' EROEI fall below the 3:1 $_{\text{minimum}}$ ratio. Or, as Hall et al worry, '... fall below some unknown ratio higher than 3:1 that represents the real cut-off appropriate to society, though this higher ratio is not yet calculable'. Heinberg (2007: 222) stresses this discussion, and points out that once the electricity grid collapses "… the party is well and truly over".

Trade undoubtedly has transformed communities, often for the better, but sometimes regions have been vandalised[8]. Many regions have been made much more prosperous by trade supporting new townships and further development (Ayres & Warr, 2009). An example quoted by Bernstein (2008: 330) notes how the construction of canals, their locks, and a railway infrastructure opened up the North American wheat-growing plains to the export of grain and incidentally to the betterment of Europe and elsewhere as they received cheap grain. While it was the canals of the Great Lakes that effected the initial changes from 1830, it was the expansion of the railways after the 1870s that permitted cheap and rapid journeys from far inland carrying Illinois and Iowa grain, and Minnesota's mineral deposits to the US East Coast docks. Their early trade was promoted by the steam engine: now it uses diesel-electric engines – but what will occur if there is no diesel fuel for the railway engines, or oil for shipping?

After the oil peak

As hinted above, there is no dearth of ideas as to how to create 'new' electricity. Some options are – increased nuclear power generation notwithstanding a public worry about its safety; increased use of new techniques such as using bio-mass to create steam which may be used in co-generation for space heating as well as electricity generation; growing more or new varieties of plant that have a high yield

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[8] Detrimental 'land grabbing' is reported at http://www.future-agricultures.org/index.php

of oil; or using algae to directly create oils from chemicals. Most of these ideas are at the laboratory stage, some are entering the pre-commercial stage – even the nuclear power options.

At present there are about 450 nuclear plants installed globally, mainly of Type I (pressurised water type), which have a modal age of about 25 years with a designed life of 40 years. It is a fact that many are retired 'young' for various reasons leaving behind their legacy buildings that are "hot" due to their irradiation, parts of which must be safely contained for at least 50 years. A casual review of 'early' retirements for all causes (accidents, political, or because the plant was experimental) suggests an average operational age of 25 years (WNO, 2010). The new-build generators are to be Types III or even IV – which are still on the drawing board – so like many of other new ideas these are unlikely to be productive for many years yet, if at all. The 'greens' concerns and demonstrations against new-build nuclear sites are relevant as the *Precautionary Principle* suggests (UN/Comest, 2005:14), and as we observe from the evidence of the major accidents at Three Mile Island, Chernobyl and Fukushima Dai-ichi.

> When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm. Morally unacceptable harm refers to harm to humans or the environment that is
>
> - threatening to human life or health, or
> - serious and effectively irreversible, or
> - inequitable to present or future generations, or
> - imposed without adequate consideration of the human rights of those affected.
>
> The judgement of plausibility should be grounded in scientific analysis. Analysis should be ongoing so that chosen actions are subject to review. Uncertainty may apply to, but need not be limited to, causality or the bounds of the possible harm. Actions are interventions that are undertaken before harm occurs that seek to avoid or diminish the harm. Actions should be chosen that are proportional to the seriousness of the potential harm, with consideration of their positive and negative consequences, and with an assessment of the moral implications of both action and inaction. The choice of action should be the result of a participatory process (UN/Comest, 2005:14).

Returning to 'oil' - researchers seem to forget that we must have sufficient *liquid* fuel supplies (oil) to maintain our transport systems, instead they concentrate on *total electrical* power (CCC, 2010a, 2010b; EU, 2010). Worryingly, some have reported that decision makers have not understood the time-scales involved. Sorrell et al (2009:13) refer to Hirsch et al (2006, 2005)

> "… a report for the US Department of Energy argues that large-scale programmes of substitution and demand reduction need to be initiated at least 20 years before the peak if serious shortfalls in liquid fuels supply are to be avoided. While this report overlooks many important mitigation options (e.g. public transport, electric vehicles) it also assumes a relatively modest post-peak decline rate (2%/year) and ignores environmental constraints. Hence, even 2030 may not be a distant date in terms of developing an appropriate policy response".

Notwithstanding an apparent lack of response by the US administrators, US President Obama in announcing his *Blueprint for a Secure Energy Future* on March 30th, 2011 noted in his speech "… a major cause of the recent gas price rise (ie petroleum fuel for cars) is the concern that global oil demand will outpace supply over the next few years. The dependence of the global vehicle fleet on oil makes this problem especially acute…."

> "We cannot keep going from shock to trance on the issue of energy security, rushing to propose action when gas prices rise, then hitting the snooze button when they fall again. The United States of America cannot afford to bet our long-term prosperity and security on a resource that will eventually run out. Not anymore. Not when the cost to our economy, our country, and our planet is so high. Not when your generation needs us to get this right. It is time to do what we can to secure our energy future." Obama, 30th March, 2011

We might thus expect the US across its wide-ranging experimental and legislation base to search for lower oil consumption while encouraging more alternative sources for energy, including oil and gas substitutes; however, they may increase subsidies for bio-ethanol that will distort food prices and skew the values for ERORI $_{\text{minimum}}$ discussed above.

Research does not seem to be the target, as Obama [14th May, 2011] directed his administration to ramp up U.S. oil production by extending existing leases in the Gulf of Mexico and off Alaska's coast and holding more frequent lease sales in a federal petroleum reserve in Alaska. Obama's announcement followed passage in the Republican-controlled House of three bills that would expand and speed up offshore oil and gas drilling. In ordering these changes he is simply pandering to the oil industry lobbyists and drawing nearer the time when $\text{ERORI}_{\text{minimum}}$ will become a reality and the oil industry will [logically] shut down.

We suggest here, that in the times scales envisaged (given Hirsch's worry about the long lead times from discovery to exploitation), the only viable systems to support our immediate electrical energy security are those presently working commercially, and thus proved. These are wind turbines, photo-thermal or photovoltaic systems, deep-well thermal systems (though limited to certain geological locations), hydro-electric generators where river flows are deemed adequate, and concentrated solar power. All have their obvious drawbacks even though they are truly renewable sources of power. However, in combination, using a new smart electric supply grid, these sources offer our main hope for the future – especially when augmented by solar power from desert regions. It will be an electrical future garnering our dwindling liquid/gaseous fuel supplies until such a time comes when we will be able to manufacture these products based on sustainable electrical energy supplies.

For the immediate future we need to assure ourselves we have enough [raw] electricity for our many needs; and as mentioned earlier, we must invest in a viable intercontinental land-based transport system powered by electricity since our present transport system is mainly powered by oil (Table 1).

Building new infrastructures

Already the developed world knows it has to rebuild its legacy systems. These include electricity grids and transportation systems that have been extended incrementally from their inception without much discussion on alternatives. The US and the EU consider we will have to spend heavily on creating so-called 'smart grids' that allow for detailed control and switching of the electricity supply in order to 'save electricity' and thus to reduce our CO_2 pollution. In the case of the EU, this grid redevelopment has been estimated to be at least 200 € billion, and may be up to 1 € trillion over the next decade when considering the total cost of energy restructuring (EU, 2011:11). This EU publication acknowledges that an EU-wide programme needs to be addressed because purely national programmes will be more costly overall since they will not correctly address integration through an emergent market-place.

Perhaps more fundamental is the restructuring of the global transport system to cope with a future without oil. Oil (and oil-based lubricants) are needed to power our earth-moving equipments be these tractors or vast machines digging for minerals. Their efforts need trucks to shift the grains or minerals to the rail-head for transportation to further processing; and after that trains and trucks are needed to deliver the goods to market and we then need some transportation to bring their production to our tables. Even oil and gas are not immune to the need for oil to help shift these fuels from source to user – drilling requires motive power, pumping also - over long delivery distances the oil and gas pipes are regularly re-pressurised by huge pumps run by diesel or gas fuels. We must therefore carefully consider how to release ourselves from the 'grip of oil'. We must do this very soon as we have noted above that predictions of oil pumping "failure" lie only 20 years away, and in the interim period fuel prices will rise rapidly.

a) The transport 'grid'

We will note briefly rail, maritime and road transport grids which require better integration into a global mesh that considers firstly its primary motive power source and secondly its ability to deliver sufficient volume of goods in a reasonable time. This is not to say we should continue to rush headlong into the growth and the lifting of global GDP as a gaol. But better integration with a wider reach will address many the issues associated with rural poverty, starvation and their health and education issues, and in meeting the Millennium Goals (Annan, 2000).

For instance, most mainline rail in the US is limited in operational speed due to poor signalling controls and poor track quality to maxima of 60-70 mph (~100 km/hr) for freight and ~90 mph (~150 km/hr) for passengers (FRA, 2007; Economist, 2011b). In comparison, the high speed passenger track of Europe, Japan and China regularly operate at much higher speeds. Specific development definitions by the European Union include 200 km/h (124 mph) for upgraded track and 250 km/h (155 mph) or faster for new track: and there are regulations in place for full-EU interoperability of rolling stock. In Japan, its Shinkansen lines run at speeds of up to 300 km/h (186 mph) and are built using standard gauge track with no at-grade crossings. In China, high-speed conventional rail lines operate at top speeds of 350 km/h (217 mph), and one Maglev Line in Shanghai reaches speeds of 431 km/h (268 mph). In these countries with high-speed rail they are trying to separate freight from the passengers and potentially lift the average freight speed; though by little as many wagons still need to be sorted in slow-moving freight-yards to be assigned to trains to new destinations. The major beneficiary of the easement in freight transport are not the general trades in containers (potentially of high valued), but bulks like grains, coal, oil, gas and general minerals (all necessary, but cheap per ton) that can reach their destinations faster. Often, in the developing nations, we see a rapid rise in the numbers of air freight flights as forwarders and users both command the rapid delivery of goods, sometimes as it is a fashion so to do, sometimes as a ‘work-around’ of poor local infrastructures, but often because ‘time-to-market’ has become a critical issue in the supply chain.

Kaps & Wolf (1997) say that European freight moved at only 16 km/hr (10 miles per hour) on average – partly due to it being diverted to sidings to allow faster (more important?) passenger traffic to overtake, and partly due to considering a myriad of rules and regulations as trains cross national borders. Whenever freight and passengers share the same track it is the freight that is sidelined, and so many nations have developed their high-speed passenger systems on separate tracks to maintain passenger average speeds while offering the older track to freight – though the older track may hold uncertain operational capabilities due to its age and maintenance needs. It is not surprising therefore to find much freight being carried across continents by road: trucks are flexible in pick up and drop off, and can maintain a high overall average speed even when drivers obey regulations about rest-times. Those comments are emphasised by the Economist (2011b) which notes the US transport infrastructure is in a shambles – roads are blocked by traffic, so passengers might then choose to use a train which is held up by slowly moving freight trains ahead, and thus in frustration passengers try short-haul air routes finding they too are subject to long delays due to congestion caused mainly by air traffic controllers using 1950s-based control systems that cannot cope with the traffic densities demanded in the 2000s. The solution, according to President Obama in his 2012 budget proposal is to spend upwards of $556 billion over the next six years on transport re-development.

As global freight volumes increased it was not surprising to find that freighter ships became larger with their associated economies of scale. The Malacca Max vessels (so described as they are sized at the draft limit of the Malacca Straits) carry about 10 – 12,000 containers at a designed speed of ~25 knots consuming ~ 300 tons of fuel per day. They may be operated at slower speeds, but that is commercially inefficient both for traders and for the engines: but at an average of 17 knots they will only consume ~ 100 tons of fuel per day. Now, Maersk Line has commissioned new container vessels to carry about 18,000 containers at only 19 knots: they say of themselves -

> Currently, Maersk Line has the largest market share of any container shipping line in this trade, moving 18 percent of the container cargo leaving Asia for Europe and 15 percent of the container cargo travelling from Europe to Asia.
>
> In 1968, Maersk Line had only one non-containerised service connecting Asia and Europe that consisted of twelve sailings per year and carried approximately 8,000 tonnes of cargo. Today, there are a total of 10 ‘strings’ consisting of 83 vessels travelling east and west covering the Asia - Europe trade. Together, they carry approximately 1.4 million FEUs (forty-foot equivalent units) every year between the two continents. Two-thirds of this cargo goes to and from China.

One presumes that the engineers and the management at Mearsk have carefully considered the life-cycle economics for these new massive boats. For instance their assumption of the ship’s daily capital cost (which relates to their overall economies of scale and operational modes) based on a ship’s life that might be 20 years (Cullinane & Khanna, 2000). We believe that Mearsk look to accrue profits early based on their larger boats’ economies of scale even as higher fuel prices kick-in as ‘peak-oil’ issues begin to dominate.

We noted in Table 1 that ‘transport’ uses much of the global oil supply (61%), and some of its gas. Of the oil use 85% is consumed by land transportation with road [passenger] transport using 60 – 70% of this figure in relatively inefficient vehicles: though a modern mid-size diesel car will deliver passengers across the UK more economically than short-haul aircraft (UK Ultraspeed, 2005). Air transport takes up a further 8% of total oil use; and maritime transport also using oil carries about 90% of cross-border trade using about 7% of the total oil. Users of refined oil pollute at different rates with maritime transport polluting most heavily and indeed mortally, as it uses very dense bunker fuel only slightly cleaned by refineries, and few ships carry on-board pollution traps (Corbett et al, 2007). Yet shipping as a transport mode is efficient – it is estimated that a towed inland waterway barge [note – canal traffic has no waves or tides to plough through] while using 3.785 litre (1 gallon) of fuel can move one ton of cargo 875 kilometres; or by rail only 337 kilometres; and worst of all, road transport would only travel 98 kilometres (Rodrigue et al, 2009).

At the present time most of the inter-continental and cross-border freight (mineral, oil and gas bulks, as well as higher unit value container freight) is carried by deep- and short-sea shipping, though air traffic carries freight it is of low total weight, but high in relative pollution. Road transport also plays a part in the overall supply chain system, with rail systems unable to compete for a variety of reasons despite having a low pollution rating per kilometre/tonne. The dominant model is thus of very high capacity maritime shipping moving goods at slow speed and often over very long distances – for instance, from China to Europe and vice versa. Shipping trade estimates are often calculated in tonne-miles, as a way of measuring the volume of trade (or "transportation work ", as it is sometimes referred). In 2008, for example, it is estimated that the industry transported over 7.7 thousand million tonnes of cargo, equivalent to a total volume of world trade by sea of over 32 thousand billion tonne-miles[9]. And with the present price of fuels the transport cost element in the shelf price of goods is ultimately marginal. For example, transport costs account for only 2% of a television shelf price, and only 1.2% of a kilo of coffee. However, this model will radically alter as fuel becomes more expensive and ultimately is unavailable. Well before this time we must create a new model of transport that does not rely on oil as its fuel.

We suggest below that we must move as quickly as possible to an electricity generating system to guard any remaining oil, gas and coal for their chemicals. In parallel, we must invest in a truly disruptive transport mode unlike any seen before – that is very fast and uses electricity for its motive power. It would carry both passengers and freight at very high speeds (so have the capacity to transport high volumes on few tracks), and it would operate intercontinentally to substitute for maritime and air freight (before oil production fails). This alternative model postulates moving goods at very high speeds per unit of carriage in order to maintain the required volumes of trade and the new system must be land based to avoid any requirement for shipping: only maglev systems match this requirement.

Maglev is often discussed as a high speed passenger system; its freight capabilities are not discussed - but there is no reason to confine it to one mode only. The maglev systems have a motive-power platform above which people sit. If these platforms were redesigned slightly they could easily accommodate aircraft style containers. Or if more radically redesigned they could transport anything that can be containerised – the usual dry goods, bulks, or even liquids: they may possibly be converted to carry standard TEU or FEU containers.

In this proposal we disruptively redesign all transport systems to permit maglev as the only long-distance transport (no air or shipping routes). Maglev will serve exchange points where goods or people will transfer to national electric traction systems (ie the traditional electric railways re-organised now for journeys of only a few hundred kilometres) and some national rail track will have to be constructed or be electrified if not already wired. Finally, for only the traditional “last mile” delivery, we would use bio-diesel trucks for freight, or battery cars for people. The beginning of the supply chain would operate in the same manner – trucks (or battery cars) over a short distance, then electric rail, and then maglev for all the longer trips greater than, say, 500 kilometres. Figure 3 illustrates this system.

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[9] http://www.marisec.org/shippingfacts/worldtrade/volume-world-trade-sea.php

Maglev has been described as ‘disruptive’ only in so far as it will not travel along traditional railway tracks, or vice versa. But as a system it is no more ‘disruptive’ than the introduction of aircraft to surface transportation systems: people have to use a ‘port’ to transfer from one mode to another just as they do in railway stations to a train, a ship, or an airplane. Maglev adds one new choice to a multi-modal exchange point.

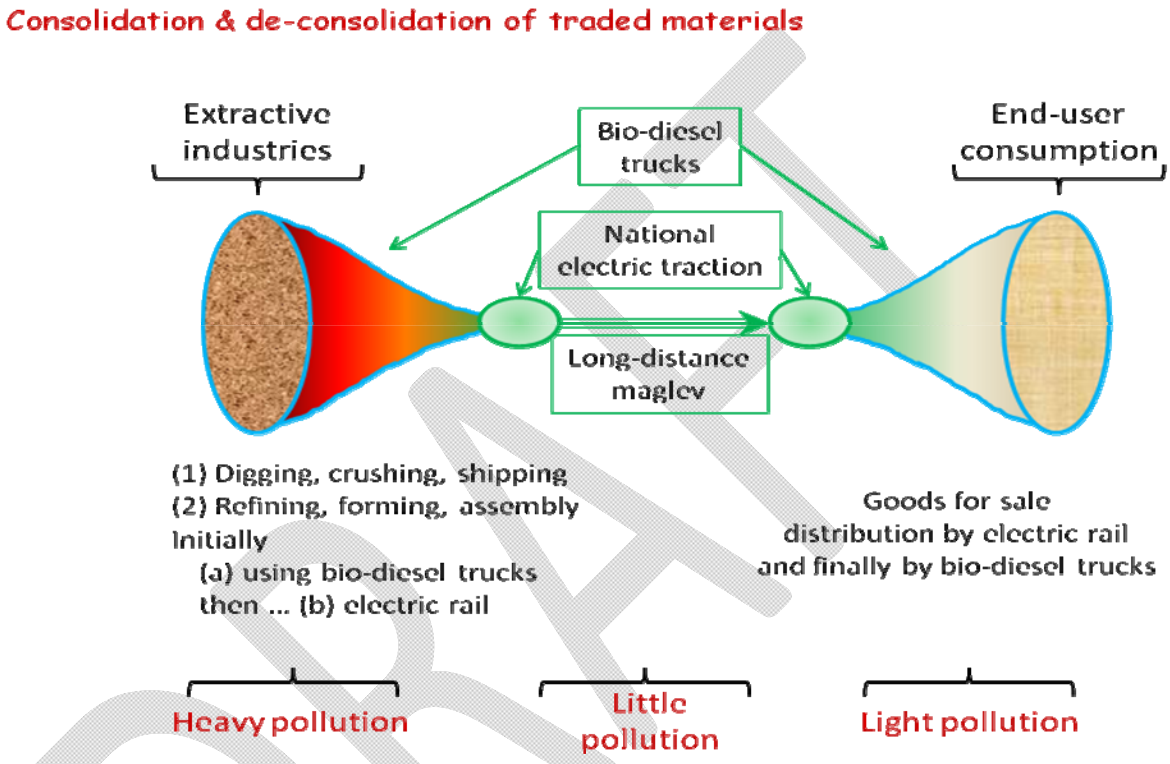

Figure 3: The transport modes for resources extraction and for distribution of goods.

Although ‘pollution’ is mentioned in Figure 3 it will be of little concern as the mass use of oil as the main transport fuel will have been removed. Electrical power will be substituted for all journeys other than the ‘first/last mile’. For the beginning and end of the supply chain bio-diesel will be used which is environmentally neutral (and we could probably make enough to meet our needs – but not if we wished to continue all our present transportation modes). The electricity would have been generated through renewable sources and distributed on high-voltage direct current (HVDC) grids as described below and highly polluting coal will not have to be used. It will be imperative that the new routes of the HVDC electricity grids align with the routes of the maglev so as to provide easy access for the electrical power required by maglev.

In fact, maglev will use far more electricity than standard electric rail, though less than the present high speed rail ie TGV (UK Ultraspeed, 2005): this ‘fuel’ cost at the present time makes it expensive to run, but not prohibitively so. But when oil prices increase vastly, or are non-existent, and with ‘free’ renewable electrical power widely available that cost factor become redundant. Maglev’s high speed is required to deliver the goods and people in order to maintain high track capacity without multiplying the number of required tracks (Kidd & Stumm, 2009). As well described by Lever (1999), maglev can work in ‘pipe-line mode’ where individual units, even whole trains, may travel closely coupled, with little gap between each unit/train. Standard ‘wheels on rails’ traction suffers from low adhesion on the rail track so must maintain a very long distance between trains to avert disaster if the train in front stops abruptly. For maglev all units are propelled by the same electro-magnetic wave, so if one stops all stop – they do not skid as they have a contactless connection between track and transport vehicle. And the same argument applies for accelerating maglev – no skidding occurs under any track condition (wet, snow…). The contactless contact and the absence of any moving or rotating parts in maglev ensures very low operational cost; and with no wheels on the track their noise of passage is quite low – almost zero at 80 km/hr and much less than TGV at 300 km/hr (when it is only air displacement noise that affects maglev, having no wheels or pantographs). As maglev is designed to travel at 500+km/hr it can be canted up to 15º or more on curves so will maintain high speeds along winding routes obviating the need for many tunnels or bridges which, with its ability to climb/descend ± 12% slopes, allows very easy route planning across all terrains compared with TGV that require very wide turning arcs and less than ± 5% gradients (Harding et al, 1999). In towns maglev is able to follow the built environment - elevated along road or rivers - and do this silently while maintain faster speeds than local metro systems. All in all maglev is a superior transport system which has not been deployed because of its novelty – no group wishes to be at the “bleeding edge of technological implementation” as undoubtedly some aspects will have to be redesigned ‘on the fly’ in the first systems that are deployed. Further, as Takahashi et al (2006) say, the bidding process for high speed rail systems (HSRS) is biased in favour of conventional systems as the maglev proposals are usually ‘forced’ to be deployed in the same way as HSRS: same gradients, curves, routes – so cannot capitalise on any of the intrinsically strong advantages of maglev, including cost. Maglev costs about 30 € million per kilometre to construct in comparison to about 36 € million for TGV[10] in part because maglev is an elevated system able to be factory built and field-assembled.

The only reason for rejecting a maglev proposal is that maglev is new (thus thought disruptive); and because it is novel it suffers from decision makers’ procrastination. However, it remains the only viable ground transport system for the future that is able to carry high volumes of both passengers and freight at high speeds using a mixed operational mode on few tracks powered only by electricity.

b) The electrical grid

This paper advocates the deployment of the efficient long-distance high voltage direct voltage (HVDC) transmission systems to serve our future needs. That is, for the replacement of legacy alternating current systems (HVAC) that are the predominant US, European and other nations’ systems. Efficiency of DC transmission (ie reduced transmission losses over long distances) is one major criterion for electricity derived from concentrated solar power sources in deserts; the second consideration is the ease of DC supply switching from regions of light demand to those of heavy demand; a third criteria is that HVDC systems are lower in total system cost than an equivalent AC system (lines, transformers plus switch gear) over the proposed long transmission routes. HVDC is simply much more efficient and effective than HVAC. Of course, for local power the DC will be converted to AC and users will see no difference at all.

In April 2006 H.R.H. Prince El Hassan Bin Talal, President of the Club of Rome addressing the World Energy Dialogue said

> “The sun-belt and the technology belt can become very powerful when they begin to understand themselves as a community: a community of energy, water and climate security; a community for their common future.”

This hope is echoed in a report by the German Aerospace Centre (DLR) wherein they evaluate the scope for a pan-European electricity grid that incorporates concentrated solar power (csp) from the deserts of North Africa (DLR, 2006). Some of the demand assumptions of DLR have been criticised by Possoz & Jeanmart (2007) but without criticising the need to build a European DC grid as soon as possible: they only question the final demand/supply balance. The EU has noted that a pan-European market place for electricity needs to be initiated, and that would incorporate not just the traditional

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[10] Train à Grande Vitesse – in France: this acronym is used often to describe other nations’ high speed passenger systems. TGV are usually designed to travel at 300 – 400km/hr whereas maglev operates at 500+ km/hr.

renewable power sources (wind, hydro, geo-thermal, solar thermal and solar voltaic) but also the concentrated solar power that would be best found in the desert regions of North Africa (EU, 2011). Indeed a group to exploit this aspect has been set up – EUMENA (European Union, Mediterranean, and North Africa) - under the aegis of Desertec[11]. It is somewhat clear that the new HCDC grid must allow north/south interchanges of power so as to be able to switch northern power from wind, wave or river to the south after sunset when the stored heat from the csp falters late in the night; or vice versa in the daytime. Also we must allow easy east/west interchanges to allow brightly lit [daylight] areas to provide electrical power to the more eastern lands that will be entering their evening and suffering reduced solar power generation; and equally, be able to offer power to the more western regions who will still be in their dawn but experiencing rising power demand as people make ready for work.

A further aspect, little discussed by electrical distributers at present, is their need to boost local supplies to meet an increased domestic consumption when electric battery cars are more widely used. Any purchaser of a battery car knows that they may plug it into their home domestic supply to re-charge, but that will take many hours at the usual limit of a 15 amps supply. Heavy cabling must be installed to allow a higher charge rate and thus reduce the incapacitated hours of the vehicle. If many people demand these cables in a town or village in a rural area the implication is that the district power supply will be insufficient. As it stands at present, distributors have incrementally increased capacity, perhaps by re-cabling, or usually by installing higher capacity step-down transformers (from their local higher voltage grids to the district cabling) but they have not really increased their overall capacity to meet a rapid growth in demand. All they have coped with is our slowly increasing use of electrical domestic appliances: electrical cars imply a fast and heavy growth in demand. Some discussion has been observed about the use of a car's batteries as a form of supply back to the grid in times of heavy regional need. However, few expect battery cars users will comply with this request unless the pay-back is large, as their perceived inconvenience cost of owning an immobile discharged car when faced with their own immediate needs of going to work or delivering children to school is likely to override any sensible level of payback. Ironically, the greater use of economical' LED lighting might not reduce aggregate demand by much. Tsao et al (2010) suggest that while solid-state lighting (SSL) is remarkably efficient there may not be an overall reduction of electrical demand as people perceive their power consumption as 'cheap' and illuminate areas hitherto left dark…

> … a principal conclusion is that there is a massive potential for growth in the consumption of light if new lighting technologies are developed with higher luminous efficacies and lower cost of light. A secondary conclusion is that this increased consumption of light has the potential to increase both human productivity and the consumption of energy associated with that productivity. These conclusions suggest a subtle but important shift in how one views the baseline consequence of the increased energy efficiency associated with SSL. The consequence is not a simple 'engineering' decrease in energy consumption with consumption of light fixed, but rather an increase in human productivity and quality of life due to an increase in consumption of light (Tsao et al, 2010:15).

The concept of csp is taken further by the Global Energy Network Institute (GENI)[12] who agree with Desertec, noting that as there are so many deserts around the globe their local csp could supply 90% of the global population via relatively few 3000 km HVDC cables. In this sense we might be able to envisage a global electricity trading system bringing electrical modernity to many poor people as their required power could be tapped from these new main-line cable grids.

This is not to say that we can forget the plight of the globe's poor at the present time. Much can be done for these people given good will, education, and the application of simple science. Sachs (2008:238) describes how simple changes to rural agriculture projects such as applying [small] quantities of fertilizer and importantly using drip-feed irrigation has vastly increased grain yields thereby bringing hope for these people. Across India, Asia and Africa the *Barefoot College*[13] provides the initial education and training for rural communities to create solar powered food-heating systems (so they do not have to forage for dung to heat food, which, when burned inefficiently at low temperatures create carcinogenic fumes). And also, using rechargeable battery systems, their newly

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[11] See http://www.desertec.org/.

[12] see http://www.geni.org/

[13] See http://www.barefootcollege.org

built photo-voltaic systems provide enough power to light lamps, run computers and allow Internet connections. They can thus help themselves to be better educated. However, while there are many poor, it is the mass of urban people who will need the support of the new HVDC electricity grid and the new maglev transportation system. It is the urban population using the new sustainable electricity supply that will provide the manufacturing capacity for development that would flounder when the oil and gas runs out, not the almost self reliant rural poor.

This is not to say we ought to charge ahead always striving for greater global GDP, or growth at any cost. But we in the developed nations have achieved a life-style that we would be reluctant to relinquish – we are selfish, and we know no other style: and those in the developing nations aspire to join this [wealthy] life-style. In this way global GDP will rise and as economists concur, there will be convergence between the ‘haves and have nots’. Therefore, for some considerable time, producers will search for low-cost regions to assemble goods (as they do at present), and most likely the mega-cities of Asia will offer the mass of hands to be assemblers. This implies that Asia will continue to be the global assembly region for the rest of the world - as at present, where China excels at this task since it possesses a mass of cheap labour. However, demographers’ note that China has about one generation left of this numerical superiority, thereafter its work-force labour will rapidly diminish as its one-child policy comes to fruition and then India could dominate the production arena (Economist, 2011a). One must therefore carefully consider the layout of the global HVDC grid, as well as the future transport grids, as we will need to shift part-finished goods to assemblers and finished goods to market under a no-oil global transport regime.

Estimates of infrastructure costs

It is comparatively easy to create ball-park estimates of the costs of the global electricity grid and the global maglev system.

The EU has suggested a cost for the re-development of its electricity grid as being perhaps 200 € billion, and may be up to 1 € trillion[14] over the next decade when considering the total cost of energy distribution restructuring (EU, 2011:11). We noted above that the domestic electricity supply needs to be greatly boosted to accommodate both battery cars as well as to support the potential for more power demand due to increased lighting and other electrical requirements. We note that the UK has already spent 5 € billion on its wind farms, so perhaps the EU total of 1 € trillion might be inclusive of all the present and future renewable systems that will be connected to the new grid. Therefore, to aggregate cost globally - let us accept 1 € trillion for Europe, and then simply multiply that figure over the other large land masses – north America, central and southern America, east Asia, Australia and south-east Asia, India and its close nations, and Russia – in total, 7 masses. We suggest the global electricity grid, its cables, transformers, and associated inputs of solar power and other renewable sources would cost about 7 € trillion.

The maglev costs are also simple to estimate. A twin track maglev from China to Europe could deliver far more containers per day than presently shipped if it runs in pipe-line mode at 500 km/hr; and we might thus consider that it could run more slowly (so conserving power) even though it would have also to carry passenger load. Nevertheless a twin track over 10,000 kilometres would cost 300 € billion (at ~30 € million/km, based on UK Ultraspeed 2005 figures). A China to middle-America twin-track would cost about the same – perhaps slightly more, as it is about 2000km further and will have to run via a 60 km tunnel under the Bering Straits. If we suggest all land masses ought to carry *two* twin-tracks (roughly towards each side of each nation) we estimate across the above seven land masses – a total cost of 4.5 € trillion. In addition ‘rolling’ stock would be needed, so raising total costs to 8 € trillion may be appropriate.

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[14] There is some doubt about the expression of ‘trillion’. Let us define million as 10^6; billion as 10^9; and trillion as 10^{12}. This in accord with the scientific community notation: see Wiki at http://www.jimloy.com/math/billion.htm

We are not sure of the EU definition of trillion, but the non-scientific trillion would be 10^{18} which would be a huge cost.

Even if the total solution (the global electricity grid, and maglev tracks + vehicles) each cost 10 € trillion, that money would be committed over several years. It does not represent a vast amount of cash from any single nation. It would be affordable to save our planet and ourselves.

Many would express doubt about the high costs of these two programs – initially for new pan-Continental electricity grids, and for global maglev systems initiated first as a China-Europe venture (presently the largest global trading partners). However, there are several examples of nations spending on tasks we might not have wished them to do. For instance, Stiglitz and Bilmes (2008) suggested that the second Iraq war may have cost the US some US$ 3 trillion which increased the cost of oil globally, and affected many other imponderables. Of course, it is not easy to 'not go to war', and some of the projected costs of Stiglitz and Bilmes are opportunity costs, and we may also argue about the discount rates used by the authors. But whatever we may say, the cost of this war is truly high. In a similar vein, addressing imponderables, Steve Killelea, Chairman of Integrated Research, Australia, presented surprising evidence to the January meeting of Horasis on the cost of global conflict. He said, for the period 2006 - 2009 the total [positive] economic impact of the cessation of violence could have been US$ 28.2 trillion (20 € trillion) … an estimate supported by both the Institute for Economics and Peace, and Economists for Peace & Security (Horasis, 2011). Simply put, violence alone wasted about US$ 7 trillion (5 € trillion). Thus the stark reality is that we globally waste a great deal of cash through conflict that could be put to a superior purpose as peace creates a better business and social environment. It would behove us to consider our future in the light of oil and gas supply failure; and what might we do now, jointly and globally, to avert disaster.

Discussion

Sociometrics

Individually we are all different – across the globe we are visibly different, we have achieved varying states of education to realise our potential (though many millions have little education, and work with only their innate knowledge), and we all have different attitudes to our organisational and social milieu. Hofstede (1980, 1991) characterised many nations of the world under five aspects – whether we tolerate uncertainty, are individualistic, work happily in hierarchies, are tender, or have a long-term view. In developing our global projects we accept there are large sociometric differences between people of the nations along the routes of the proposed electrical grid and maglev, as well as between the actors who might cooperate in building this infrastructure and those who would use it. Hofstede says individual differences create organisational chaos if not managed transparently – and this poses problems when groups of people have their own natural kinship groups, such as the Russians (with *blat*) and the Chinese (with *guanxi*). It is difficult for outsiders to become members of these circles, and in the project management of the scale we envisage here there is no room for understandable but negative bickering (Michailova & Worm, 2003).

In a similar vein, if we consider only leadership – an important trait everywhere – we find again consistent global differences. House et al (2004) write on the results of a world-spanning research project that indicates, importantly for this paper, that our 'simple purpose' of initiating a twin-pronged solution for global survival will be hampered by the many leadership issues found across the globe; Silverthorne (2005) also supports this finding. For instance, Japanese managers at their European headquarters were confused when attempting to guide individual managers of their European subsidiaries (Kidd, 1992). His findings were supported by the research of Calori & de Woot (1994) and Brodbeck (2000) who found distinct differences in European managerial styles and attitudes north/south, east/west. This portends grave future problems in getting this paper's projects underway even within the borders of EUMENA; and further, it allows procrastination to play its negative part.

There is also no room for corrupt practices. These too vary across the globe (TI, 2010) with some nations remaining 'squeaky clean' over many years if not decades, and others seem naturally corrupt. Transparency International quotes "… corruption has increased over the last three years - say six out of 10 people around the world"[15]. Of course trust and corruption and their interrelations are difficult

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[15] http://www.transparency.org/policy_research/surveys_indices/gcb/2010

to manage and they are a serious moral hazard for businesses in Central Asia - more so than China - since the degree of trust within the people of Central Asia is much lower than in China. In the latter country, there is institutionalized trust within the form of *guanxi* that has been internalized by the Chinese people since the time of Confucius. Li & Wu (2007) suggest that in countries where there is a low level of trust corruption becomes a severe economic burden, akin to robbery. But in countries where both the briber and the corrupt official can trust each other (!) it is not in either of their interests to be a whistle-blower, so corruption volumes will be high as the process is almost risk free. We might suggest that as the entrepreneur is naturally opportunistic he or she might think of bribing their way out of any difficulty, and as officials are often low-paid and thus rent-seeking they are quite inclined to accept bribes in many countries, not just in Asia. In these circumstances it becomes difficult for the international project teams and the eventual global operators of the 'grid' and maglev system to trust deeply the others on whom they must rely.

Returning once more to the potential for sunlight on deserts to supply electricity to centres of population some distance away, and in particular the Sahara desert as it relates to EUMENA: we must consider the present political unrest in the North African nations. In January Amre M Moussa, Secretary General of the League of Arab States, presented a keynote address as well as fielding several questions on the [then] very topical news of unrest in Tunisia, Lebanon, Egypt and the Yemen. Overall he was optimistic about all the 22 Arab nations, "… come back to this question in 5 years" he suggested, "… we will have seen many changes" (Horasis, 2011). In fact, as fighting died down, emergent representatives of some of these Arab nations suggested there would soon be more scope for commercial ventures in their newly democratised nations. Therefore, it is with hope, we look to the further development of the Desertec model which will bring many benefits to the nations generating electricity. We would hope this might become a global exemplar.

'Trust' has been stated to be at the heart of all our endeavours. Möllering (2006) considers that trust has a basis in reason, in routine, and in reflexivity - these are the processes we may pass though in evaluating our circumstances vis a vis another. However, in the case of this paper and its twin goals – to implement a global electricity grid and in parallel to implement a global maglev transportation system – we must invoke the fourth stage suggested by Möllering. That is, "to take a leap of faith" as we will have procrastinated enough, and circumstances will press us so hard that we must jump to find how to guard ourselves against a global catastrophe. There are no exemplars to call upon, no incremental developments to build up from – we simply must install what is possible, and do it world-wide believing it will work.

Conclusions

We said earlier that this paper was about being pragmatic. And it is for all of us -

> … thus the central challenge we face today is to ensure that globalization becomes a positive force for all the world's people, instead of leaving billions of them behind in squalor. Inclusive globalization must be built on the great enabling force of the market, but market forces alone will not achieve it. It requires a broader effort to create a shared future, based upon our common humanity in all its diversity (Annan, 2000:6).

To achieve these goals - to lift people out of poverty, lifting also those people in the developing nations, and to maintain those in the developed world - requires that we secure our energy and transport security globally using methods not yet widely deployed but which are practical and which presently exist as fully operational solutions. This paper has described the two ventures to capture renewable energy and to use its electricity for our transport needs.

The conclusions are stark. We have all become dependent on oil and gas as fuels and as feed-stocks for a wide variety of essential goods, and soon we will have no further supplies. The many regulations and voluntary changes that mitigate global climate change by reducing pollution also reduce our consumption of oil and gas – but it is a goal slightly misplaced. It is a goal that will only delay the real problem – of having no oil or gas.

This paper states that we must install a global electricity grid (supported by renewable sources) of sufficient capacity to drive our existing industrial, commercial and domestic processes. In parallel we must create a new global ground transport system that does not depend on oil as a fuel: only maglev systems will do this transportation task as they have sufficient capacity to deliver both people and goods, and would be propelled by electrical power.

If we do not ensure our future capacity to mine, deliver and transform our raw materials; and further, to deliver goods to the people of the globe most of us will die soon after the oil supply fails. Achieving the two simple goals of a sustainable electricity supply and a sustainable ground transport system will give us time to develop the inventions which people say at present will 'save the world'. At present however we do not have the time to wait for laboratory experiments to come to fruition as our oil and gas supplies are very limited and they will not last long. Some say 20 years at the most, and during this time the cost of oil and gas will rise rapidly thereby promoting ever more research into alternative fuel sources. Unfortunately, even in those future times of dire need (as in wartime when Health and Safety rules are broken), we will not then have enough time left to develop sufficient new capacity as much would still languish in laboratory experimentation. We are not concerned herein with 'climate change' but survival. Yet, though moving to an electrical world it would, at a stroke, remove most of the greenhouse gas production and thus the global concerns about climate change. If however, we continue "business as usual", we will run out of oil and gas and most of us will die. Ironically, that would be our final affirmative action against pollution emissions and climate change.

Our choice is simple: procrastinate for longer and die, or invest very heavily on a global scale on the two globally-scoped projects discussed here – an electricity grid and a maglev transportation system – to give us the productive capacity and the transport facilities to continue into the future.

End note

One of the major factors that will affect the outcomes facing us globally is involved with politics: in fact we need to change from the old-style divisive politics of us/them, east/west, elites/proletariats. Now, in the spring of 2011, we seem to be on the cusp of a new change. Over many years we have seen 'revolutions' each 20 years or so: there was the financial collapse in 1929 followed by the great depression of 1930; a surge of social welfare policies in 1950; the aftermath of the Vietnam war, the rise of feminism and black power, student revolts and other civil unrest by 1970; the migration of manufacturing to developing nations, the widespread fall of communist states and break-up of the Soviet Union by 1990; and now in 2010 there is the demand for democracy and not just within the Arabic world - there is more than a hint of this demand in all nations with long-standing dictators, despotic monarchies, or oppressive presidencies. It is the Arabic nations of North Africa and the Middle East that are achieving wide media coverage; and some states like Egypt are moving rapidly towards 'normality' with the promise of open elections and rule-by-the-people: a regime that is called for in the other nascent revolutionary regions.

If this change does come about without these emergent democracies rallying against the so-called aid of the UN, US, NATO and the developed nations of the EU, we may have a chance to convince them of the need for cohesive and decisive action as described in this paper – to save the world. This can only occur if all nations pull together recognising that no single nation can stand aside, and all must contribute for our common well-being.

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