Crowd-Pleasing Alternatives?

Danger in Anger Management Strategies

Stimulating economic growth and sustainable global peace are inextricably linked. Entrapment of world leaders caught in the net of their polling data works wonders to push popular measures rather than the balanced choices, the prudent options. Energy deprivation is one cause whose effects are staggering. Energy politics is a reason why a third of the world struggles to survive on about a dollar a day or less than one meal a day. There are no major insurmountable barriers to alleviate this dysfunctional energy dynamics except the ignorance of a few who choose to remain scientifically illiterate. But governments are pawns in their hands! They are skilled rebel rousers and formidable political operators. They are brilliant in massaging public opinion and hence, polling figures, to force the implementation of policies that fuels riots, wars, poverty and hunger but detracts from manufacturing energy.

GEMS: Green Energy Manufacturing System

Carbonomics: Trinity of Elements 6, 92 & 94 may Re-define World Economy

R_x GEMS

GREEN ENERGY MANUFACTURING SYSTEM

Prescription for Sustainable Economic Growth

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Summary

A *Prescription for Survival* [00] is not enough! Nations need a robust prescription for sustainable economic growth. Availability of energy at a competitive price must be a priority. The general ignorance of masses and the politicians who serve them, have made it difficult for the solution, at hand, that is energy from nuclear fission, to be used in alleviating global poverty and hunger. The social limitations of physics in energy generation may find some solace through the advances in biology and that of genomic sciences, in particular. The tools of molecular biology and biotechnology are making it possible to engineer metabolic systems in organisms to optimize pathways that can synthesize short chain carbon molecules as alternative liquid fuels, for example, butanol or pentanol, from biomass waste, especially, ligno-cellulose. Promoting metabolic engineering may retain the liquid fuel (petrol) infrastructure but replace fossil fuel with short chain butanol or pentanol type fuels that can be used even for automobile engines, with minimal changes. There is another equally compelling reason to champion the manufacturing of energy to use low-carbon liquid fuel obtained from metabolic engineering of harmless bacteria. Metabolic engineering catalysed GEMS offer the possibility of ***both*** scalable and portable plants. The benefit of a portable plant as a domestic fuel source is valuable if viewed as a power source for fuel cells and electrolyzers. The latter can replenish hydrogen in storage systems, for example, hydrogen fuel cells in automobiles.

Following in the footsteps of Penicillin (chemically synthesized at MIT in 1930's), this article makes the case for bio-engineered alternatives to non-fossil fuel and proposes an immediate exploration to scale manufacturing processes necessary to extract short chain carbon molecules from designer microorganisms. It may reduce our dependency on petroleum as a key source of energy. Metabolic engineering may become synonymous with prosperity and peace.

Solipsistic Bliss or Bluff?

On 13 January 2009, light, sweet crude was down 91 cents at US$36.68 a barrel [1] in electronic trading on the New York Mercantile Exchange (NYMEX). On 11 April 2006, just 3 years ago, forecasters outlined scenarios [2] that could take oil prices up to a terrifying US$262 a barrel. On 6 June 2008 it reached US$147 per barrel, a cost at which nuclear energy from fission is a better bargain! Oil price increase was unaccompanied by any known catastrophe, reduction in resources or loss in capacity. On 11 October 1990, the then highest recorded price was US$40.42 per barrel. It took more than 13 years to 'peak' again at US$42.33 on 1 June 2004 [3]. Is there a rationale for the volatility [4] that took $40 per barrel in 1990 to $147 per barrel in 2008 and dropped it under $40 in 2009? Compared to the actual cost of production of crude oil by OPEC nations, at about only US$5 per barrel [5], the price of crude violates supply and demand rules. It appears to reflect an orchestration of power play or an exhibition of greed. The sinusoidal fluctuation is not novel and is known to recur (Figure 1). It may reflect a reaction from the OPEC cartel to investment in alternative non-fossil fuel that becomes more attractive with high price of oil [6]. By lowering the price of oil, the cartel stokes the global sense of solipsistic bliss and fuels lethargy to do little but prolong the irrational 'trust' in oil with the bleak hope of a return to the halcyon days. Some predict that oil prices may remain around US$35 per barrel through 2012-2013 before the next wave of increases [7]. The latter may strike another destabilizing blow and inflict bold new punctures in the global economy just as the world begins to emerge from the current economic meltdown.

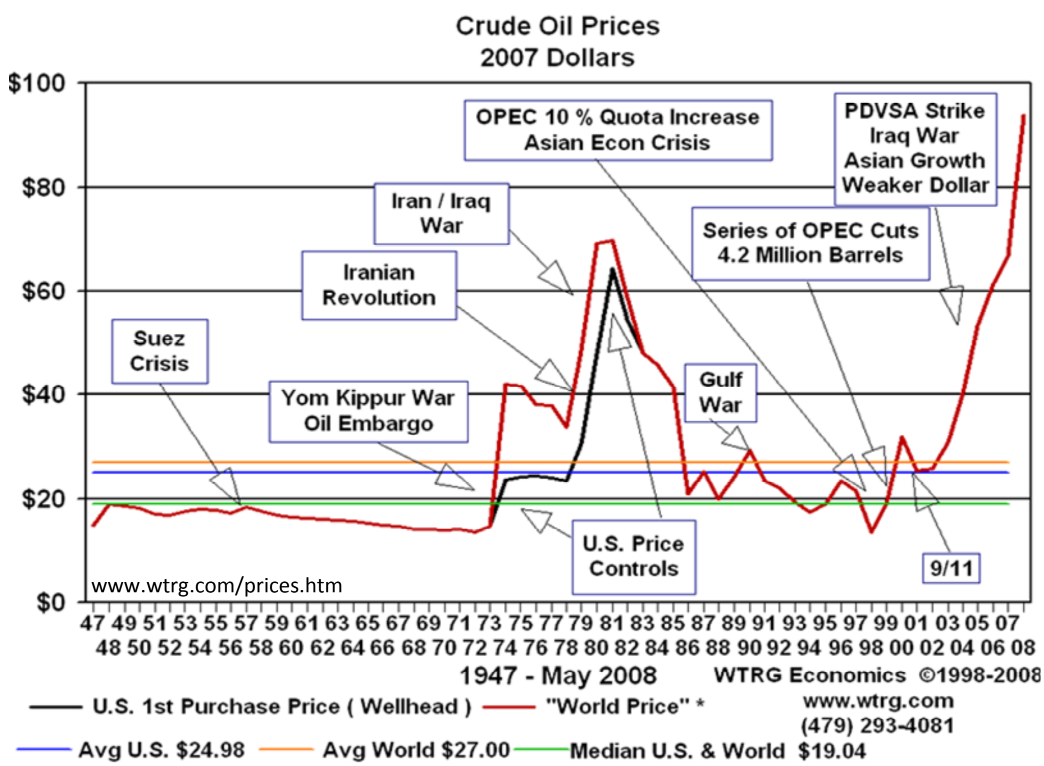


FIGURE 1: PERIODIC (?) VOLATILITY OF OIL PRICE

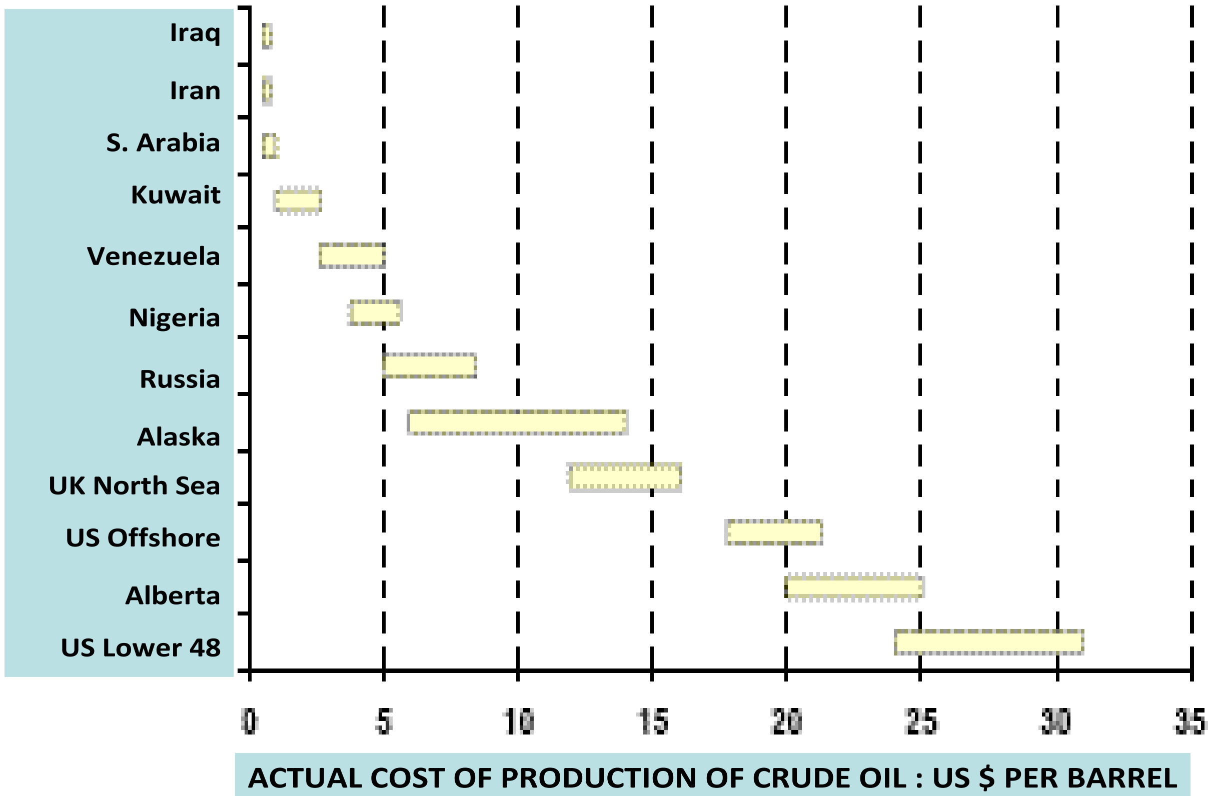


FIGURE 2: COST OF OIL PRODUCTION

FIGURE 3: OPEC REVENUE from OIL EXPORT

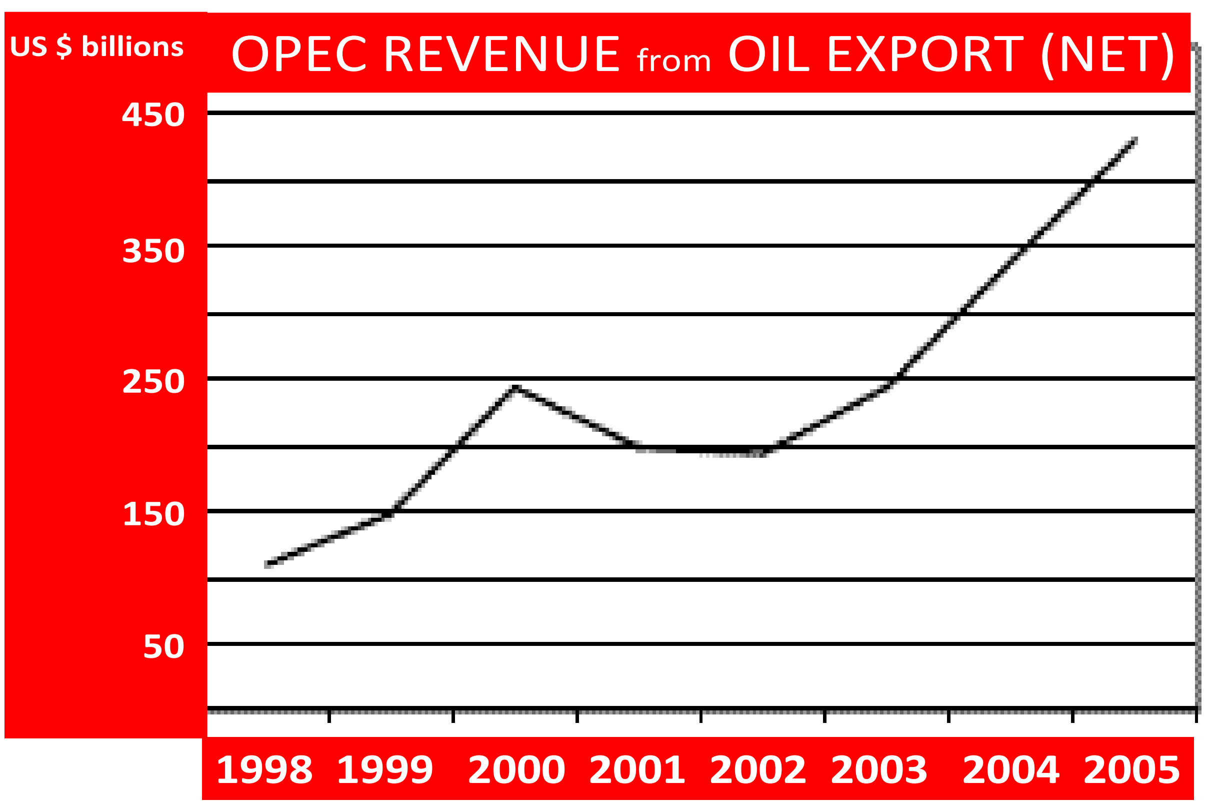
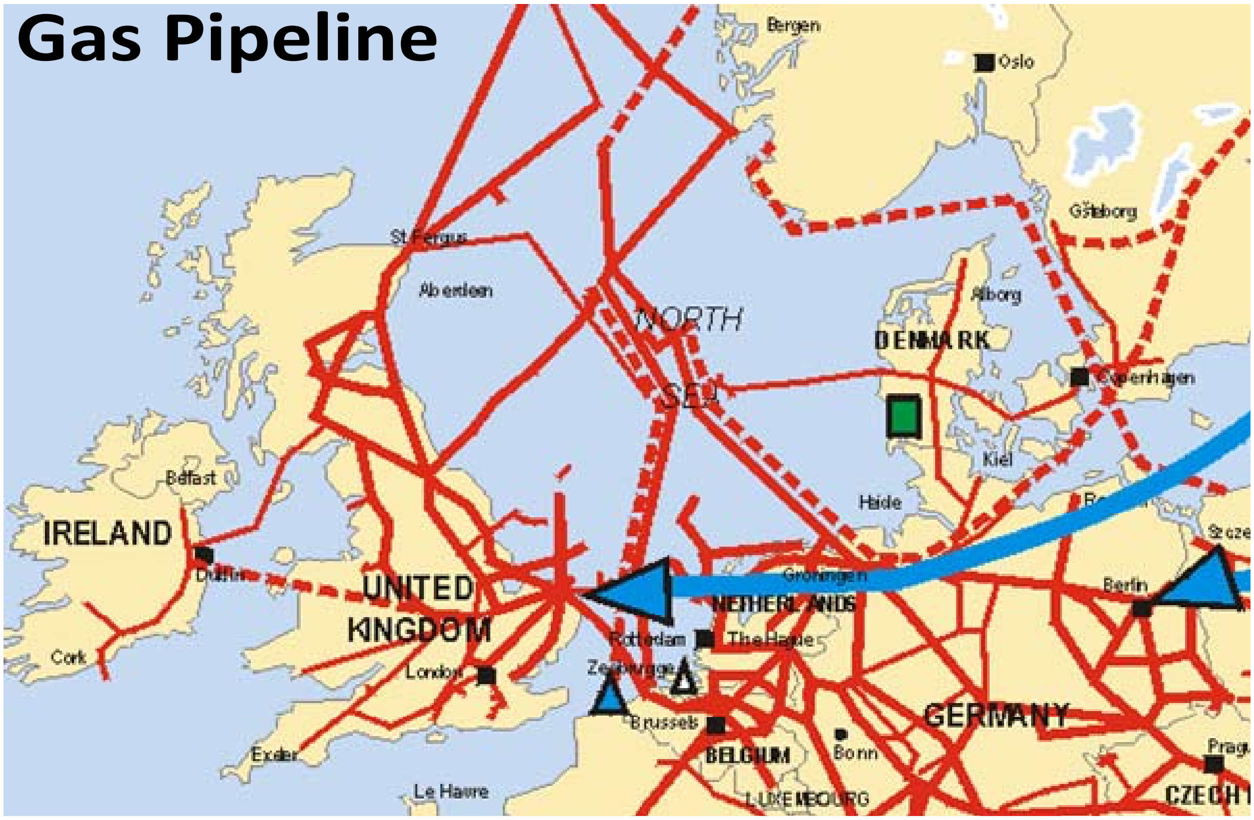
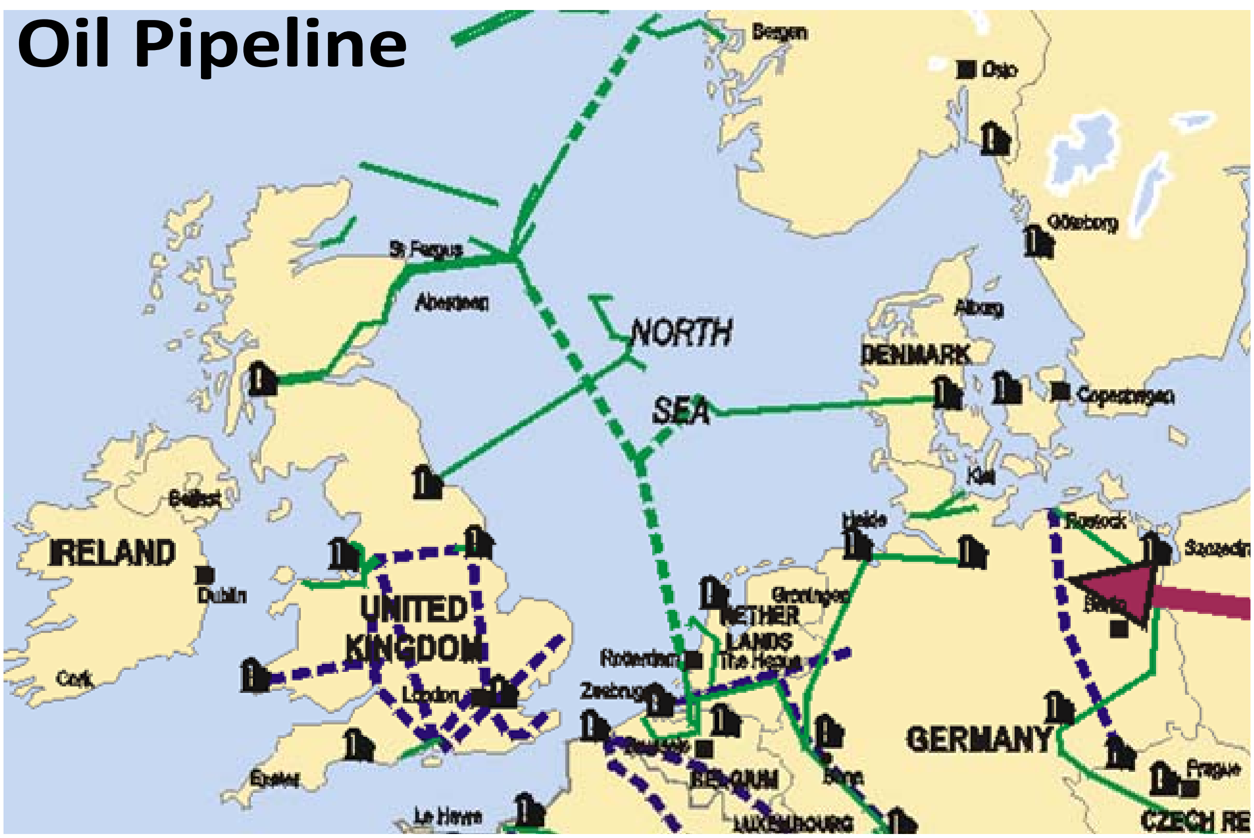


FIGURE 4: Partial Map of GAS PIPELINE **FIGURE 5: Partial Map of OIL PIPELINE**





Economic Recovery and Long Term Sustainable Growth: The Energy Genie

On 20 January 2008, an august Irish academic wrote that “although the 2007 and 2008 budgets have permitted a significant decline in the general government budget balance, the Irish fiscal position is very healthy [8].” The incredible shrinking economy of Ireland (by 4%) with €13 billion in the red in 2008 [9], a banking crisis that could eventually swallow a €40 billion bail-out using tax-payer’s money [10] and a near-collapse of the housing industry (prices plummeting by 15% to 30%) are indicative of the forecasting wisdom of Irish pundits or the lack thereof [11].

This series of unfortunate events has triggered a conservationist *modus operandi* in full swing in Ireland. Education and healthcare budgets are bearing the brunt while the salaries of government employees remain unscathed, thus far. Is a healthy way out of this doom and gloom only a hypothetical possibility? Not quite. To the politically naïve and academically optimistic, at least one path for Ireland’s recovery is still a brilliant beacon of hope. The suggestion is to embrace innovation and help release the energy genie out of the bottle! Not a panacea to cure all ills but availability of energy is catalytic, now, more than ever before. In figure 4 and figure 5, partial maps of EU gas and oil pipelines, respectively, are illustrated. Figure 6 (below) summarizes the energy mix and dependency of Ireland [12].

Key Figures (2004)

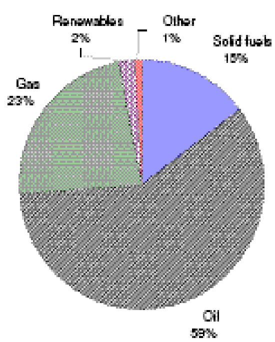
Mtoe	Primary Energy Supply	Domestic Production	Net Imports	Final Energy Consumption	Electricity Generation (TWh)
Solid fuels	2.3	0.9	1.8	0.5	7.7
Oil	9.3		8.8	7.5	3.2
Gas	3.6	0.7	3.0	1.3	12.9
Nuclear					
Electricity			0.1	2.0	
Renewables	0.3	0.3		0.2	1.4
Other	0.1				0.3
Total	**15.7**	**1.9**	**13.7**	**11.5**	**25.6**

The source for all data is the European Commission, unless otherwise stated

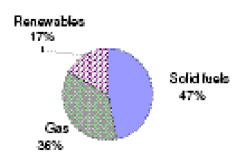
Key Indicators (2004)

	IRELAND	EU-27
Energy per capita (kgoe/cap)	3 870	3 689
Energy intensity (toe/MEUR '00)	122	185
Energy import dependency %	86.5	50.1
CO_2 Emissions (Mt)	43	4 004
CO_2 intensity (tCO_2/toe)	2.7	2.2
CO_2 per capita (kg/cap)	10 589	8 180

2004 Primary Energy Supply



2004 Domestic Production



http://ec.europa.eu/energy/energy_policy/doc/factsheets/mix/mix_ie_en.pdf

FIGURE 6: MIX OF ENERGY AND SOURCES OF ENERGY SUPPLY FOR REPUBLIC OF IRELAND

Renewable Uncertainty

If the sun is shining [13] and if the wind is blowing [14] the additional capacity from renewable energy may be significant in geographies near the equatorial belt or with balmy coast lines. If the problems associated with extracting renewable energy, storage and transportation (grid) were nugatory [15], the countries of Africa with vast deserts, should be quite wealthy nations and net exporters of energy. The arid state of Bihar, India should have a surfeit of renewable solar energy. The crippling poverty in Africa and Bihar are a reminder that forcing a blind eye to the solution of nuclear energy [16] amplifies the morbidity and mortality associated with energy deprivation.

The 'green corporate responsibility' buzz has induced investment from Sun Microsystems co-founder Vinod Khosla of Khosla Ventures and Sapphire Energy in San Diego has raised millions from investors including Bill Gates (Cascade Investments) for algae bio-fuel. Can the next green fuel be the pea-green pond scum? At current production costs upto US$100 per gallon, the answer is largely speculative [17] but metabolic engineering to improve 'lipid triggers' may improve the prospects for algae [18]. It will be remiss not to mention the significant advances in mimicking photosynthesis achieved in the laboratory [19]. Coupled with catalysts, for example, for hydrogen fuel generation [20], the convergence of these developments may spur innovation in the embryonic energy manufacturing industry.

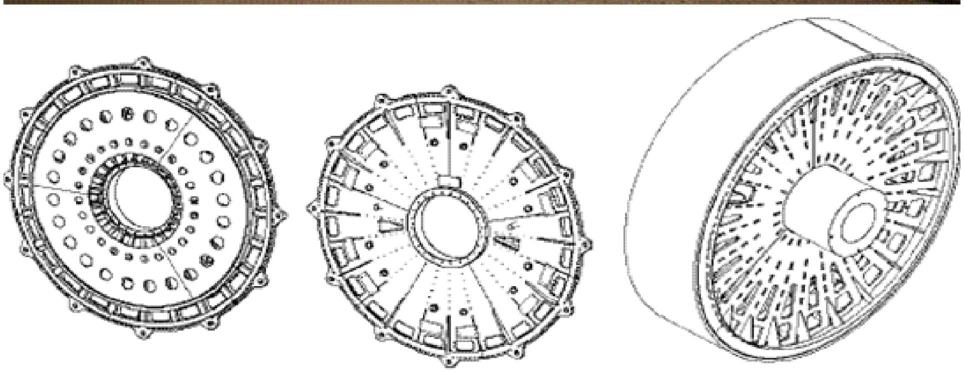


FIGURE 7 (TOP): SOLAR FARM IN SPAIN - Parabolic troughs capture and focus the sun's energy to heat synthetic oil at Acciona's Nevada Solar One. Heated oil will in turn heat water into steam to power a turbine.
FIGURE 7 (BOTTOM): WINDMILL MANUFACTURING - Components manufactured by Rotatek (Finland) for 3.5 MW generator: on the left, two steel shields (diameter 6 metres and weight 9 tons per shield) and on the right, a rotor (diameter 5.25 metres, width 2.5 metres and weight 37 tons). http://www.tukkk.fi/~ohilmola

Manufacturing Energy: Metabolic Engineering of Microorganisms (MEMEM)

The intrinsic biological machinery of the cell produces fatty acids, lipids and natural alcohols, such as ethanol. All carbon containing chains are potential sources of energy. The synthesis of biological molecules specifically for use as fuel, either *in vivo* [21] or through catalytic modifications *in vitro* [22], represents significant opportunities to ***manufacture*** energy. These developments, particularly the *in vivo* engineering of carbon synthesis pathways to render the products (molecules) as efficient sources of fuel, was made possible by developments in molecular biology in the past quarter century and recent advances in genomics. The emergence of metabolic engineering is unleashing the potential to use nature's factories (bacteria) to produce fuel. Credible scientific reviews outline the process [23] and engineered bacteria are increasingly [24] available [25] but still within the academic community. Organisms capable of producing liquid fuel have been tested only in the lab scale. The use of agri-waste (biomass) to feed microorganisms avoids the food-fuel debate (ethanol from sugarcane and corn). The energy that nature captured from sunlight to create cellulose (hemi, ligno) can be hydrolyzed by enzymes inside bacteria, instructed (engineered) to follow a specific system of operation in stages, eventually to produce what we need, liquid fuel that can be extracted from microorganisms (chemical process engineering) in a simple manner that is financially feasible.

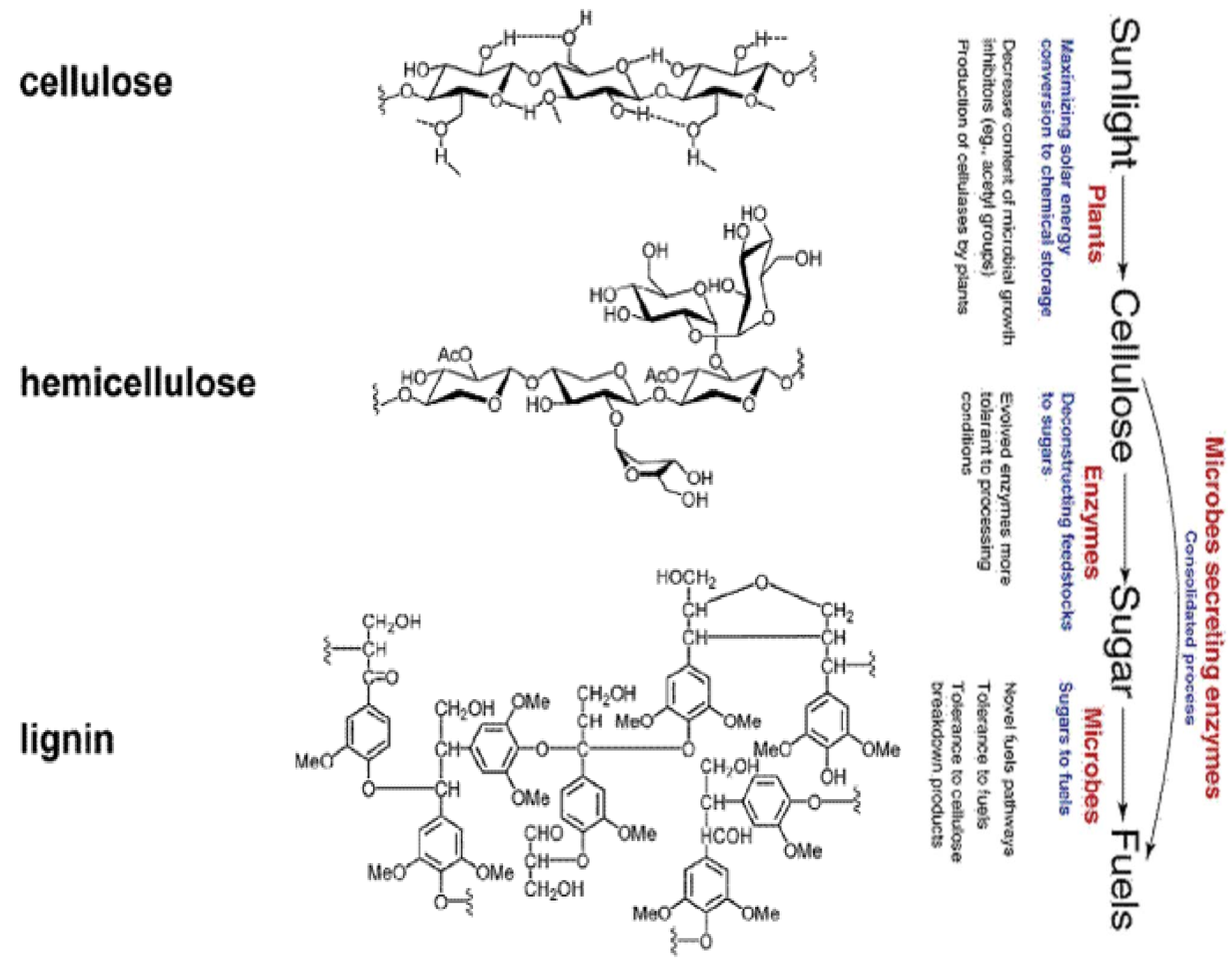


FIGURE 8: THE NEW CURRENCY OF GLOBAL POWER

Scalability: An Opportunity for Innovators in Manufacturing

Nations aspiring to chart new approaches to economic recovery [26] must seek tools that can deliver sustainable growth over the medium term and simultaneously exhibit the ability to take risks and be bold enough to grasp the first-mover advantage, albeit temporary, latent in metabolic engineering to manufacture energy from organisms. The political volatility of traditional oil and gas supplies taken together with the ignorance about the benefits of nuclear energy is a debilitating burden on most nations. Metabolic engineering represents one emerging alternative to partially shed the dependency on foreign oil and gas. The knowledge tools from metabolic engineering can create a new legacy in business services.

Creating the perfect metabolically engineered bacteria or algae to produce commercially useful liquid fuel (butanol, pentanol) may be a worthwhile academic goal but the pragmatism necessary to bolster energy supply in the real world calls for a multi-pronged application-specific research and development. Academic-industry partnerships may explore bio-chemical process engineering optimizations necessary for manufacturing scalability for the alternative liquid fuel products. Lab vs commercial scalability are different dimensions where applied R&D may be required. The ability to scale manufacturing of energy from microorganisms not only leads to commercial production but also represents a service function that may be exemplary of a knowledge economy [27] for global public goods [28].

Conclusion: Invest to Explore Manufacturing Scalability of Metabolic Engineering

From common sense, it stands to reason that an ENERGY PARK approach with complementary R&D endeavours in scalability issues may help migrate the MEMEM lab experience to a commercial dimension in manufacturing energy. Although metabolic engineering has failed to push its ‘green’ credentials or align itself with environmental lobbyists, to the future innovators, leaders and citizens, GEMS shall slowly but clearly reveal that it is pragmatic, productive and green.

The facts quoted here are supported by evidence or references. The interpretation of the facts and opinions expressed here are solely due to the author. Opinions and interpretations do not represent or reflect the views of MIT or the institutions with which the author may be associated.

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CARBONOMICS

Trinity of Elements 6, 92 and 94 may Re-define the World Economy

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Progress of civilization and ethical gains from global productivity are held hostage by Element 6 [1]. To pay the ransom, the existing world order may need re-engineering to sense and respond with a dynamic and agile economic infrastructure that can sustain higher transaction costs [2]. The international currency of growth shall be forced to adapt and adopt an economic standard where operations may be pegged to the cost of unit energy based on an index of about US$100-US$150 per barrel of oil at 2008 rates [3]. This prediction is not about actual cost of crude but based on estimates that energy from nuclear fission and coal with carbon sequestration will be comfortably competitive if oil price approaches US$150 per barrel [4].

The cartel of oil producing nations may be unaware that they may be fueling a designed dis-incentivization strategy to punctuate the pursuit of alternative non-fossil energy sources by aiding price volatility. The inflation of $35 per barrel price of oil in 2004 to nearly $150 per barrel in July 2008 occurred without any key changes in production. The current price (January 2009) under $50 per barrel does not appear to be associated with any major resource reorganization. Coordinated development and deployment of non-fossil energy sources must be a priority for 21st Century world leaders who may need to inculcate the personal discipline necessary to remain oblivious of the Russian roulette of oil prices and platitudes from actors, such as, OPEC.

The obvious answer to the carbon conundrum is US Patent 2,708,656 and has been staring in our face for half a century: nuclear fission [5]. The political positioning of 'nuclear' catalysed by the well orchestrated 'march of unreason' [6] by effective groups of environmental dissidents are forcing rational thinkers with good intentions to generate short lived, poorly designed, crowd pleasing, semi-scientific, *ad hoc* measures [7]. Carbon pricing, carbon calculators, carbon credits, carbon exchanges, carbon policy compliance and environmental risk management [8] are a part of our current vernacular.

These carbon initiatives are gaining momentum. It may serve as a necessary but perhaps a bit wobbly platform for the climate control debate. In the next quarter century, with the rise of a new generation of thinkers and leaders, the potential for demise of carbon regulatory measures are imminent. One reason is embedded in the flawed principle of its construction. It assumes that enforcing a price on carbon will act as a financial incentive to use non-fossil fuels. The logic is weak because carbon taxation primarily impacts the end-user or the average citizen. But, the investment and ability to manufacture and distribute non-fossil energy is concentrated in the hands of a few behemoths and/or governments. The stimulus for the end-user to use green or renewable or non-fossil fuel is blunted by the lack of adequate non-fossil energy supply. Availability of the latter is not controlled by the consumer but carbon pricing may affect the cost of goods and services, which will be passed on to the end customer, in some form or the other.

Hence, carbon pricing may be viewed by some as a deterrent to productivity and may increase transaction cost, if implemented. Having said that, a pragmatist faced with the present state of global quagmire must reluctantly add that the short-term impact of carbon pricing may merit implementation despite the bleak prediction about its long-term value (beyond 2050). Thus, the current call for carbon pricing is a sign of the times [9]. Perhaps 'doing' something is viewed with sympathy by the public even though citizens may not be scientifically literate to understand that tax and price does not address the science of reducing carbon emissions or the root cause producing the effect (i.e. emissions). In fact, carbon pricing may turn the age-old aphorism on its head: go where the pastures are not so green! Carbon pricing in the 21st Century "systems age" may also ring similar to the cliché of running out of iron ore in the middle of the industrial age.

In other words, carbon pricing may produce the unanticipated effect of industries migrating to zones where carbon regulation is not ratified or sloppy in its execution and enforcement. It may be optimistic to anticipate global harmony on carbon pricing and taxation (carbox) schemes [10]. Governments may ignore carbon regulations to attract businesses. Ireland, an EU member state, has successfully resisted EU calls for uniformity in corporate tax. In order to attract and keep big corporations operating and "cooking" their finances in Ireland, the government has held fast to the low 12.5% corporate tax. Recently, the Irish ignited the wrath of some in the EU by ignoring EU's call for constitutional harmony by voting against the adoption of the Lisbon Treaty.

Technically, carbon pricing initiatives shall be plagued with acrimony stemming from ambiguities about models, standards, metrics and data dependencies. Lack of global accord shall segue to an uneven playing field of carbon haves and have nots. But, viewed from the perspective that the glass is half full, legislating carbon pricing may drive home the awareness that climate change affects all and each one of us has a role to play, no matter how small or insignificant. Perhaps, imbued by a genuine sense of camaraderie to reduce carbon emissions or stimulated by an urgency to shake off the economic burden of carbon taxation or to legally defy the validity of carbon legislation, the energy industry may join forces with other industries, academia and government to educate and inform the masses why investment in nuclear fission energy guarantees sustainable return with long term benefits for the economy and the environment. The prudent solution is to immediately ramp up to generate an abundant supply of non-fossil energy from safe nuclear fission, without aggravating the global carbon footprint.

Hence, it may be good news that the US Nuclear Regulatory Commission (USNRC) has registered applications for licenses to build 25 new reactors, since July 2007. The projection that in 2030 nuclear energy shall provide about 10% of the global energy demand may be short sighted [3]. By 2030, China and India's energy demand is expected to be in excess of 4,000 and 1,000 million tones of oil equivalent (MTOE), respectively. The global demand for energy is expected to approach 15,000 MTOE by 2030. It should be met by an abundance of non-fossil energy supply.

The advances in the next few decades should enable reduction of the unit cost of nuclear energy from $150 per barrel oil equivalent, estimated at present. Capital expenses, amortized over time, shall further aid nuclear energy cost reduction and stabilization rather than carbon taxation and the burden of bureaucracy implicit in carbon compliance. It appears that the energy debate is losing its coordinates in the cost versus value argument. The value of non-fossil nuclear energy is far more important that the present or perceived cost. In 1960, DEC produced PDP-1, a desktop computer at $120,000. Today, even Wal-Mart sells super powerful desktop computers and they are priced at $500 or less. In 1956, Ampex pioneered the video recorder market and each VCR unit was priced at $50,000 [11]. If you can find a VCR in 2009 then expect to pay $50 or less. By 2050, the unit cost of clean and safe non-fossil energy from nuclear fission may follow similar trends in addition to competition from emerging energy supply from nuclear fusion plants [12].

The path to global productivity and improvements in standard of living may not be constructed through the tunnel of energy conservation. Availability of energy to fuel progress should be almost a non-issue. An analogy may be found in the cost of computing. It has decreased so much so that applications, irrespective of complexity, may ignore the cost of processing power as an insurmountable transaction cost. The amount of computing power (micro-processors) in a birthday card that sings a tune, when opened, is greater than all the computing power that existed on this earth before 1950. A garden variety chronometer watch bought from a corner convenience store has more computing power than all computers in Silicon Valley before 1975. Can we imagine a world where Nintendo Wii, Sony PSP, Match.com, Facebook, eBay, Amazon and Google users may be required to pay a “computer processing tax” or “MIPS based pricing” for using computing intensive applications? How about an IOU (internet over-user) tax scheme?

Innovation in renewable sources may add to the safety net of grid based electricity powered by nuclear energy. Innovation in hydrogen generation through replication of photosynthesis [13] and hydrogen storage in carbon nanostructure [14] based fuel cell may usher in key changes in the transportation industry [15]. Other forms of entrepreneurial innovation may make it possible for green energy manufacturing systems (GEMS) to produce alternative liquid fuels such as butanol and pentanol, through metabolic genomic engineering of microorganisms [16] feeding on biomass waste, rather than items with food value (corn or sugarcane) as a source of carbon.

Harnessing the power from renewables begs innovation in storage technologies. Wind, wave and solar energy are excellent alternatives as long as the need for affordable storage does not arise. The best batteries, at present, can store only about 300 watt-hours of energy per kilogram (gasoline stores about 13,000 watt-hours per kilogram) and is one of the available solutions for storing solar energy (or any energy) if it is to be used when the sun is not shining. Similarly, the numbers add up poorly if wind energy [13] is used to pump water at an elevation and then (run the water through a turbine to) generate electricity. One kilogram of water raised to 100 metres stores about one kilojoule of energy. One kilogram of gasoline stores 45,000 kilojoules of energy.

If policy and principles are based on scientific evidence, then, one must wonder whether carbon pricing or levying a duty based on emissions can be rationalized as an incentive when non-fossil alternatives are still embryonic in their development or demonized by society (nuclear energy).

But, there is no doubt that 'something' must be done to restrain the unbounded and perhaps irrational growth of the carbon footprint created by human endeavour. Energy conservation through micro-metering and monitoring usage by deploying wireless sensor networks [17] to reduce waste are healthy approaches to limit the carbon footprint. Accumulation of carbon credits by demonstrating the reduction of carbon footprint is certainly a goal worth pursuing, at all times. However, the metrics and data stream necessary to determine carbon savings and assignment of carbon credits are still developing [10]. This quagmire may offer temporary advantages and innovative opportunities for integrating systems that may meter and monitor usage, document reduction in footprint over time and generate online metrics-based real-time analytics. This integrated system may serve as a platform or a standard operating procedure promoted the by climate control organizations [18] or innovators [19]. Entrepreneurs [20] may have the wisdom to grasp these emerging needs and profit from creating analytics (eg: metrics, carbon calculators) and predictive engines [21] that may eventually surface from cloud computing as web services. It may also enable grocery chains to affix carbon footprint numbers to your banana [7], depending on its source, production, transport and distribution, or, in other words, the digital carbon supplychain [20]. If you pay more for a banana imported from Central America, then, the carbon pricing scheme in effect, masquerades the temporary failure of government incentives and leadership to provide global public goods [22], in this case, safe supply of non-fossil energy.

Later in the 21st Century, to provide about 10 billion people in the world an adequate level of energy prosperity, conservatively estimated at a couple of kilowatt-hours per person, the global demand may exceed 60 terawatts or the equivalent of almost a billion barrels of oil per day [23]. The largest hydroelectric power station in China (Three Gorges Dam), when completed at a cost in excess of US$22.5 billion, may generate peak power of 22.5 gigawatts, an order of magnitude more energy than what is currently generated by the Hoover Dam or the largest nuclear reactor in operation [24]. The sheer construction necessary to build enough power plants to meet the domestic energy demand will be staggering even if the US were capable of reducing its energy craving and consume a mere 10% (only 6 terawatts) of the projected global energy demand.

Climate control and carbon pricing may soon become synonymous but will it address the root cause or aid the terawatt challenge? The implication of taxing the key mediums of global productivity (i.e. energy) is similar to the scenario where one hopes that a race horse will win despite the burden of a carrying a heavy load around its neck. Economic hindrances imposed on mediums of growth (i.e. energy), communication (i.e. internet), human capital (i.e., healthcare) and capacity development (i.e., immigration) may only serve to slow the progress of civilization.

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