Communications & Opinions

New energies : The European Estate*

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According to the International Energy Agency (IEA), it is unlikely that the world can meet the expected increase in energy demand of 60% by 2030 while stabilizing GHG emission. Our energy policies are non sustainable within one generation. This is one reason why new, renewable energies became a star sector in our economies since climate change considerations took center stage. As oil prices rise, new investments in clean or low carbon energy spread ($148bn in 2007). There are unprecedented opportunities for transforming the economy from high-carbon and environmentally unfriendly to low carbon and environmentally sustainable producing "green growth" (Sir Nicholas Stern). The potential of such investments is enormous unless oil prices plummet (as in 2008). There has been talk of a "Green New Deal" to get us out of the economic crisis. Lord Stern has put its annual cost at 1-2% of global GDP by 2050, requiring some $45,000bn (or $1,200bn per annum) investments in clean energy. Early, shrewd investors can make huge profits. But irrational investor exuberance for renewable businesses launched on flawed economics faces growing risks, particularly if and when government support is withdrawn.

Climate change puts all businesses and society at cumulative, long-term risk. The failure of agriculture alone would lead to widespread hunger in developing countries and mass migration of people (half a billion according to the UN), mostly to developed countries.calls for more renewables. This begs two questions: a) whether renewables can replace oil and coal energy, and b) which renewables have the best prospects and should be encouraged most.

Regarding the first question, fossil fuels (oil, gas and coal) remain the key energy sources for the foreseeable future. According to the International Energy Agency (IEA) fossil fuel contribution to the world's energy mix will still be overwhelming. Business as usual would require oil production to rise from 87m b/d today to about 116 b/d by 2030. The world will need to invest $360bn a year (which is difficult when oil prices are low) to meet oil demand. Even if all plans for renewables, energy efficiency, savings were implemented the share of fossil fuels would go down only slightly from an expected 82% to 76 % in 2030. While oil production is unlikely to decrease very much, prices will rise.

As to the second question: what are the most desirable new and/or renewable energy sources? There is no single, definitive answer. It all depends on geography, technology, costs, public opinion as well as politics, events, repercussions, and of course cost.[1] If one wants to avoid misjudgments, political blunders and misallocation of resources, no new and/or renewable

[1] It has been calculated that investment costs of off-shore wind farms in the UK is $4,000 per MW are comparable to those of 1MW of nuclear power, or twice those of state-of-the-art coal-fired power stations, and four times those of standard-combined-cycle gas turbine plants. Cost of wind energy, which were supposed to go down, have been rising because of supply-chain shortages.

energy sources should be promoted without first submitting each to a Life Cycle Analysis (LCA).[2]

Let me make two general observations: not all fossil fuels pollute a lot, and not all renewables are green.

First, **not all fossil fuels are strong polluters**. Coal is the dirtiest. Gas is much cleaner then oil, and clean coal technologies exist: US coal-based electricity providers already emit 70% less pollutants per unit of energy than 30 years ago. Work is going on regarding a next-generation clean coal-fired source of power with even less emissions and carbon and storage power plants. "Super-critical" boilers can increase coal's low energy efficiency by 45%. "Carbon-capture and storage" (CCS) power plants can cut emissions from fossil fuel power plants by 90% by liquefying the carbon-dioxide and storing it in salt caverns or depleted oil and gas fields.There are also prospects for carbon underground storage, eventually.

Second general observation: **"Renewable energies may be renewable, but they are not green".** If one submits each of them to proper Life Cycle Analysis, all renewable energies are net producers of CO2 via their production systems. Every form of renewable energy involves vast infrastructure such as concrete, steel and access roads. Their net emission scores are thus much higher than manipulative advertising material and unenlightened public perceptions would seem to indicate. Because renewables don't benefit much from economies of scale, more renewable kilowatts require more and more land as the best land for biomass, hydropower, solar power and wind gets used first.

After analyzing the amount of energy that each renewable source can produce in terms of Watts of power output per square meter of land disturbed, Jesse Ausubel of the Rockefeller University, New York, who made these calculations, asserts that **nuclear energy**, followed by gas are "the best options to minimize new structures and the rape of nature". The full footprint of uranium mining involves relatively little land, and the dense heart of the atom has the smallest footprint of any energy source in nature. It has been calculated that if one wants to obtain the same amount of energy/electricity that a 1000 Megawatt nuclear power plant can produce, one would need: 2500 square kilometers of prime agricultural land producing biomass, 770 square kilometers with wind farms, and 150 square kilometers of photovoltaic solar cells plus land for storage and retrieval. In other words, a 1.5GW nuclear plant would need 10 hectares as against 18,700 hectares for an equivalent amount of wind energy. These figures must let us reflect in a world in which human habitats, agriculture, transportation and ecosystems compete for land. The limitations of alternative energy sources explain why we experience an atomic revival. One can indeed expect nuclear energy demand to outrun supply for decades. There are of course problems also with nuclear power, which are as yet unsolved: radioactive waste storage, safety and security. Public opposition remains strong, new installations difficult to place, and "geological disposal" of waste encased in tough materials unresolved. Nor is there agreement on the real costs of nuclear energy. To keep costs down and provide economies of scale, nuclear reactors will have to be standardized. But nuclear energy is not renewable.

[2] LCA calculates all direct and indirect inputs and outputs (including waste), and costs on the basis of (ISO 14040-43) international standards. Admittedly, LCA analysis is nothing more than an instrument and can provide widely different conclusions regarding emission and energy consumption. Much depends on location, timing and technological change.

Currently it is claimed that the cleanest renewable energy source, with the lowest emissions, is **hydroelectricity**, which accounts for barely 2.2% of energy capacity. But dams cause destruction of habitats, deterioration of water quality, delta erosion; and dams in tropical areas cause a number of water related illnesses and can produce so much methane that there emissions are comparable to those of natural gas power stations. Other potential clean energy sources are hydrogen and wave and tidal power. But, none of them are commercially feasible as yet.

Two alternative renewable sources, currently very fashionable are solar and wind energy. The latter two have grown over the last quarter of a century by 41% and 28% per year, respectively (from a low level), but still represent, no more than 0.1% of energy capacity. Solar and wind energy suffer from intermittence and lack of energy storage capacity. Unlike solar, wind has the additional disadvantage of generating most of its energy at night, when demand is lowest. As energy networks cannot accept more than one third of power from intermittent sources solar or wind energy cannot produce much more than 8% of their power (1/4x1/3).[3] Both may become more attractive if the electricity they produce could be stockpiled by more efficient and less polluting batteries.[4] This would indeed be a major step, in particular as regards the transport industry, which causes 20% of world emissions.

Regarding **wind energy**, there is growing controversy as to the environmental impact of wind turbines. 5MW masts are as high as 180 meters with a diameter of 150 meters with enormous stability problems. A wind farm of 1GW needs 360 tons of concrete (which emits C02), or 60% of what is needed for a nuclear installation; it also requires 125t of steel, a far greater emitter of CO2, twice as much as for nuclear. Wind farms also cause noise, and impact on birds and on the landscape. Off-shore wind farms, albeit more expensive, have fewer draw backs and are much more acceptable to the public. Supporters of wind energy consider it the most economic and sustainable of all new energy sources, whereas critics consider it contrary to EU sustainable development policy. Fault finders minimize its contribution to lower emissions because of the frequent resort to gas or diesel plants back-up (increasing fossil fuel imports). Wind farms require high-voltage power stations in order to compensate for intermittence of supply and regulatory costs. The excesses of an artificial wind energy market feed private riches to the benefit of subsidized investors and operators financed by taxpayers without true environmental benefits. Wind farms ruin the common natural landscape and cultural context, reducing the real estate value of private properties without compensation, degrade the quality of life of way-side dwellers, let alone their health, and affect natural habitats and biodiversity.

As to solar **energy**, it suffers from high costs (five times those for fossil or nuclear energy) due to its low efficiency (10%) and to shortages of silicium panels. Moreover, it needs heavy metals in batteries and panels, and the low quality carbon used by the world's biggest producer of solar panels in China causes high CO2 emissions. However, while solar is more expensive than wind energy, its costs are coming down and may dwindle with new materials. One can expect to silicium production (which currently represents half of the cost per Watt) to become less refined and cheaper; experts expect solar energy costs to match those of fossil fuels. New technology will soon allow applying photovoltaic cells on glass as a paint, and

[3] It has been estimated that the European electric black-out of 6 November 2006 was partly due to the network instability caused by Germany's vast wind energy farms.

[4] Some 30kgs of lead are needed to allow a battery to stock 1KWh of energy. In order to have autonomy of 60km a vehicle would need 100-150kgs of lead batteries.

even to replace it altogether with organic composite products, not to mention plastics. The main advantage of photovoltaic energy is perhaps that as an electronic product it has an enormous innovation potential. Moreover, it has great prospects for individual units in the developing countries and lacks the negative landscape impact of wind energy, which is running into increasing popular opposition.

Last, but not least, another energy source that deserves special attention and is of particular interest to European Estates is agro-fuels.

One generally calls biofuels, or better **agro-fuels**, those renewable fuels derived from biomass, generally in the form of liquid transportation fuels. There are two main categories:

- bioethanol (ethyl alcohol), which can be derived from sugarcane, sugar beet, maize, wheat, and starchy cereals (barley, sorghum, rye)
- and biodiesel (fatty-acid methyl ester), which is derived from oilseeds crops (soyabean, sunflower, rapeseed) and palm oil.

There is also biomass from wood. It is mostly used for heating wood (10% of energy consumption, but 80% in several African countries).

Agro-fuels are being promoted as the philosopher's stone for cutting emissions and energy independence. Governments are pushing their production via excise tax credits, renewable fuel standards and mandatory blending, farm and vehicle subsidies, R&D support, loans and grants, and import protection and taxes. According to the OECD, such public support is "irrational" and market distorting. Public support is wasted unless a country is competitive (Brazilian ethanol), has the capacity to become a competitive producer (Malaysian palm oil), or has the potential to achieve the technological capacity and economies of scale required for efficient production.[5]

There are increasing warnings from scientists, academics and institutions such as EEA, EFSA, FAO, IFAD, OECD, JRC and the BRS[6], as well as (initially favourable) NGOs, that beyond limited production there are serious flaws with subsidizing agro-fuels. Current agro-fuel production has an unsubstantial and shaky record in reducing greenhouse gas emissions as compared to conventional diesel or petrol, except Brazilian ethanol from local sugarcane. In fact, gas emissions of biofuels depend on the production process and the fuel, agricultural machinery and plant protection products used in crop growing, as well as on the alternative uses of land.

Although their market share remains small (currently 1% in the EU and 3% in US road transportation), agro-fuel production has escalated reducing food production and increasing food prices (according to FAO, by 30% in 2007) thus causing a major structural shift in commodity markets.[7] Mounting competition between food for people and fuel for cars has

[5] Removing budget support and mandates for biofuels would reduce biodiesel production in the EU and the US in 2013-2017 by over 80%, and reduce EU bioethanol production (if import tariffs are dropped as well) by 80%.

[6] European Energy Agency, European Food Safety Authority, Food and Agricultural Organization, Organization of Economic Development, EU Joint Research Center, International Fund for Agricultural Development, UK Royal Society, and World Food Program

[7] Currently some 6% of cereal production and 8% of vegetable oil production are devoted to agro-fuel feeding 954 biofuel plants world wide (2007). Acreage under oilseeds (soya and colza) declined to make place for maize; soybean-and-colza-based oil supplies contracted and their prices shot up, pulling palm oil prices along to the point that palm oil itself became less interesting for bio-diesel production.

had serious implications for food prices and world hunger, worsening the food balance.[8] Grain price changes have knock-on effects on livestock, poultry and pork prices because maize/corn, wheat and soyabeans (soy meal) are used also as animal feed. Agro-fuels penalize the poor, who spend most of their income on food, with the seventy odd net-food-importing developing countries having to pay the bill increasing their indebtedness; income differentials will grow, and additional food costs will nullify budget restoration and development assistance efforts; the drive towards economies of scale has forced the expulsion of small farmers from their land.

Agro--fuel targets have knock-on effects on the destruction of natural habitats. They help drain tropical peat lands, which contain vast quantities of CO2. They cause deforestation and hence additional CO2 emissions. Agro-fuels require a lot of water, and mostly good, irrigated agricultural land, both of which are finite, and cause environmental degradation (mainly in non-European countries). Greenpeace has called palm oil (the most energy efficient crop so far) a "climate bomb" in Indonesia. Carbon certification and sustainability criteria and supervision are currently too weak to allow to decide which plants and production methods provide an acceptable net contribution to greenhouse gas reduction to deserve to count towards target implementation; 10,000 square meters of agricultural land are needed to produce 1,500 liters of ethanol a year with only limited CO2 savings compared to a liter of petrol. Agro-fuels are of little help in reducing prices of heating oil and petrol at the pump. Unlike energy savings, their availability tends to increase overall energy demand, leaving oil demand unchanged. [9]

The OECD concludes that biofuel support policies in OECD countries are costly, any savings of GHG emissions and fossil energy are limited, impact on commodity prices is substantial, and consequences for environmental sustainability and biodiversity negative. They actually have questionable effects on all of the three main challenges: food security, energy security and environmental security. Environmental NGOs have called for a moratorium on agro-fuels.

However, agro-fuel advocates respond to criticism by underlining that first-generation agro-fuels represent but a necessary phase towards the development of **second-generation** technology such as bioethanol from lingo-cellulose, which is said to be just around the corner without involving loss of food production.[10] These are notably agro-fuels made from waste products such as straw, husks and weed.

Potential second-generation agro-fuels are mostly based on cellulose that is present in many biomass sources such as trees (cellulosic ethanol), switch grass, willows, jathropa, myscanthus, pongamia); they can also be obtained from food crop waste such as wheat stalks, straw (corn stover), husks, grass and from weed food refuse. One can also use biotechnology to decrease the production costs of agro-fuel plants, increasing yields up to three times those

[8] It has been calculated that every 1% price increase in commodities increases the number of undernourished by 16 million (Runge and Senauer). If the US mandated biofuel production targets are to be met, 2/3 of corn will have to be transformed into ethanol, making the US a net importer of corn.

[9] Incidentally, Biomass from cultivated forests would compete with crop land or with wood for housing and furniture and produce CO2 when transported. Its burning produces emissions of dioxin and fine particles. As to biomass from deforestation, is not renewable: it actually emits more than coal.

[10] There are other more interesting second-generation biofuels such as synthetic diesel produced from biomass inputs including wood pulp and waste (Sun Diesel), biomass-to liquid (BTL) plants, biodiesel from biogas, and biofuels derived directly from the photosynthesis of green micro algae. As these are basically no typical agro-fuels, they are not dealt with here.

of wheat, or 20 tons/ha. Yield per hectare may be boosted with genetically engineered sugar (by 100%); rape seed (+60%) and sweet sorghum. Several potential crops for second-generation agro-fuels have the advantage not to be grown on farmland, or deforested land, or to preserve the food component of plants, and may be grown with relatively little water and fertilizer on fallow land, without therefore displacing food production.

But second-generation agro-fuel skeptics recall that relevant research started a long time ago (early seventies). They retort that most agricultural waste is organic material useful to maintain the soil structure, nutrients and its store of carbon function. According to a letter sent to Science Magazine, removing 75% of crop residues to transport them (at a CO2 cost) to the biofuel refinery could increase the rate of soil erosion hundredfold. Our addiction to cars would then lead to "peak soil as well as peak oil" (Monbiot). In order to compensate for the nutrient loss, more fertilizer (potash) would have to be used, causing additional CO2 emissions. It is therefore unlikely that second-generation agro-fuels could get clear of most of the pitfalls of the first generation. Moreover, it remains to be proven whether large-scale cultivation of myscanthus, jatropha or pongamia are commercially feasible, and whether the benefits will trickle down to the small farmers instead of concentrating on big farmers and large corporations.

Scientists are actually working to improve the efficiency of photosynthesis, carbon capture, nitrogen fixation and many other cellular processes that boost biomass yields. There are several ways of making second generation biofuels. However, cellulosic molecules are difficult to transform into sugar to produce ethanol.[11]

There are good prospects with genetically modified algae ponds yielding ten times as much bio-diesel per hectare than jathropa and any other plant, and minimizing ecological damage (if grown in closed tanks). Algae can also help capturing carbon dioxide from burning fossil fuels. The most efficient may become micro-algae, which may prove able to convert into bio-diesel with a yield 30 times above that of oilseeds with a much lower need for fertilizers and pesticides. Enzymes can allow production of cellulosic ethanol from the inedible parts of crops such as straw stalks (or from wood or food waste). Bio-mass-eating bacteria can break down cellulose quickly. It may become possible to plant crops in soils lost to salinisation, and to genetically produce plants that can grow in marginal or otherwise unusable farmland.

To conclude, climate change cries out for new sources of energy. Oil will remain the main energy source for the next generation. Nuclear energy is on the way up, because one cannot do without it to meet the Kyoto targets. Renewable energies are the stars of the show. But, it is worth reminding the warning of the English novelist and scientist C.P. Snow (1905-1980) who once said: "Technology is a queer thing. It brings you great gifts with one hand, and it stabs you in the back with the other". All renewable energies have more net emission foot-prints than most people are aware of. No new energy sources should therefore be promoted without submitting them to Life Cycle Analysis. This would notably slow the current political band-wagon regarding on-shore wind farms, and even more so, agro-fuels.
Current agro-fuel policy in Europe (and more in the US) is an illustration of "The March of Folly" described by the late American historian Barbara Tuchman, of pursuing government

[11] There are at least three ways to make such fuels: pushing the brewing process coverting grain or sugar into ethanol, the thermal method heating waste products to produce synthetic gas, which is then recombined to form a liquid fuel, and making biofuels from algae using carbon dioxide as a feedstock. But there are huge problems to bring each method to fruition. For instance, using enzymes to ferment starch or sugar into alcohol is easy, but waste products contain much larger amounts of lignin, which is harder and more costly to break down ("Hopes ride on the next generation" by Fiona Harvey, Financial Times 16/09/08)..

policies contrary to their own interests ("misgovernment"). Agro-fuel subsidies, together with tax-rebates and import protection, impact on all three major looming world scarcities: food, energy and the environment. On all three there has been market failure. Current agro-fuel policies do not help correct such failures, they aggravate them. They actually ignore fundamental political realities, economic and social aspects, power and income differentials among and within countries, let alone human rights. They are an ethical failure.

We should therefore recognize reality. We cannot expect to be able to substantially reduce emissions with existing energy technologies. There will be "no substantial progress without new kinds of energy systems, new kinds of automobiles and new buildings" (Jeffrey Sachs). According to the IEA "The world faces a fossil energy future to 2030", and General Electric CEO does "see a disruptive new technology that changes the game in the next 20-30 years. It is not the nature of this industry. Everything that has been developed so far – wind, solar and so on – has taken decades to come to fruition. My expectation is that it will remain that way." Instead, we might witness breakthroughs from outside the energy industry such as nanotechnology, bio-sciences or an unsuspected other source.

All things considered, among potential new renewable energy source, the best hope of low emission renewable energy,[12] may one day be **hydrogen.** Scientists are trying to bring hydrogen and oxygen together releasing just energy and water. Hydrogen is one of the most abundant elements in the atmosphere. While it can be extracted from coal, natural gas and organic waste, scientists try to break apart the hydrogen and oxygen atoms and use fuel cells to bring them together again releasing energy in the process. Using renewable sources to split the water and initiate a "water to water" hydrogen fuel cycle would allow to produce energy with zero pollution. As cheap catalysts have now be found for the electrolysis process making hydrogen from water, MIT professor Nocera believes that it will be possible within a decade to use solar panels to simultaneously power homes and charge hydrogen fuel cells

The best way to **reduce** e**nergy demand** is not to generate emissions. It is less costly to save energy than to produce it in the first place. US expert Amory Lovins has been talking of "negawatts" to define a megawatt of power avoided or saved from use on the grid. This can be obtained through energy saving technology, which is developing fast, as well as through energy-saving consumer behaviour, which still leaves much to be desired.
Behavioural changes can mean such things as turning down thermostats for heating and turning them up for air-conditioning, and turning off lights and appliances when not needed.
Technology and regulations can help reduce energy use by appliances, develop micro-generation units such as roof solar panels and mini-wind turbines, and upgrading current energy networks around such units (smart grids) and building smaller power stations close to energy users. Smart grids would allow to fully use intermittent energy sources, limit stand-by, back-up energy supply, reduce power-line losses and use waste heat to warm local buildings..
But there is also another effective way Reducing Emissions from Deforestation and Degradation (Redd). So far forests have not been valued except for their wood, although they provide a lot of value in the storage and reprocessing of carbon. Deforestation accounts for up to 25% of all GHG emissions. If Redd is included in the Kyoto process, this will be a momentous event. In the Eliasch Report (linked to the Stern Review in 2008) it is estimated that it will cost up to $33bn a year to halve emissions from forests by 2030, but that long-term benefits would be $3,700bn. Redd proposed payments in the form of carbon credits to

[12] For the following part see notably "Le dossier noir des energies vertes", Science et Vie, March 2008

encourage forests to be saved. Forest and land use credits should be included in emission trading schemes like New-South Wales, Australia has already done.[13]
[14]

The second generation is one or two decades away. Meanwhile, it is of the essence to adopt a number of measures:

- increase R&D on new energies,
- update biofuel strategies suspending or abolishing the 10% Biofuel target,[15] not on the basis of lobby pressures and political expediency, but on the basis of science,
- use the fiscal instrument to limit emissions,[16]
- improve and generalize the European Emissions Trading Scheme, a mandatory cap and trade system for CO2 emissions setting limits to the emissions of the most energy-intensive companies, penalizing company emission increases and rewarding reductions. Companies are allowed to trade their allocations of permits to limit C02 with one another. Such permits should be bought at auction and generalized world-wide,
- strengthen regulations promoting moderate temperature targets in public buildings, both in summer and winter, and recommended targets in private homes,

- upgrade electricity distribution systems to a "smart grid", or *electranet*, that would allow people to generate their own electricity from renewable sources and sell it back to the power grid,[17]

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[13] Financial Times, Climate Change, The Redd Planet, 2 December 2008, p.41.

[14] For instance, modern wood-burning stoves have a 90% energy efficiency, three times greater than old stoves and far greater than rural stoves in Africa, which need 20 times more wood for the same heat.

[15] The independent Scientific Advisory Committee of the European Environment Agency asked for the suspension of the "overambitious" 10% biofuel target, "an experiment, whose unintended effects are difficult to predict and difficult to control", carrying out a new, comprehensive scientific study on the environmental risks and benefits of biofuels. It has been estimated that meeting the 10% target may require devoting 10m hectares to agro-fuel production. Meeting the more ambitious US bioethanol target may require shifting 40m ha of land to biofuels. These remarks are taken from Bos Eickhout's presentation at an EPC seminar in May 2008.

[16] Al Gore suggested to "Eliminate the payroll tax and replace it with carbon dioxide tax" . Over twenty years ago the Jacques Delors' Commission proposed to reduce taxes on labour compensating the fiscal shortfall via a CO2 tax (rejected by the UK on grounds of principle). Scandinavia and some other European Countries have done so. Moreover, one should offer full investment tax credits, subsidies, and price support for renewable energies like solar energy (who's prices are plummeting), wind energy (off-shore), other bio-energies in the form of landfill and sewage treatment gas, biogas from organic wastes, sewage sludge and demolition food, renewable-energy-based hydrogen fuel cells, and low carbon technologies such as batteries, carbon capture and storage. One should also establish punitive fees for ^private and company energy consumption exceeding strict levels. In addition, one should impose a large surtax on gas-guzzling road transport vehicles, steeply increase motorway fees, particularly on lorries, using the proceeds to subsidize rail and combined transport, making (privatized) train prices for piggy-backing motor-vehicles so cheap as to become irresistible.

[17] From « International star (Al Gore) plays coy on domestic plans », Financial Times, 13 November 2007.
Al Gore was reported joining Silicon Valley in setting up the fund management company Generation Investment Management in order to tap the public markets, where "more money is allocated in an hour than by all governments in the world in that space, and promote clean technologies".

- consider ethical and political issues related to bio-fuel subsidies such as food security, food-fuel competition, and the geopolitical consequences such as potential adverse impacts on the developing world,
- clear signals by all governments – including the US and China which together represent 45% of total world carbon emissions – taking into account the need for fairness,[18]
- give priority to energy efficiency and carbon saving on the demand side, whose potential is far larger than carbon savings on the supply side.

Jeremy Rifkin's vision is to retool the motor industry, reconfigure the power grid, and covert buildings into power plants. He believes in the shift of our energy regime from national power grids and transmission lines and centralized control, to distributed, digitalized management capturing local, renewable technologies. He advocates an accelerated development of automotive technology from the internal combustion engine to electric and hydrogen fuel-cell plug-in vehicles. He also calls for new construction designs and materials. All these he sees as the entry points to a third industrial revolution and a post carbon economy.

None of the suggestions above are easy to implement. As long as governments continue to support new energy strategies that help politicians (with the best intentions) to acquire green credentials, and provides them with the illusion of an easy technological fix, they will divert their attention from getting on with more important, less popular measures for saving the planet, such as those I just described, starting with energy conservation.

[18] Per capita emissions in China, India and Sub-Saharan Africa are 1/3, 1/5 and 1/10th of US emissions respectively.