Climate Change & Energy Implications

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24th June 2015

"The future is going to have to be different to the present." - Dr Martin Dwyer

After much thought I have come up with a loose plan for the future of energy production, or more a set of principles which must be applied if humanity is to have any chance of averting the catastrophic economic, social and environmental collapse that will ensue as a result of climate change.

1. CO2 emissions must be brought quickly to near zero, obviously - though not 'obviously' to conservatives all around the world who choose to disbelieve in the very science which couldn't possibly be sending out a clearer message of impending danger!

2. World population is over 7 billion souls, and before long might drift upwards to 9 billion. The affluence that is possessed by developed nations, and aspired to by poorer ones, depends on energy.

Energy, gives each of us in the UK **100 invisible slaves** which power our lights, washing machines & televisions, power factories and the transport systems we use to get to work, and build the structures we live and work in. I would even venture to suggest that we abolished 'slavery' because we could! New, better slaves came along in the form of the industrial revolution, when we learned how to use coal. Without the continuous flow of a lot of energy (5kW for every adult and child in UK), things very quickly go wrong.

We live in a 'just in time' society which requires near-perfect conditions to function. World energy demand is currently running at about 12,000 GW. If the world's 9 billion inhabitants in the future achieve our current level of energy affluence, then demand will rise to 45,000 GW (9 billion x 5kW). So in the future, our 'wealth' and affluence requires that we have access to energy but we must learn to derive it without CO2 emissions (as in '1') and seek to waste as little as possible and find ways to minimise its use.

3. Emissions arise not just from energy systems but also deforestation and agricultural methods. Both of these must be challenged, the insolent contempt we seem to have for Nature and the incontinent rape of the planet must be abated.

4. As described in '2', energy use should be minimised by all possible means by measures which would include:

- providing electrically-powered, cheap (subsidised), safe (properly manned), accessible public transport systems to reduce personal car use. Cars with smaller, more efficient or hybrid engines encouraged. Electric vehicles (which consume only a quarter of the energy used by internal combustion cars) used as far as possible.
- Existing and future homes must be better insulated and heating provided by electrically-driven heat pumps (which function with 200%+ efficiency) instead of by burning methane. Pre-heating of water can be accomplished by solar-water heating panels.
- Generally we must learn to be less wasteful and re-use, re-condition and re-cycle to a greater degree!

5. Nearly half of emissions come from electricity generation. Burning fossil fuels to make electricity is inefficient and most of the heat supplied escapes uselessly up power station chimneys. Future electricity generation MUST come from renewable sources only: onshore & offshore wind, PV solar, CSP solar (in hot sunny countries), tidal barrages/lagoons/stream turbines, geothermal, hydroelectric and wave power. There is wide variability in the output of renewables but there are ways that this can be managed:

- sharing of energy across continents using high voltage DC interconnectors,
- storing hydrogen (made by water electrolysis) to use as backup fuel in turbines,
- flow cell Zn-Br batteries, and putting to good use the 'excess' energy available when it is very sunny and/or windy
- In hot dry countries like Australia, otherwise unusable renewable electricity could be used to make potable water by reverse osmosis (making a ton of water uses about 3kWh).

6. Burning carbon just to make heat for electricity or any other purpose is simply wrong! We need to appreciate that carbon-based fuels are precious and not to be squandered, even if the cost of getting them out of the ground suggests they are not. We must reserve liquid fuels for planes and ships (which will never run on batteries) and road vehicles which cannot be electrically-powered.

7. By stopping using fossil fuels for electricity generation, using heat-pumps for heating and making transport systems electrically powered as far as possible, energy-related emissions can be greatly reduced, perhaps to less than 25% of current levels. In order to provide for the residual demand for gas and liquid fuels, these must be derived from renewable technologies instead of current oil and gas exploitation. For us to keep in harmony with Nature, the carbon in gas and fuels we use MUST come from the atmosphere and not from oil, this can only be achieved in a limited number of ways: land-fill gas recovery, anaerobic digestion of waste, and specific growing of energy crops.

8. 'Bio-gas' from land-fill and AD (anaerobic digestion) and also from wheat consists of 40-50% methane, 30-40% CO2 and some contaminants. Renewably generated electricity can be used to supply hydrogen (water electrolysis) which can improve the calorific value of the gas by reducing CO2 to more methane. After cleaning, the gas can enter the existing gas distribution network and be used for essential purposes which will include conversion to liquid fuels chemically. It MUST be recognised that bio-fuels are carbon-based, and hence are too precious to just burn (as is currently the case with bio-fuels, to make a paltry amount of electricity) and that the carbon in them has a much more important purpose, namely to be converted to petrol, diesel and kerosene (jet-fuel).

9. Shell have demonstrated how it is possible to replicate all the products of the petrochemical industry from gas as feedstock at their Pearl GTL plant in Qatar. This would allow biogas distributed via the gas network to be converted to essential fuels and other products. The Pearl plant cost $18 billion and can process about 18 GW of gas supply.

10. Liquid fuels can also be made from algae which use photosynthesis to capture the Sun's energy and convert CO2 to energy-bearing molecules. This process can 'grow' fuels with yields of 10 MW per square km or better, but a flux of CO2 is still required, which would have to come from co-located industrial processes or plant. This would have the advantage of not having to separate CO2 from flue gases, then liquefy or compress it as would be the case for CCS (requiring 30% more input energy), since the flue gases merely need to be diverted to the algae plantations and bubbled through the reactors at low pressure. Such 'carbon capture' is essential to reduce emission and ensure that the carbon can be re-cycled as high-grade fuel.

11. *The CCS Conundrum* - Given the above, the idea that CO2 should be captured from coal or gas-fired power stations, then pumped down old oil wells (as is the current intention of CCS) is bizarrely misguided and backwards! Electricity MUST come from renewable sources, and the carbon in the residual hydrocarbons we need MUST be provided for by carbon from bio-gas or bio-mass.

12. Waste materials from agriculture like straw, wood and fast-growing Miscanthus, which aren't suitable for anaerobic digestion nevertheless contain valuable carbon. When these are burned to make (paltry) electricity then the flue-gases can be guided at low pressure to co-located algae plantations.

13. The future is going to have to be different to the present. This will either be in a very very bad way, with the planet becoming uninhabitable for humans within perhaps a century... or we can learn to live sustainably by managing carbon more intelligently. This will entail some compromises in the way we live and expend energy as well as the ubiquitous presence of the means of renewable energy generation: wind farms, solar panels and the like.

14. There isn't some magical solution which is going to suddenly save us from having to do all this. Nuclear fusion is still decades away (which is too late, we need to act decisively within a few decades to prevent climate disaster) from even providing more energy than has to be supplied, let alone enough to power a lossy Rankine cycle to generate the electrical input required. It's almost certain that the apparatus needed to produce energy from fusion will be a scaled-up '**tokamak**' the size of a cathedral containing high-grade ceramics, helium-cooled super-magnets and other extremely expensive kit which will ensure that the renewables already available will always be cheaper!

15. Nuclear power (even from Thorium which is **only experimental at this time**) is not the answer either, it's dirty, dangerous and not even cheap! In fact nuclear power is ludicrously expensive and shouldn't even be considered. Even with nuclear power, the carbon in fuels still has to come from somewhere and civilisation would still have to manage carbon precisely as described above to achieve zero-emission. UK current primary energy demand equates to 100 Hinckley C projects!

16. *States, not markets, have to lead.* - It is difficult to imagine how any of the above will ever come about while free-market fundamentalism prevails, or without massive state intervention and international cooperation on an unprecedented scale. All this is utterly repugnant to the right-wing who despise state intervention and can barely bring themselves to believe that human-caused global warming is taking place. This is because to admit such is to recognise that all they have ever believed about how the world should be run and organised, is and always has been WRONG!

17. Finally, ‘fracking’! This is almost unbelievably stupid. Fracking shale for gas risks permanently damaging our water supply, causing quakes which will damage homes through subsidence, and poisoning air locally which will have severely deleterious effects on the health of citizens living nearby. There is enough evidence from relatively sparsely populated USA and Australia to indicate that this technology is entirely inappropriate for UK, or anywhere else on the planet for that matter! The fugitive (well-head) methane emissions ensure that the process is dirtier even than coal (a low bar to aim for in any case) and massively harmful to the planet.

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