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Broad Band Effective and Affordable Approaches to Climate

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Broad Band Effective and Affordable Approaches to Climate

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Although we have had many decades of projections and warnings about climate change it is, as is all too usual, only fairly recently that actual impacts have stirred serious societal interest in mitigation efforts. Such efforts will involve changes, and changes are always difficult. In fact, although renewable energy is a bedrock mitigation approach, it is only as technology has reduced renewable costs below parity with fossil carbon that they have been taken very seriously. Renewable energy technologies are already producing some 25% of electricity worldwide and constitute some 65% of new generation. It appears that favorable economics motivates change more often than longer term issues. In the case of Climate change, it is no longer long term. In fact many indicate we have a decade or less to institute serious mitigation or rather dire impacts are projected. Fortunately humans have invented approaches which would be effective in that decade time frame and be overall economically advantageous.

In October of 2018 Bill Gates wrote a piece entitled "*Climate Change and the 75% problem*".[1] This article states that electricity, agriculture, manufacturing and the combination of transportation and buildings were to first order each a quarter of the Fossil CO_2 source problem driving climate change. Examination of this indicates that except for methane produced by cows, some manufacturing processes and land clearing, fossil carbon produced electricity and fossil carbon transportation fuels are responsible for CO_2 emissions, plus some other bits and pieces of sources. Therefore, by far, the major climate mitigation approach is to accelerate renewable energy adoption, which in many cases requires serious storage, which is also developing rapidly and reducing in cost. Renewable electricity much reduces the CO_2 associated with buildings, electric motors, and manufacturing. Storage enabling electric transportation for land, sea, and air greatly reduces CO_2 from transportation.

It is interesting to examine the current and projected status of the 5 major climate mitigation approaches. These approaches include, renewable energy, conservation [the Rocky Mountain Institute terms conservation savings 'Negawatts"], storage, electric transportation and geoengineering to ascertain the apparent climate mitigation state of play and outlook with respect to climate going forward. It should be noted that to first order, aerosols are equal in magnitude and opposite in direction to CO_2 with respect to climate and humans have greatly increased atmospheric aerosols. This has mitigated thus far many manifestations of climate change. Aerosol content in the atmosphere, those that reduce effects, changes vice the type that increase such, needs to also be "managed" for climate purposes.

Firstly, to define the climate problem. What started out as a CO_2 and methane anthropogenic emissions issue primarily is amplified by what are termed positive feedbacks. These are largely not yet fully included in the IPCC [Intergovernmental Panel on Climate Change] projections due primarily to a lack of sufficient data to do so. However, they are probably responsible as they kick in for the changes such as sea level rise, ocean temperature and acidification, ocean CO_2 uptake, CO_2 level, etc. to be at or above the top of the IPCC projections. These positive feedbacks include ocean acidification and impacts upon ocean CO_2 uptake and algae, release of fossil CO_2 and methane from the tundra, which is warming fastest of all and the ocean, and several others. These have been projected by some to significantly increase the IPCC projected levels going forward. So we probably have an increasingly more difficult problem to work then we are presently aware of.

CONSERVATION – Estimates indicate that serious conservation could reduce CO_2 emissions by perhaps up to some 30%. This is a large number. Buildings are a large driver of fossil carbon emissions. As we heat and cool them with renewable energy far less so. Negative energy buildings, buildings that generate renewable energy instead of consuming energy, either fossil or reusable have been built and their technologies are developing rapidly. People, these past decades, are

increasingly shifting to tele-everything, tele-working, teleshopping, tele-socialization, tele-education, telemedicine with printing on site, tele-manufacturing, tele-commerce, tele-travel, tele-socialization, tele-politics, etc. This has reduced overall impacts on the ecosystem and in particular, teleshopping has a 15 times reduction in carbon emissions versus physical shopping. There are improved methods to regenerate and reuse waste heat. These methods include regeneration of waste heat from roads and parking lots and car exhausts. Then there is passive building ventilation and lightweight materials, up to 5 times better with factors of 10 in the offing will reduce transportation energy use. Some are developing seasonal energy storage by storing heat in the summer and cold in the winter. Heat pumps are far more efficient. Electric motors, which consume much less electricity have been developed, along with greatly improved insulation.

RENEWABLE ENERGY – Conventional renewable energy sources are well known and include hydro, geothermal, solar PV, solar thermal, wind, terrestrial and off shore, fresh water produced biomass. We utilize some 500 exajoules of energy planet wide. The estimated capacity of these conventional renewables are some 15,000 exajoules, so capacity is not a limiter for renewables. Some additional, largely untapped renewables include high altitude wind off the U.S. east coast and heat exchangers in the Gulf Stream, each estimated at some twice the U.S. grid load. Then there is CO_2 conversion into hydrocarbon fuels and hydrogen from water, both using solar energy, and osmotic power, from the mixing of fresh and salt water. Finally there are Halophytes, a huge number of them, salt plants, that grow on deserts and waste lands using saline, salt water. 44% of the land is wastelands, deserts, not productive, and 97% of the water is saline. By utilizing more farming, very cheap land, water and halophytes we could essentially solve the shortages of arable land, fresh water [use halophytes for food to get back the 70% of fresh water now used for agriculture], food [from halophytes], clean energy [cheap, massive quantities of biomass], clean petrochemical feed stock [replaces petroleum for such] and climate change [from biomass fuels] as halophytes sequester some 18% of their CO_2 uptake in their

deep roots. Seawater contains some 80% of the nutrients for plants and bio science has developed means for plants to extract nitrogen from the air. Then there are genomic microbes, aquaculture, producing some projected 20,000 gals of renewable fuel per acre year and ocean wave and current energy.

The dominant renewables are hydro, wind and solar photovoltaics (PV). Their efficiency is increasing and for the latter two their costs have reduced massively. Both wind and PV are selling in many markets for some 2 cents per KWH, below gas and coal, with costs still dropping. Costs for most of the renewables are low, causing coal plants and nuclear plants to close. While many of the renewables are base load, do not require storage, including geothermal, biomass, and hydro, wind and solar either have to be buffered by storage or be part of a smart grid with other energy sources. Due to the rate at which the renewable costs and efficiencies are improving some are starting to refer going forward to energy too cheap to meter. Such cheap energy would change a great deal and enable a much different economy. Enabling serious water desalinization is just one example of such changes.

ENERGY STORAGE and ELECTRIC TRANSPORTATION – There are a plethora of ways to store energy including electric, gas pressure, as heat, mechanically, phase change, chemically, along with a myriad of energy conversion approaches such as thermal-electrics, pyro-electrics, Sterling cycle, thermal-PV etc. Devices employed include capacitors, batteries, flywheels, high pressure tanks. Thermal storage is developing nicely, being stored chemically as Fulvalene Diruthenium, in molton salt, in rocks and in zeolites. Hydrogen storage is very much a work in progress, there are many ways to store such, including cryogenically, in pressure vessels, chemically as ammonia, etc. but thus far there are issues with all such.

The major storage interest in many markets is batteries. These come in two flavors, weight sensitive for utilization in transportation and non-weight sensitive for utilization on the grid, where storage is useful for

leveling the variability of wind and solar energy and also for regulating voltage and frequency, energy arbitrage and distributed generation. The latter is changing the entire energy landscape. Using the renewables at the scale of the actual consumer, homes and factories, it is increasingly advantageous for individuals, hundreds of thousands thus far, to go off the grid. The economics for this are increasingly favorable and the energy situation where this occurs is proving to be more reliable in the case of severe storms. Weight sensitive transportation batteries are progressing from lithium ion, to twice that with lithium metal and making excellent progress on lithium air, which is nearly equal to chemical energy density. Lithium air class batteries would essentially enable all transportation to shift to electrics and the need for petroleum as a heavy transportation fuel would greatly diminish. There are a plethora of advantages, besides CO_2 reductions, to going to electrics in transportation including obviation of fuel fires in a crash or collision. Other advantages include no gear boxes, regenerative braking, doubling of efficiency, quieter, reduced vibration, much lower energy costs, high reliability, reduced maintenance, far fewer parts and less expensive. The bottom line on storage is large research investments, greatly reducing costs, greatly increasing adoption and efficiencies and a plethora of approaches.

GEO-ENGINEERING – There are two approaches to geo-engineering. The first approach is to block sunlight, incoming energy and the second is sequestering CO_2. There are major lists of approaches, including some that could possibly wreak havoc with the Ozone layer in the process and most require serious study with respect to unintended consequences. The approaches mentioned below are probably the more benign but still useful as part of an overall climate solution. The fact that these are even included herein is an indication of how far we have let the climate issues fester until we took them at all seriously. There are increasingly strident cries for Geo-engineering solutions as folks start to realize the true situation, how far we have already come with this issue in terms of "baked" in changes and the probable impacts, which approach, per the book *Under a Green Sky*[2] by Peter Ward, Existential levels for humans.

White roofs and white roads – The impacts of the humans upon the countryside are now so pervasive that some suggest that altering the albedo by changing to white roofs and roads would delay serious climate impacts by a decade.

Halophytes – Planting halophytes on deserts and wastelands, where they sequester up to 18% of their CO2 uptake and essentially stop desertification, reverse it, put back green landscapes in a serious fashion, produces many favorable climate effects, along with, as stated, solving food, water, land and energy.

Putting CO2 into the oceans to sequester it, producing calcium carbonate, - Probably a better approach that trying to sequester it underground, and cheaper.

Ocean Fertilization – Spreading iron rich dust to incite/ enable algae blooms. Algae sequesters some 35ish % of their CO2 uptake at the ocean bottom

Inexpensive Renewable Energy to extract CO2 from the Atmosphere to sequester in the Ocean or Make HC fuels.

Synthetic Biology developed high albedo crops

Overall, we now have or are working on technologies that COLLECTIVELY could, in a decade, and in the process create wealth, severely mitigate climate change. We are awash in ever cheaper and more efficient renewable energies and the approaches to store such. We have the technologies to solve land, water and food challenges. However, in the process we have to change some things: the current power grid, current agriculture, current lifestyles and infrastructures in some cases, but the innate resources and technologies are or are nearly THERE to mitigate climate change. As many have stated, there is no single golden bullet, the magnitude of the climate issue is nearly incomprehensible. It will take many changes and approaches, but what is amazing is that costs will go down, lifestyles will improve, even employment increases. There are marching armies of photovoltaic installers now, far more than are being made redundant at the closing coal plants. But there will be different winners and losers at this scale,

and to operate this differently such has to be expected. The current winners are not, understandably, pleased with that, and in most cases they are powerful entities.

The projected climate changes are far more than warm days and wet feet. In Under a Green Sky Ward discusses that in the Permian, the great dying, with CO2 from the Siberian traps volcanoes orders of magnitude less than our current anthropogenic release rate, the ocean thermohaline circulators died, ours are changing now. This resulted in an overgrowth of cyanobacteria in the increasingly anoxic oceans, which produced huge amounts of hydrogen sulfide, which is a poison in the atmosphere and took down the ozone layer. Some 90% plus species extinction. As stated, far more than warm days and wet feet. The fate of our grandchildren and children etc. is up to the collective us, and each one of us can take personal actions. The techs to counter this are increasingly available on the shelves of the local supply stores. The alternative to mitigating climate change is to morph the humans and the ecosystem to accommodate the altered climate conditions via synthetic biology, genomics, etc. We are studying extremophiles, biologics that live in deep ocean vents, in deserts and in Yellowstone pools, which provides useful information and research to address designer humans capable of taking the heat etc.

References

1. "Climate change and the 75% problem", https://www.gatesnotes.com/Energy/My-plan-for-fighting-climate-change, October 17, 2018
2. Ward, Peter D., Under a Green Sky, Smithsonian Books, 2007

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