

Seawater/Saline Agriculture for Energy, Warming, Water, Rainfall, Land, Food and Minerals

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Abstract

The combination of the incipient demise of “cheap oil” and increasing evidence of Global “Warming” due to anthropogenic fossil carbon release has reinvigorated the need for and efforts on “Renewable” energy sources, especially for transportation applications. Biomass/Bio-diesel appears to have many benefits compared to Hydrogen, the only other major renewable transportation fuel candidate. Biomass Production is currently limited by available arable land and fresh water. Halophyte Plants and seawater irrigation proffer a wholly new biomass production mantra – using “wastelands” and very plentiful seawater. Such an approach addresses many-to-most of the major emerging Societal Problems including Land, Water, Food, Warming and Energy. For many reasons , including seawater agriculture , portions of the Sahara appear to be viable candidates for future Biomass Production. The apparent nonlinearity between vegetation cover and atmospheric conditions over North Africa necessitates serious coupled boundary layer Meteorology and Global Circulation Modeling to ensure that this form of “Terra Forming” is Favorable and to avoid adverse “Unintended Consequences”.

Introduction

Beginning with the Technological Development of Fire in the Human “Hunter-Gatherer” period Biomass was, until the 1800’s, THE dominant “Energy Source”. The subsequent development and utilization of fossil fuels including coal, oil and natural gas powered/enabled tremendous technological progress and major increases in societal population and “wealth”. The consequent “emission” into the atmosphere of the products of combustion of these fossil fuels has now altered the atmospheric composition sufficiently to affect the planetary radiation budget causing increasing global “warming”. Ice cores indicate that atmospheric CO₂ concentration is greater today than at any time in the last 650,000 years. Influences of this warming are already apparent according to some analysts,

including some 5 million cases of illness and 150,000 deaths/year. Potential impacts of Warming include Arctic /glacier “melting”, alteration of species and disease patterns, heat waves, floods, increased incidence of and more severe storms, rising ocean levels, droughts, enhanced pollution, extinction of some million terrestrial species and resultant tremendous economic impacts. The arctic region/tundra melting is releasing immense amounts of fossil Methane, which is a global warming gas with some 22 times the impact of CO₂, greatly accelerating the warming process. Nominally some 75% of the world’s energy is currently generated using Fossil fuels/carbon [Adams,2002]. Since plants take up CO₂ during growth and then redeposit the CO₂ back into the atmosphere they are a “renewable” /”Green” energy source. The use of FOSSIL [vs. “Renewable”] carbon is the warming issue. There are serious calls for and work on CO₂ sequestration, potentially a major engineering and economic endeavor.

Warming is one of the major current concerns regarding use of fossil fuels ,the other is the incipient demise of “cheap” [high quality, ”sweet”] oil. There are immense deposits of Fossil methane and Coal still extant but oil production has peaked in many areas and is expected to peak within 10 years or less in most others, at a time when demand for oil is rising rapidly – driven in a major way by the phenomenal growth of the Asian Economies. This combination of reducing production and increasing demand will inexorably drive up petroleum costs. Oil is currently THE fuel of choice for transportation. Alternative transportation fuels, at higher costs and with a warming penalty, could be extracted from coal. Other transportation fuel alternatives include hydrogen and Biomass/bio-diesel. Hydrogen has major production and storage problems and, for warming aversion H₂ production should be via “renewables”. Biomass/Bio-diesel has production problems associated with increasing shortages of suitable arable land and “sweet” water. There are suggestions that water scarcity is now the single greatest threat to human health, the environment and the global food supply.

Biomass and the Sahara

Of the “Renewables” [Solar, Wind, Hydro, Geothermal] [Touryan,1999] only Solar has the potential to provide the requisite “capacity” to replace Fossil Energy sources, “solve” warming. Solar energy can be utilized in many ways including direct heating, photo-catalytic disassociation of water, hydrogen production from [Genomic and Artificial] photosynthesis, electricity production from Photo-voltaics [including the emerging nano/plastic PV] and Biomass [Smith et al,2003]. As a potential

transportation fuel Biomass/Bio-Diesel requires no new storage/transportation-specific infrastructure as does H₂, has minimal sulfur and is “relatively” inexpensive - Competitive with oil at the current nominal oil price of \$60/Barrel. Biomass availability is currently limited by a combination of shortages in arable land/sweet water and suitable processing plants. Due to the cost[s] of transporting Biomass, the requisite processing plants should be distributed/located near the biomass production sites. Bio-diesel is obviously transportable via the current oil transportation Infrastructure[s] [pipelines, tankers, etc.]. “Bio-Refineries” currently under development include Bio-Chemical/fermentation, Thermochemical / Pyrolysis /Gasification and Chemical [Morris 1999, Klass 2004].

The potential Biomass Utilization Spectrum encompasses transportation fuels [Bio-Diesel, H₂], heat generation, electricity generation via Bio-fuel cells, food and petrochemical feed stock for plastics etc. Estimates indicate that some 6% of the U.S. land mass could via Biomass supply/replace both oil and natural gas at current U.S. usage rates. Biomass grown on less than the land mass of the Sahara could supply/replace the worlds Fossil energy requirements.

As stated previously, shortages of water and arable land currently limit Biomass Production. This is especially true for the Sahara, which constitutes a portion of the some 44% of the planet’s land mass considered “wastelands” due primarily to shortages of “Sweet Water”. Sahara water availability has decreased by a factor of 3 since the 1950’s. The region is increasingly resorting to inherently expensive long distance water transfer and Desalinization and therefore would appear to be an unlikely candidate for major biomass production. The Sahara does have vast distributed underground aquifers, largely transnational and currently underutilized [Shahin 2002]. These aquifers are often saline and becoming more so. Their utilization is causing land salinization with some 20% of irrigated land in the region affected by salinity and the percentage growing rapidly. The water “age” in these aquifers is some 20,000 years and there is little replenishment. As an example of the “sufficiency” of these aquifers for Biomass Production, the Nubian Sandstone Aquifer in the Eastern Sahara would provide only some 60 years of Biomass Production, altogether not a long term solution.

A review of the “resources” of the Sahara region indicates coastlines and sunlight as major advantages. The sunlight could be utilized either for Direct electricity production via the emerging nano plastic inexpensive and potentially highly efficient photovoltaics or, given suitable water, Biomass Production. The electricity could be utilized to produce H₂ directly via

electrolysis using saline or salt water. Direct photocatalytic electrolysis could also be utilized on the Sahara for H₂ Production.

Saline-Saltwater Agriculture

Conventional wisdom throughout most of the world is that saline water/soil is detrimental-to-disasterous for Agriculture. However, there are indications, both historical and recent that saline/saltwater Agriculture is a viable to [for portions of the Sahara?] desirable alternative to Conventional Agriculture. In several areas around the globe people have utilized a class of plants termed “Halophytes” [salt-plants] and brackish/saline water for both food and fodder and to “reclaim”/”desalinate” land [Ahmed & Malik 2002, Glenn et al 1998, NRC 1990, Khan 2001, Yensen 1988]. The advantages of, for example, Seawater Agriculture is that 97% of water on the planet is seawater, difficult to “run out”. Also seawater contains a wide variety of important minerals and order of 80% of the nutrients needed for plant growth. Nitrogen, Phosphorus and iron are the required additives. “Nitrogen Fixation” from the atmosphere would be the approach of choice for this important growth requirement. There are actually 4 methods of utilizing seawater for agriculture. Of these, Desalinization is in general too expensive for agriculture, Deep[er]/colder ocean water can be used to precipitate moisture from the local atmosphere and seawater greenhouses utilize sunlight to vaporize/re-precipitate the seawater. The fourth is direct seawater irrigation utilizing Halophyte Plant Stock.

There are some 10,000 “natural” Halophyte Plants of which some 250 are potential “staple” crops. Genomic/Bio Research is ongoing worldwide to enhance the overall productivity of Halophytes with the goal of Halophilics [salt-loving], the more salt the better. Huge land areas worldwide are already salt-affected and major regions overlie saline aquifers. Over 100 halophyte plants are now in “trials” for “commercial” applications. Nearly 20 countries are involved with Saline Farming experiments for FOOD Production. In particular the Chinese have reported Genomic versions of Tomatoes, Eggplant, pepper, wheat, rice and rapeseed grown on beaches using seawater. The outlook for genomic-derived halophyte enhancements appears to be quite favorable, with considerable improvements thus far and research still in the early stages regarding enhanced growth rates, reduced water/nutrient requirements and plant optimization for specific bio-refining processes.

Rough estimates regarding feasibility of using seawater to irrigate the Sahara for food and [primarily] Biomass are , with oil at \$60/barrel, not

ridiculous and for certain areas appears to be favorable. 1.2 Acre-meters of water per year is nominally required to produce Biomass. An acre produces 10-to-40 tons of Biomass/year and a ton of biomass is equivalent, energy-wise, to nearly 3 barrels of oil. Therefore the estimated “value” of an acre of Biomass, after refining, could be as high as \$3300. It would appear to be worthwhile to pursue further definitization of Sahara biomass production using Seawater irrigation near dry and flatish coastal areas as well as inland wherever the seawater pumping economics are reasonable. Saline irrigation could also be utilized wherever saline aquifers are available at reasonable pumping depths. It should be emphasized that what makes such an approach interesting now is the increasing cost of oil and the unique characteristics of biodiesel vs. hydrogen as a transportation fuel [utilization of existing infrastructures and lack of “storage problems”]. Given the innate desert advantage of plentiful and intense sunlight the emerging inexpensive Plastic/nano photovoltaics could perhaps be used to generate “inexpensive” pumping power for more “inland” and “higher” [elevation] seawater irrigation activities. The average inland Sahara elevation is some 450 meters, with a vertical lift pumping cost the order of \$1200 for the requisite 1.2 acre meters[in the absence of such less costly [solar] power.

Additional Impacts/Benefits of Saline/Seawater Agriculture

Seawater/Saline agriculture utilizing “improved” Genomic versions of Halophytes offers the potential to significantly contribute to the “solution” of many-to-most of the current/emerging societal/global problems. The obvious first order contribution[s] concern/address global warming, energy and food. Additional issues addressed by Saline/seawater Agriculture include land, water and minerals. Seawater irrigation can convert major areas of the planets “wastelands” into productive land, addressing the increasing shortage of arable land. By substituting in many cases seawater for fresh/sweet water in agriculture seawater agriculture “returns” some of the 66+% of the available fresh water we now use for conventional agriculture crop irrigation back to/for other human uses, a major favorable potential impact upon the increasing water scarcity problem. In the minerals arena, conventional mining is one of the most environmentally damaging activities conducted by humans. Seawater contains a large number of minerals which could both put missing/trace minerals back into the food supply and be recovered after evaporation. Current seawater mineral extraction activities involve magnesium, bromide, salts, phosphorites, and metallic sulfides. There are also nascent low cost bio/algae extraction

technologies. Although it is projected that the nature of the soils in coastal deserts such as the Sahara, Peru, Australia, The Middle East, South West U.S., etc. should allow much of the salts to leach back into the Ocean technological processes could probably be developed to capture/utilize such if the economics is favorable.

Seawater Irrigation upon coastal deserts could also have impacts upon local-to-regional atmospheric water and heat balances [Boucher et al 2004]. Such irrigation produces cool and wet surfaces which increase low level atmospheric instabilities, leading to increasing incidence of storms. Various studies indicate that irrigation and associated vegetation changes have a direct influence upon atmospheric moisture content and produce increased rainfall. Therefore Irrigation could be considered a mild form of “Terraforming”. There are some indications that, for North Africa, greatly increased vegetation cover could affect continent-scale atmospheric motions as the interaction between the atmosphere and land cover in North Africa appears to be non-linear [Raddatz 2004]. Therefore serious predictive computations and model studies should probably be undertaken previous to any large irrigation efforts in the region to ensure that any “unintended consequences” are “favorable”. Such studies should include the atmospheric particulate loading, which can allow cloud formation at .1% saturation [Mason & Ludlam 1951].

Summary

The combination of the incipient demise of “cheap oil” and increasing evidence of Global “Warming” due to anthropogenic fossil carbon release has reinvigorated the need for and efforts on “Renewable” energy sources, especially for transportation applications. Biomass/Bio-diesel appears to have many benefits compared to Hydrogen, the only other major renewable transportation fuel candidate. Biomass Production is currently limited by available arable land and fresh water. Conventional Wisdom indicates that Saline soil and water are highly detrimental-to-devastating to sweet water agriculture. There is, however, an alternative approach to agriculture utilizing bio-engineered versions of the more than 2000 natural Halophytes [Salt Plants]. Experiments indicate that Saline/Seawater Agriculture using this plant stock can provide conventional agriculture productivity using what are regarded as deserts or wastelands [some 44% of the planets land mass]. Many of these deserts are adjacent to Salt Water Oceans/Seas. Fuels produced from the enabled/resulting biomass are CO₂ Neutral [plants take up the CO₂] and viable alternatives to increasingly expensive petroleum. To

the extent that such Saline agriculture replaces conventional agriculture for food production Fresh Water would be "released" back for direct Human use. Thus far Saline Agriculture is essentially an experimental activity worldwide with considerable promise for major productivity increases. Halophyte Plants and seawater irrigation proffer a wholly new biomass production mantra – using “wastelands” and very plentiful seawater. Such an approach addresses many-to-most of the major Societal Problems including Land, Water, Food, Warming and Energy. For many reasons including seawater agriculture portions of the Sahara appear to be viable candidates for future Biomass Production. The apparent nonlinearity between vegetation cover and atmospheric conditions over North Africa necessitates serious coupled boundary layer Meteorology and Global Circulation Modeling to ensure that this form of “Terra Forming” is Favorable/avoid adverse “Unintended Consequences”.

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