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- Currently the U.S. power consumption is about ten thousand watts per person, averaged 24/7/365, and is mostly derived from fossil fuels.
- Preventing severe global climate change and replacing depleted fossil fuels requires that the source of that power be switched from fossil carbon to sustainable sources as quickly as possible.
- Macrocystis pyrifera, also known as Giant Kelp, has numerous advantages when farmed in the open ocean:
    - it does not compete with agriculture for land
    - it does not compete for fresh water
    - it does not compete for fertilizer since deep ocean resources are used[1]
    - it is relatively easy to process because it has no lignin and little cellulose[2]
    - it is fast-growing[3] at ~30 cm/day, and average photosynthetic efficiency of aquatic biomass is 6-8%, which is higher than terrestrial biomass at 1.8-2.2%[4]
    - it has a non-destructive harvest, leaving the base of the plant in place to grow further
    - it is not seasonal, and can be harvested 3-4 times per year[5]
    - it has demonstrated yields at >15 dry ash free tons per acre per year with individual plants producing three times the average 15 ton yield[6]
    - has co-products such as potash, iodine and bromine with commercial value that can contribute to early revenue streams[7]
    - has production volume in the open ocean that, at ~1 Watt/m^2, can expand to supply all the energy requirements of the projected peak world population at the current U.S. per capita rate of consumption.
- Marine BioEnergy, Inc. has an analysis that indicates that kelp can be delivered to the dock in California at an energy price comparable to coal (<$2/MMBTU or $2/GJ) and can be converted to pipeline-quality methane at a price comparable to the current (fracking-reduced) price of natural gas (~$3.50/MMBTU).
- It is likely that the low price of natural gas will spawn an industry to convert natural gas into liquid fuels. Kelp-derived methane can feed this industry with no modifications.
- Note that BAL (Bio Architecture Lab founded in Berkeley and partnered with Dupont) has an ARPA-E grant and funding from the government of Chile to research the conversion of kelp to butanol. Their effort to convert kelp to butanol could be critical to the future success of biomass fuels. The State of California needs to encourage BAL and similar efforts to locate in California.
- Marine BioEnergy, Inc. recommends the California Energy Commission craft calls that allow organizations to respond with macroalgae. As noted by others during the discussion of the Investment Plan on December 4, maintain flexibility in fuel types since various feedstocks (including macroalgae) can be used to produce various fuels and development of the feedstock and related fuels should not be artificially limited by the calls.

[1] Roesijadi, G., A.E. Copping, M.H. Huesemann, J. Forster, and J.R. Benemann, *Techno-Economic Feasibility Analysis of Offshore Seaweed Farming for Bioenergy and Biobased Products, Independent Research and Development Report*, IR Number PNWD-3931, Battelle Pacific Northwest Division, March 31, 2008, pp 4-5.

[2] Ross, A.B, J.M. Jones, M.L. Kubacki, and T. Bridgeman, "Classification of macroalgae as fuel and its thermochemical behavior", Bioresource Technology 99, 2008, pp6494-6504. See p 6497, and 6500-6501.

[3] North, Wheeler J., ed. *The Biology of Giant Kelp Beds (Macrocystis) in California*, Verlag Von J. Cramer, publishers, Lehre, Germany 1971, Chapter 4 - Photosynthesis and general development in Macrocystis by Clendenning, K.A., p189.

[4] Ross, 2008, page 6494.

[5] Bird, K.T. and Benson, P.H. Eds, *Seaweed Cultivation for Renewable Resources* Developments in Aquaculture and Fisheries Science, Vol 16, Elsevier Amsterdam NL, 1987, p83.

[6] Tompkins, A.N., Marine Biomass Program, Annual Report, January - December 1982, for Gas Research Institute Contract No. 5081-323-0452, March 1983, page 6-1/6-2.

[7] Tompkins, A.N., 1983, page 5.5-12.