Roadmaps for powering the world, U.S., and individual states for all purposes with wind, water, and sunlight

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Global warming, air pollution, and energy insecurity are three of the most significant problems facing the world today. This talk discusses these problems and technical and economic plans to solve them by powering 100% of the world, individual countries, and states for all purposes, including electricity, transportation, industry, and heating/cooling, with wind, water, and sunlight (WWS) together with efficiency measures, within 20-40 years. New specific plans for New York and California are discussed. Relevant papers are at http://www.stanford.edu/group/efmh/jacobson/Articles/I/susenergy2030.html.

Impact of iron limitation on marine unicellular diazotrophic cyanobacteria

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Marine diazotrophic cyanobacteria are able to use dissolved dinitrogen (N_2) as nitrogen source for primary production. These cyanobacteria play a key role in the global carbon and nitrogen cycles as they contribute to significantly increase the oceanic N pool and thus primary production and carbon export to deep ocean. Due to the high iron (Fe) content of nitrogenase, the enzyme required for N_2 fixation, and to its low solubility in seawater, Fe is widely suspected as a key controlling factor of the activity of diazotrophic cyanobacteria. Nevertheless, the influence of Fe limitation on the recently discovered unicellular diazotrophic cyanobacteria (UCYN) is poorly understood. To address this knowledge gap, we conducted culture experiments on the UCYN *Crocosphaera watsonii* WH8501 growing under a range of bioavailable Fe concentrations (from 0.017 nM to 2.53 nM). Overall, severe Fe limitation leads to significant decreases in growth rate (-60%), C, N and chlorophyll *a* contents per cell (-70%), N_2 and CO_2 fixation rates per cell (-90%) as well as in cell volume (-60%). Regarding these cellular contents and fixation rates on a volumetric basis we highlight two distinct responses of *Crocosphaera watsonii* depending on the degree of Fe limitation: (i) under low Fe deprivation, cells only reduced their volume while their growth rate, cellular contents and N_2 and CO_2 fixation rates per μm^3 remained maximum, and (ii) when increasing Fe deprivation, cell volume remained unchanged while growth rate, cellular contents and N_2 and CO_2 fixation rates per μm^3 strongly decreased. The half saturation constant for growth with respect to bioavailable Fe of *Crocosphaera watsonii* was 70% lower than that of the large diazotrophic filamentous cyanobacterium *Trichodesmium*. This indicates that UCYN are better adapted to poor Fe environments than large filamentous diazotrophs. Furthermore, the physiological response of *Crocosphaera watsonii* to Fe limitation was different from that shown in a previous study on the UCYN *Cyanothece* sp, indicating potential differences in Fe requirements or Fe acquisition within the UCYN community. Conclusively, our results contribute to a better understanding of how Fe bioavailability can control the activity of UCYN and explain the biogeography of diverse N_2 fixers in ocean.

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