Table S1. ECE calculation of combining the light cycle method of 2 min light/3 min dark [1] with the substrate limitation method [2], which is expected for sustainable bioH$_2$ production by preventing inactivation of hydrogenases by O$_2$ and competition by the Calvin cycle, respectively.

Conditions	Production rate or yield
Illumination regime [1]	2 min light/3 min dark
Medium [2]	Acetate and carbon free
Light intensity (I$_r$) [1]	370 μE m^{-2} s^{-1}
Average rate of bioH$_2$ production (n$_a$) [1]	49 μmol (mg Chl)$^{-1}$ h^{-1}
Alga DW per m^2 (based on 2 g DW per L alga culture & a culture depth of 10 cm) [3]	200 g m^{-2}
Amount of Chl per m^2 (C, at 30 μg ml^{-1}, corresponding to ~1.5% of DW) [3]	3 g m^{-2}

Calculations	Algorithm	Production rate or yield
H$_2$ energy (E$_H$, based on E$_0$ 286 KJ mol^{-1}) [4]	E$_H$= nE$_0$= n$_a$CE$_0$	42042 J
Light energy (E$_L$, based on 1 h of illumination) [3]	E$_L$= tE$_{L0}$= tN$_A$I$_r$hc/λ *	289546 J
ECE (%) [3,4]	ECE (%)= 100 E$_H$/E$_L$	14.5 %

* N$_A$ the Avogadro constant 6.02 ×10^{23}, h the Planck constant (6.62×10^{-34}), c the light velocity (3×10^8 m/s), λ the light wavelength. For solar energy, 550 nm is used as an average light wavelength.

Table S2. Amount of nonarable land needed to supplement 30% of oil consumption for different regions around the world based on replacement by algal $bioH_2$ with two scenarios of high and low ECE, i.e. 14.1% and 2.5%, respectively.

Location		Typical $bioH_2$ production with 14.1% ECE, kg m^{-2} yr^{-1}	Nonarable land, ha	30% of transportation fuel consumption, L yr^{-1}	$BioH_2$ required for 30% replacement, kg yr^{-1}	$BioH_2$ production with 14.1% ECE, kg yr^{-1}	Nonarable land required, %	$BioH_2$ production with 2.5% ECE, kg yr^{-1}	Nonarable land required, %
Australia	Learmonth	8.2	2.74E+08	1.63E+10	4.16E+09	2.25E+13	0.019	3.98E+12	0.104
China	Guangzhou	4.8	2.22E+08	1.90E+11	4.85E+10	1.07E+13	0.455	1.89E+12	2.567
Colombia	Magdalena	7	3.80E+08	4.43E+09	1.13E+09	2.66E+13	0.004	4.72E+12	0.024
India	Trivandrum	6.9	6.08E+06	5.99E+10	1.53E+10	4.20E+11	3.644	7.44E+10	20.555
Japan	Fukushima	4.7	9.16E+04	7.61E+10	1.94E+10	4.31E+09	451.178	7.63E+08	2544.645
Russia	Poltavka	3.9	2.41E+08	5.15E+10	1.31E+10	9.40E+12	0.140	1.67E+12	0.789
United States	Hawaii	7.4	7.03E+07	2.86E+11	7.30E+10	5.20E+12	1.403	9.22E+11	7.914

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