**N = f{Cy • CE • MF • Area • (GC)-1 • (Ep)-1}**

= 7.8 x 1011 people

**≈ 800 Billion People**

*(about 100 times our current population)*

*(Up to 100 times that or 80 trillion people if the oceans are farmed intensively for plant food rather than meat)*

| **Factor** | **Description** | **Units** | **Value** | **Reference Values** | **Source** | **Comment** | **M[[1]](#footnote-1)** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Factors Directly Proportional to Carrying Capacity*** |
| Cy | Crop yield | Kg/m2 | 2 | (250 -300 bu/acre)top corn yield, hypothetical(18,750 Kg/hectare)corn yield, top US county(2750 Kg/hectare)wheat-Afghanistan10,000 m2/hectare | USDAUSDAWikipediaLookup | Crop yield is a function of soil, climate, irrigation, fertilizers and pesticides, agricultural practices, and, importantly, drying, among others. I used the productivity of the US county with the highest yield in 2008, rounded up, as a basis here; some believe this can be increased significantly, say by a factor of 10 or more, especially with genetic engineering. Yields from low intensity agriculture are about 10% - 30% of those from the most intensively farmed fields (note the yield of Afghanistan wheat). | 0.1to10 |
| CE | Crop Energy[[2]](#footnote-2) | J/Kg | 2.5x107 | (2805KJ/mole)glucose(314,000 Btu/bushel)corn | WikipediaInternet | Energy (Enthalpy) content of crops is the energy released when burned. Here I use an energy density value for pure glucose. I suspect the energy densities of “crops in the silo” are less due to more complex carbohydrates and residual moisture content. This should be a lookup parameter for various crop types, I just haven’t found the right web site yet. However, I suspect the range is quite small and the value of glucose is a close approximation. This parameter cannot be significantly increased. | 1 |
| MF | Metabolized Crop Energy | Fraction | 0.1 | (3000 Kcal/Kg)pigs(~1.2 x 107 J/Kg)Estimates from 2.4% to 30% | Internet ArticleInternet | Fraction of crop (food) energy, Ecc, extracted by human metabolism. An internet article on pigs indicated about 3000 Kcal/Kg were extracted from feed. This yields about 50% extraction, seemingly high. Other estimates range from <1% to >30%. Most mammalian metabolism rates are probably similar and not subject to much variabilty. However I am having trouble finding data on this parameter. I use a value of 10% here, but it is likely lower, probably not higher. | 1 |
| Area | Cultivated Land Area | m2 | 5x1012 | (1.38 x 106 Km2)Arable land(4.88 x 106 Km2)Cultivatable Land(1.48 x 108 Km2)Total Land Area(5.10 x 108 Km2)Total Earth's Surface(3.10 x 108 Km2)55N to 55S | WikipediaLookupCalculated | Total land used for food production depends on many factors including energy for irrigation and fertilizer, genetic engineering, hybridization, climate, topography, competing land uses, preservation of parks, and two noteworthy variables, biofuels and timber harvesting, etc. I use 5 x 1012 m2, an estimate of "cultivatable" land. Total land area, total area of earth, and land area in the 55N to 55S latitude zone are shown for comparison. This latter zone receives more than about 100 W solar energy at the surface and can support intensive agriculture, including possible algae farms on the oceans, hybridized of course for palatability, packaged as eye and nose candy, and labeled such as “reconstituded Tilapia” or “Soylent Green” | 0.1to100 |
| ***Factors Inversely Proportional to Carrying Capacity*** |
| GC | Growing Cycle Length | s | 3.2x107 | 1 year | Lookup | Energy extracted from a site cycles each year, so the power extracted from crops land is the energy (Joules) divided by the seconds in a year. | 1 |
| Ep | Energy per person | Watts (J/s) | 70 | 70Kg, 10o C ΔT70 W | CalculatedWikipedia | Total energy dissipation (consumption) of a typical human. This parameter well known and very narrowly defined. However, dog breeding has shown that we can significantly decrease the size of individuals (chihuahuas) but not increase it much (compare wolves, the original stock to Labrador Retrievers, for example). So we could probably reduce our physical size by a factor of 10 or so, increasing the carrying capacity for human souls by the same factor. | 1 |

Note: such extravagant food production would require extravagant energy. Strip mining about 100 meters of the earth’s land surface could provide about 10 x 1024 Joules of energy, as follows:

1.48 x 1014 m2 (land area) times

100 m depth ≈ 1.5 x 1016 m3 times

2.7 x 103 Kg / m3 (density of granite) ≈ 4 x 1019 Kg times

3 x 10-6 (U concentration in the earth’s crust) ≈ 1.2 x 1014 KgU times

7.2 x 10-3 (fraction of U235 in Utotal) ≈ 8.6 x 1011 KgU235 times

8 x 1013 J / KgU235 ≈ 6.9 x 1024 J. (U235 energy in upper 100 m of earth)

Current world energy consumption is about 15 TeraWatts or

1.5 x 1013 J\s times

3.15 x 107 seconds in a year ≈ 2.25 x 1020 J /yr (Current world energy consumption)

so U235 in the just the upper 100 meters of land (current strip mining depths) provides about 30,000years of energy at present consumption rates, BUT would require a lot of energy to dig it out[[3]](#footnote-3). Getting at U235 and others like Th233 and K40 from granite currently requires more energy than is released, possibly a thermodynamic limit, but, who knows, this analysis is about limits, not plausibility and focused intersecting neutrino beams could shatter granite, perhaps at low cost, similar to how focused lazer beams now etch solid clear glass, at, I assume, high energy cost.

Be that as it may, if current per capita energy-use rates of

2.25 x 1020 J / yr total energy use divided by 7 x 109 people) **≈** **3.2 x 1010 J / yr / person**

persist at the calculated population capacity of 8 x 1011 people, annual energy use would be 2.6 x 1022 J / yr, or just about 300 years’ worth of the energy in the U235 in the upper 100 meters. But I think you get the drift, lots of carrying capacity remains and lots of energy is probably available. So? Let the good times roll? Or conserve? Or do what we seem to do, claim to try to conserve (achieving a little efficiency at the margins, where we argue no end) and decry hedonism while increasing population and per capita energy consumption, BOTH exponentially.

1. Multipliers to account for ranges of possible parameter values [↑](#footnote-ref-1)
2. Agricultural “Capture” power = Cy **•** CE **•** secondsgrowing season,; for a 150 day growing season, = 2Kg/m2 **•** 2.5 x 107 J/Kg **• (**1.3 x 107 s)-1 = 6.5 J/s, thus 6.5 Watts, which is a little less than 5% of solar radiation incident at the earth’s surface of about 150 Watts (annual average at 45oN latitude); if we capture about 10% of that during metabolism, it seems the best we can do for food is about 0.5% of solar insolation. [↑](#footnote-ref-2)
3. Note: For any energy source, of course, net energy available for end use is Enet = Esource(in situ) – Eproduction, or its close corollary, ($net = $sales - $productio)amortized [↑](#footnote-ref-3)