Correction to Schwartzman, D. and P. Schwartzman, 2013, A rapid solar transition is not only possible, it is imperative! African Journal of Science, Technology, Innovation and Development 5(4): 297-302. (revised January 12, 2016)

Carbon-sequestration from the atmosphere must be a component of a solar transition

Carbon sequestration from the atmosphere is imperative, and must start in the near future since the longer the excess carbon dioxide remains in the atmosphere the more likely the tipping points for C3 will be reached. Only the thermal inertia of the oceans responding to the now unsafe and ever rising atmospheric level of CO2 near 400 ppm gives us a short window of opportunity (Hansen et al., 2008, 2011). Following the analysis provided in Hansen et al. (2008), to have any chance of avoiding catastrophic climate change a prevention program must include carbon-sequestration from the atmosphere to achieve an atmospheric CO2 level at or below 350 ppm as soon as possible. A follow-up study recommends a 6% cut per year in fossil fuel consumption starting now, with 100 Pg of carbon sequestered from the atmosphere by reforestation from 2031–2080 leaving 350 ppm CO_2 in the atmosphere by 2100 (Hansen et al., 2011).

Lal (2010) estimates 2–4 Pg per year of carbon from the atmosphere could be sequestered globally as soil carbon from the atmosphere using agroecological approaches. Assuming a rate of 2 Pg/year, in 50 years 100 Pg of carbon could be sequestered from the atmosphere. A likely complementary approach is solar-powered industrial carbon sequestration from the atmosphere, for example, burying carbon as carbonate in the crust. Some preliminary estimates are now available for the energy required for this industrial sequestration. For example, if 100 billion metric tons of carbon, equivalent to 47 ppm of atmospheric CO_2, were industrially sequestered from the atmosphere it would require 5.9 to 18 years of the present global energy delivery (18 TW), assuming an energy requirement of 400 to 1200 KJ/mole CO_2 utilizing a solar-powered high efficiency source of energy (House et al., 2011; Zeman, 2007). This requirement would of course be reduced by the use of agriculturally-driven carbon sequestration into the soil, as we pointed out in our 2011 and 2013 papers. This sequestration program will be imperative for the rest of this century and beyond because approximately half of the anthropogenic (caused by humans) carbon dioxide emissions go into the ocean and biota, which continuously re-equilibrate with the atmosphere (Cao and Caldeira, 2010; Gasser et al., 2015).

In our computed solar transition generating progressively increasing global energy delivery over 25 years, assuming an EROEI value of wind/solar power equal to 25 (same as their lifetime in years), a total of 18.5 ZJ is consumed, with wind/solar generating 54%, and industrial carbon sequestration energy requiring 5 to 20% of the total (Note 1). This requirement would of course be reduced by the use of agriculturally-driven carbon sequestration into the soil.

Note 1. Let "RE" be wind/solar energy as previously defined for our solar transition. Here is the function used for progressive phase-out of non-RE energy sources over the assumed 25 year transition period, with t being the time in years: $FF = 1 - 0.015\,t - 0.001\,t^2$; $\int FF dt$ from t = 0 to 25, gives a non-RE energy sources equal to 15.1 times the present annual global energy consumption level (18 TW year = 0.57 ZJ) or 8.6 ZJ. Smil (2008) cites

Ahlbrandt et al. (2005), who estimated the proven conventional natural gas reserves equal to 7.24 ZJ (55% of 415 Tm^3). With an assumed 1,354 bb for the proven conventional oil reserve (equivalent to 7.9 ZJ) this gives a total equal to 15.1 ZJ for proven conventional oil plus gas reserves ("petroleum"). Then the 8.6 ZJ for non-RE energy computed from our robust solar transition is equal to 57% of this proven petroleum reserves. (The 'proven' reserves cited do not include tar sands, oil shale or fracked gas). From Figure 2, Hansen et al. (2013), the total of "estimated" plus "recoverable resources" of conventional oil and gas can be computed, roughly equivalent to 26 ZJ (14 ZJ gas, 12 ZJ oil*). For this estimate, the 8.6 ZJ computed from our robust solar transition is equal to 33% of potential energy of recoverable conventional petroleum still in the crust. Since coal, nuclear power as well as hydropower and biofuels now contribute to global energy consumption, and will during their phase-out in a full transition to RE, the computed petroleum contribution is a maximum.

* Assumed values of 51.4 Gt CO_2/ZJ for gas, 68 Gt CO_2/ZJ for oil.

Additional references cited:

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Other references are given in Schwartzman and Schwartzman (2012), available for download on this website.