Limiting Global Climate Change **Gordon Taylor** **2016-12-19**

Global climate change is the most urgent problem faced by humankind. Professor Will Steffen of the Australian National University and co-authors have shown that the earth is liable to many tipping points, several subject to positive feedbacks. (http://www.growerssecret.com/hs-fs/hub/65442/file-571304591-pdf/docs/a%E2%80%93safe-operating-space-for-humanity.pdf) Unless there is a rapid transition to 100% renewable energy, humankind will lose control of climate change, with the planet entering the Anthropocene era. Severe global warming of 4 - 8 C would disrupt world food supplies, leading to mass starvations, migrations and war. Moreover, Professor Peter Wadhams of Cambridge University has shown that the Arctic Ocean is losing it's ice cover for longer each year. By warming the sea-bed below the fringes of the Arctic Ocean, this is allowing the release of methane – a very powerful greenhouse gas. This is mentioned on Page 5 of: 'Some Comments on IPCC AR5 and the omissions of significant 'Feedback Effects' from the Climate-Models used in its preparation'. (https://issuu.com/aubreymeyer/docs/ipcc_ar5_underestimates_climate_cha).

I recently found the paper: 'The sower's way: quantifying the narrowing net-energy pathways to a global energy transition', by Sgouridis et al. (http://iopscience.iop.org/article/10.1088/1748-9326/11/9/094009/pdf and http://iopscience.iop.org/1748-9326/11/9/094009/media/erl094009_suppdata.pdf). This is extremely important, as it estimates transition pathways based on the fossil fuel emissions cap and phase-out profile and on the characteristic energy return on energy invested (EROI) of the renewable energy (RE) technologies installed. The study assumes initial weighted-average EROIs for the renewable energy technologies of 20, with sensitivities from 6.67 to 60. With 20, solutions are still possible for global warming of 2 C. However, even the easiest pathway requires installation of RE plants to accelerate from 0.12 TW p yr –1 in 2013 to peak between 7.3 and 11.6 TW p yr –1 in the late 2030s, for an early or a late fossil-fuel phase-out respectively in order for emissions to stay within the recommended CO 2 budget. This implies increases from 2013 to the late 2030s of 61 to 97-fold.

As an example, the EROI of a 3.3MW Vestas wind turbine in medium wind conditions is about 38 and in high wind conditions 44. ('Life Cycle Assessment of Electricity....', http://www.vestas.com/~/media/vestas/about/sustainability/pdfs/life%20cycle%20assessment_v112-3%203mw_mk2c_version_2_1_210915.pdf) and the EROI of a 2/2.3MW Enercon wind turbine for inland sites is about 35, near-coastal sites about 41 and coastal sites 51. ('ENERCON receives certificate for life-cycle assessment', http://www.enercon.de/fileadmin/Redakteur/Medien-Portal/windblatt/pdf/en/WB_02-2012_en_web.pdf).

In comparison, the EROI of nuclear power plants is only about 5. ('Life cycle energy and greenhouse gas emissions of nuclear energy: A review', http://fulltext.study/preview/pdf/765138.pdf). Moreover, nuclear power is not 'low-carbon'. See: 'False solution: Nuclear power is not 'low carbon', Professor Keith Barnham. (http://www.theecologist.org/News/news_analysis/2736691/false_solution_nuclear_power_is_not_low_carbon.html).
So for equal energy invested, the electricity yield from wind turbines is at least seven times that from nuclear power plants. Moreover, nuclear power plants use depletable fuels, so they can be no part of a sustainable energy solution. Indeed, they would greatly reduce the solution-space available for limiting global climate change to 2 C.

A national solution and demonstration for limiting global climate change to 2 C is being actively pursued by Germany. Following the Fukushima nuclear disaster in March 2011, the German Government established an Ethics Commission. ('Germany's energy transition – A collective project for the future, produced by the Ethics Commission for a Safe Energy Supply', Berlin, 30th May 2011, https://www.bundesregierung.de/ContentArchiv/DE/Archiv17/_Anlagen/2011/05/2011-05-30-abschlussbericht-ethikkommission_en.pdf). Page 4 includes: 'The withdrawal from nuclear energy is necessary and recommended to rule out future risks from nuclear in Germany. It is possible because there are less risky alternatives'. Also Page 16 includes: 'The Ethics Commission has come to the opinion that a safe energy supply can be achieved which provides more jobs in business and manual trade without compromising environmental protection, whilst also avoiding a power shortage and having to import nuclear power. In the course of the energy transition, countless new businesses will be established and existing operations will extend their capacity and create new jobs'.

The German Government has therefore adopted the 'Energiewende' (Energy Transition). ('Energy Transition: The German Energiewende', 2012, 2016-07, http://energytransition.de/wp-content/themes/boell/pdf/en/German-Energy-Transition_en.pdf).

The German government recently published its Green Paper on Energy Efficiency and launched a consultation process inviting comments on the ideas put forward. (See: 'Germany Adopts "Efficiency First" Principle - Let's Work to Make it a Reality', 2016-10-28, http://www.raponline.org/germany-adopts-efficiency-first-principle-lets-make-it-reality/).

Germany recently launched the Power-to-X project, including Power-to-Gas, Power-to-Liquids, and Power-to-Chemicals. This will enable the use of wind and solar power in the transport and heat sectors that account for 80% of energy consumption, as well as the electricity sector of 20%. (See: 'Mit Power in die Energiewende', 2016-10-13, http://fz-juelich.de/SharedDocs/Pressemitteilungen/UK/DE/2016/2016-10-13-kopernikus-power2x.html).

The above paper 'The Sower's Way...' shows that for global climate change to be limited to 2 C, as agreed in Paris, all nations must adopt policies, plans and measures that are shown to meet the above criteria and none that do not. As a major developed industrial nation, Germany is demonstrating many that meet these criteria. Having adopted English-language names such as 'Power-to-Gas', 'Power-to-Liquids', and 'Power-to-Chemicals', it clearly sees major business opportunities in supplying these and other renewable energy technologies abroad as well as at home.