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MuseLetter #342 / August 2021 by Richard Heinberg

Callum Alexander from Scotland recently contacted me with a few queries about renewable energy. I thought they were interesting questions that might occur to others, so I asked his permission to publish our dialog.

Questions to Richard Heinberg from a 15-Year-Old Student

Callum: If you replace a coal- or gas-fired power plant with a solar and/or wind farm (with a back-up reliable energy source), will you reduce or possibly increase overall greenhouse gas emissions?

Richard: Most likely, emissions would be significantly reduced, though the degree of reduction would depend on the backup energy source (battery, natural gas power plant, hydrogen production and storage—there are several options). Solar and wind do offer emissions reduction; however, their widespread adoption is constrained by intermittency, materials requirements, and requirement for land space. And the efficiency of wind and solar generators is site-dependent. So, the analysis is complicated. Each case has to be evaluated separately.

Callum: If you compare the full life cycle of a fossil fuelled vehicle with an electric powered vehicle, or a biofuel powered vehicle, or a hydrogen powered vehicle—from resource extraction to beyond the vehicle's life—which vehicle overall causes most greenhouse gas emissions?

Richard: It would be a close race between the fossil fuel-powered vehicle and the biofuel-powered vehicle for the largest amount of emissions (most biofuel production uses more energy that it yields). Life cycle analysis (LCA) does show that battery-powered cars are responsible for fewer emissions overall, even considering energy for mining, etc., and even if the electricity that charges them comes from a gas power plant. However, this does not mean that electric cars are "sustainable" in an ecological sense, as they require materials that are depleting and that will, in some cases, be difficult to recycle.

Callum: If the entire world turned to 100% "green energy" overnight, what do you think would happen?

Richard: I'm not sure that's a useful thought experiment, as it assumes something (the feasibility of a full energy transition) that is exactly what is at issue. The transition cannot occur via magic wand; it will require investment,

time, and trade-offs. Our analysis at PCI suggests that scale is the biggest hurdle: it's only if we aim for a smaller energy system overall (in industrial countries, at least) that a transition is feasible. And even in the best case the end result will be an energy system that will not support the kind of economy we have now—i.e., one based on globalized manufacture and distribution, and constant growth in population and industrial output.

Callum: If we are to build the quantity of solar panels, wind turbines, and electric/storage batteries that is predicted by 2050, do you believe that we will be able to meet the Paris Climate Agreement?

Richard: Predictions for the build-out of wind and solar capacity are based on current installation and investment rates and trends, along with current economic and energy usage trends. If those trends continue, then there is no hope of meeting the Paris goals. Only if overall energy consumption is somehow constrained while we build alternatives is there any realistic path.

Callum: If demand for "green energy" increases, will demand for fossil fuels also increase (do "green energy" sources replace fossil fuels)?

Richard: Yes, a higher immediate demand for solar and wind generators would require more fossil energy for mining, panel/turbine manufacturing, transport, and installation. Only if society's *other* energy uses (for manufacturing consumer goods, travel, etc.) were significantly curtailed during the transition would GHG emissions actually be reduced.

Callum: How much land do you believe will be required to satisfy "green energy" demand?

Richard: It depends on society's overall energy usage. If we could somehow supply as much energy from renewables as we currently get from fossil fuels, the land requirements would be very significant, and would impact wildlife and, in some cases, agriculture. That's yet another argument for reducing overall energy demand.

Callum: Do electric, biofuel, and hydrogen powered vehicles make it somewhat more difficult to wean ourselves away from fossil fuel power?

Richard: The one thing we could do within the transport sector to ease and speed the transition would be to reduce transportation in certain modes, particularly air transport. Some vehicles are practical to electrify (bicycles, cars), while others aren't (planes, ships, big trucks). Biofuels are ecologically a dead end, and hydrogen is problematic because it leaks so readily, and because producing it is energy inefficient. Synthetic fuels made with hydrogen solve the leakage problem, but are even more inefficient. So: there are alternatives, all of which work in the laboratory, but each suffers from some serious practical drawback if scaled up. That's why we need to reduce transport and re-localize our economies as much as possible. As we do so, we should prioritize public transit and bicycles over automobiles of any kind, because bikes and well-designed public transit systems use much less energy and materials than cars—even electric cars.

Callum: Do you know how much energy is required to manufacture a single solar panel or wind turbine?

Richard: It depends on the specific device. You can find this information yourself by googling, for example, “solar panel LCA.” Today’s solar panels produce much more energy over their lifetime than the amount of energy used to mine materials, transport them, etc. However, because sunlight is intermittent, energy cost/yield balances ultimately have to be calculated at the system level—that is, you have to include the energy costs of batteries, transmission, etc. Doing so greatly reduces the “energy returned on energy invested” or EROEI of renewables.

Callum: I understand that if you advocate for “green energy” as a politician, it can attract millions of voters and supporters. However, do you believe that politicians understand the impact of manufacturing “green energy”?

Richard: Generally, no. They don’t.

Callum: I personally believe that burning biomass for energy is unsustainable and could further fuel the climate crisis. What do you think about burning biomass for energy?

Richard: On a small scale, it’s something we’ve been doing for hundreds of thousands of years. Once again, the problem is scale. We simply cannot get a significant proportion of energy (at our current scale of usage) from biomass, or we’ll end up burning the whole biosphere.

Callum: Do you believe that nuclear and geothermal energy are viable solutions to the energy crisis?

Richard: I’m more favorable toward geothermal (I live in northern California, where much of our electricity comes from a local geothermal plant). The environmental risks are relatively contained. Nuclear is more troublesome: the problem of waste storage hasn’t been solved, and when something goes terribly wrong (as at Fukushima), the results are beyond our ability to manage.

Callum: What other forms of energy are viable alternatives to wind, solar, biomass, and fossil fuels?

Richard: At small scales, micro-hydro can be useful. Large-scale hydro of course produces more energy, but also more environmental damage, and most of the best sites are already taken. There are some interesting ideas for putting wind turbines on giant kites that reach up to the lower stratosphere, but there are no commercial projects yet. The same with solar panels in space, beaming power down to Earth. Beyond those examples, you quickly get into the territory of speculation—which, in my view, includes nuclear fusion.

Callum: If some materials (such as rare earth materials and scarce metals) that are needed to manufacture solar panels, wind turbines, and electric batteries run out in a few decades, what do you believe will happen?

Richard: We can do a better job of recycling materials, but many materials degrade as they are recycled, and others are used in trace amounts that make them impractical to recover. Ultimately, we will have to return to a world not just of renewable energy, but mostly renewable materials—and it will be a slower way of life that’s lived closer to nature. In the best case, we will go through a transitional period in which we shrink our population and

energy/materials usage while minimizing casualties and preserving the best of what we humans have achieved in these last few decades of anomalous energy abundance.

Callum: Am I missing anything else?

Richard: Good questions! And good luck!