Would 10,000 nuclear power stations cook the planet?

Posted on 26 February 2010 by Barry Brook

 The following question (or variants thereof) have come up so many times in the comments on this blog that I think the answer deserves a post in its own right:

If we had thousands of nuclear power stations, the heat they produced would cause significant global warming — as such, nuclear power is not a solution to anthropogenic climate change.

Okay, let's look at a couple of ways to address this problem.

Prof. David Mackay of the University of Cambridge (and contributor to SCGI), had the following to say in his great book, *Sustainable Energy Without the Hot Air*:

If we got lots and lots of power from nuclear fission or fusion, wouldn't this contribute to global warming, because of all the extra energy being released into the environment?

That's a fun question. And because we've carefully expressed everything in this book in a single set of units, it's quite easy to answer.

First, let's recap the key numbers about global energy balance from p20: the average solar power absorbed by atmosphere, land, and oceans is 238 watts per square metre (W/m^2); doubling the atmospheric CO_2 concentration would effectively increase the net heating by 4 W/m^2.

This 1.7% increase in heating is believed to be bad news for climate. Variations in solar power during the 11-year solar cycle have a range of 0.25 W/m^2. So now let's assume that in 100 years or so, the world population is 10 billion, and everyone is living at a

European standard of living, using 125 kWh per day derived from fossil sources, from nuclear power, or from mined geothermal power.

The area of the earth per person would be 51 000 m^2. Dividing the power per person by the area per person, we find that the extra power contributed by human energy use would be 0.1 W/m^2. That's one fortieth (1/40) of the 4 W/m^2 that we're currently fretting about, and a little smaller than the 0.25 W/m^2 effect of solar variations. So yes, under these assumptions, human power production would *just* show up as a contributor to global climate change.

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Dr. George Stanford, also of SCGI, took a different tack:

Consider a global population of 7 billion people (7E9). Average solar power hitting the earth's surface at ground level is about 1 kW/m^2 x pi x $(6400\ km)^2$ = 1.3E14 kW. That's 18.4 MW (18,400 kW) per person from the sun.

In 2007, the U.S. used 101 quads of energy = 101 x 2.93E11 kWh = 3.0E13 kWh, for an average power usage of 3.4E9 kW. The population of the U.S. is about 300 million (300E8). Thus average power consumption per person = 3.4E9/3.0E8 = 11 kW [*Ed: check I -- this is 265 kWh/day in Mackay's terms, which is about right -- the US has about twice the energy use of Europeans*].

Thus if the whole world used energy at the per capita rate of the U.S., that would be adding 11 / 18,400 = 0.06% to the total energy input to the Earth system. (By the way, that's about 6 times the rate at which geothermal energy reaches the surface.)

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Here's another, simple way to look at it. Have a look at this page on Wikipedia on solar energy, in particular, this table:

Yearly Solar fluxes & Human Energy Consumption

Solar	3,850,000 EJ
Wind	2,250 EJ
Biomass	3,000 EJ
Primary energy use (2005)	487 EJ
Electricity (2005)	56.7 EJ

Primary (thermal) annual energy use by humans in 2005 was ~500 exajoules (EJ; see here for explanation of this and other energy terms), compared to 3.85 million EJ received from the sun. What if we quadrupled this thermal energy production by the year 2100, to 2,000 EJ/year? We would then be producing the equivalent of 0.05 % of the solar energy input.

In its 11 year solar cycle, the sun currently fluctuates between ~1,365 to 1,367 W/m^2. In percent terms this is a min-max variation at the top of the atmosphere of ~0.15 %. Compare to the above figure of 0.05 %, if humanity was producing 2,000 EJ of thermal energy per year — 1/3 of the sun's total variability. Given that the thermal [heat] energy from power stations would be released at the Earth's surface, and would thus tend to be trapped by tropospheric greenhouse gases, it would be more influential than top-of-the-atmosphere climate forcing, but still small compared to aerosols and GHGs.

So would the waste fission heat from 10,000 nuclear power stations, expelled into the environment via their cooling systems, cause significant global warming? Short answer: **No** [Long answer: Well, not really].

Based on the mid-point estimate of climate sensitivity, fast forcing yields 0.75°C of global temperature rise per W/m^2 of forcing. As such, Mackay's estimate of 0.1 W/m^2 would predict an equilibrium warming of 0.075°C for the worst-case scenario. Although this is definitely detectable, to put it in context, it is less warming than we've experienced in just the last decade due to increases in CO_2 and other greenhouse gases.

Currently, the direct heat (not CO_2) from our coal/nuclear power stations and oil/gas combustion might have contributed ~0.01°C to global warming, versus the observed warming over the last century of 0.8°C. Historically, thermal pollution could explain 1 – 2% of anthropogenic global warming.