### Long-Term Global Heating from Energy Usage

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Long-Term Global Heating From Energy Usage

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Abstract

Even if civilization on Earth stops polluting the biosphere with greenhouse gases, humanity could eventually be awash in too much heat, namely, the dissipated heat by-product generated by any nonrenewable energy source. Apart from the Sun's natural aging—which causes an approximately 1% luminosity rise for each $10^8$ years and thus about 1°C increase in Earth's surface temperature—well within 1000 years our technological society could find itself up against a fundamental limit to growth: an unavoidable global heating of roughly 3°C dictated solely by the second law of thermodynamics, a biogeophysical effect often ignored when estimating future planetary warming scenarios.

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Index Terms: 0416 Biogeosciences: Biogeophysics; 0315 Atmospheric Composition and Structure: Biosphere/atmosphere interactions (0426, 1610); 1011 Geochemistry: Thermodynamics (0766, 3611, 8411).
Long-Term Global Heating From Energy Usage

Even if civilization on Earth stops polluting the biosphere with greenhouse gases, humanity could eventually be awash in too much heat. Namely, the dissipated heat by-product generated by any nonrenewable energy source. Apart from the Sun’s natural aging—which causes an approximately 1% luminosity rise every 10 years and thus about 0.3ºC increase per century, or a 3ºC rise per million years—walk-watts per person) (Figure 1 places these and other energy budgets into a broad perspective [Chaisson, 2003]).

Rising Energy Use on Earth

Of relevance to the issue of global warming is the rise of energy use within the relatively recent past among our humankind ancestors, continuing on to today’s digital society and presumably into the future as well [Jevons, 1896; Christian, 2003].

- • hunter-gatherers of a few million years ago used about 1 watt per kilogram (0.55 kilowatt per person);
- • agriculturists of several thousand years ago used roughly 10 watts per kilogram (2.5 kilowatts per person);
- • citizens of the world today, on average, use approximately 50 watts per kilogram (2.5 kilowatts per person) and
- • residents of the affluent United States use around 250 watts per kilogram (12.5 kilowatts per person).

Such energy rate metrics have clearly risen over the course of recorded history. The cause of this recent rise is not population growth, these are power density values caused by the cultural evolution and technological advancement of our civilization. Figure 2 maps today’s per capita rate of energy consumption, globally [Energy Information Administration, 2007]. As the world population is projected to increase until at least the late 21st century, it might level off at approximately 9 billion people [United Nations Department of Economic and Social Affairs, 2006].

- • the total energy budget of society on Earth will likely continue growing for three reasons. First, world population is projected to increase to the point where the Sun’s natural luminosity rise for each 108 years and thus about 0.3ºC increase per century, or a 3ºC rise per million years—walk-watts per person) (Figure 1 places these and other energy budgets into a broad perspective [Chaisson, 2003]).

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Heat By-Products

Current fears of shortfalls aside, in the long term our true energy predicament is that the unremitting and increasing use of energy from any resource and by any technology eventually dissipates as heat at various temperatures. Heat is an unavoidable by-product of the energy extracted from wood, coal, oil, gas, and atoms, and any other nonrenewable source. The renewable, sources, especially solar, already beat Earth naturally, but additional solar energy, if beamed to the surface, also would further heat dissipated. Our planet.

Regardless of the kind of energy utilized, Earth is an astrophysical body, vastly bigger than the industrial society we already experience it in the big cities, which are warmest due to urban heat islands and near nuclear reactors, which warm adjacent waterways. Earth’s surface temperature is 306ºK, or 33ºC, which places it near the midpoint of the range, f and approximately18 terawatts, about two third of this is wasted. But with humanity’s power usage on the rise (~2% annually [International Energy Agency, 2004]) as our species multiplies and becomes more complex. society’s energy demands by the close of the 21st century will likely exceed 1000 terawatts—and much of that energy will heat our environment.

Until we use space-based arrays to redirect additional sunlight to Earth that would normally bypass our planet—then the surface temperature will rise. That is, even if we embrace coal and sequester all of its carbon emissions, or use nuclear fission or fusion to emit no greenhouse gases, these energy sources would still add enough heat above what the Sun’s rays create naturally at Earth’s surface.

Heating Scenarios

Estimates of how much heat and how quickly that heat will rise rely, once again, on thermodynamics. Because flux scales as $kT^4$, Earth’s surface temperature will rise about 3ºC (an IPCC “tipping point”) when (25/328)º, namely, when about 5ºC more than the 2ºC global average rise (25/328)º, namely, when about 5ºC more than the 2ºC global average rise (25/328)º, namely, when about 5ºC more than the 2ºC global average rise.
Riverine Flow and Lake Level Variability in Southern South America

Considerable attention was directed during the 12thWRI to the remote connection that appeared to exist between the Southern Oscillation (SO) and anomalous rainfall over southern Brazil, Paraguay, and northern Argentina (Mossmann, 1982). It was Gilbert Thomas Walker’s group, then in India seeking the prediction of monsoonal dynamics, that made the observation—seen with skepticism—that high volumes of flow along the Paraná River, as measured at the downstream Rosario (Argentina) gauging station, tended to occur during the negative phase of the SO, when surface level pressure (SLP) was anomalous northeast of the diagonal. However, in an austral summertime rainfall regime prevalent northeast of the diagonal that transports moisture along the corridor and 25ºS). Also important in the regional climate pattern is the southbound low-level jet (25ºS). This carries low-level moisture, and some seasonal variability, depending on ENSO, from the equatorial Pacific to the eastern Pacific Ocean, resulting in 40% of total precipitation in Paraguay (Fig. 2).

Fig. 2. Spatial dependence of energy rate density, or per capita power usage, across the globe today. Data from Energy Information Administration (2006).

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References


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