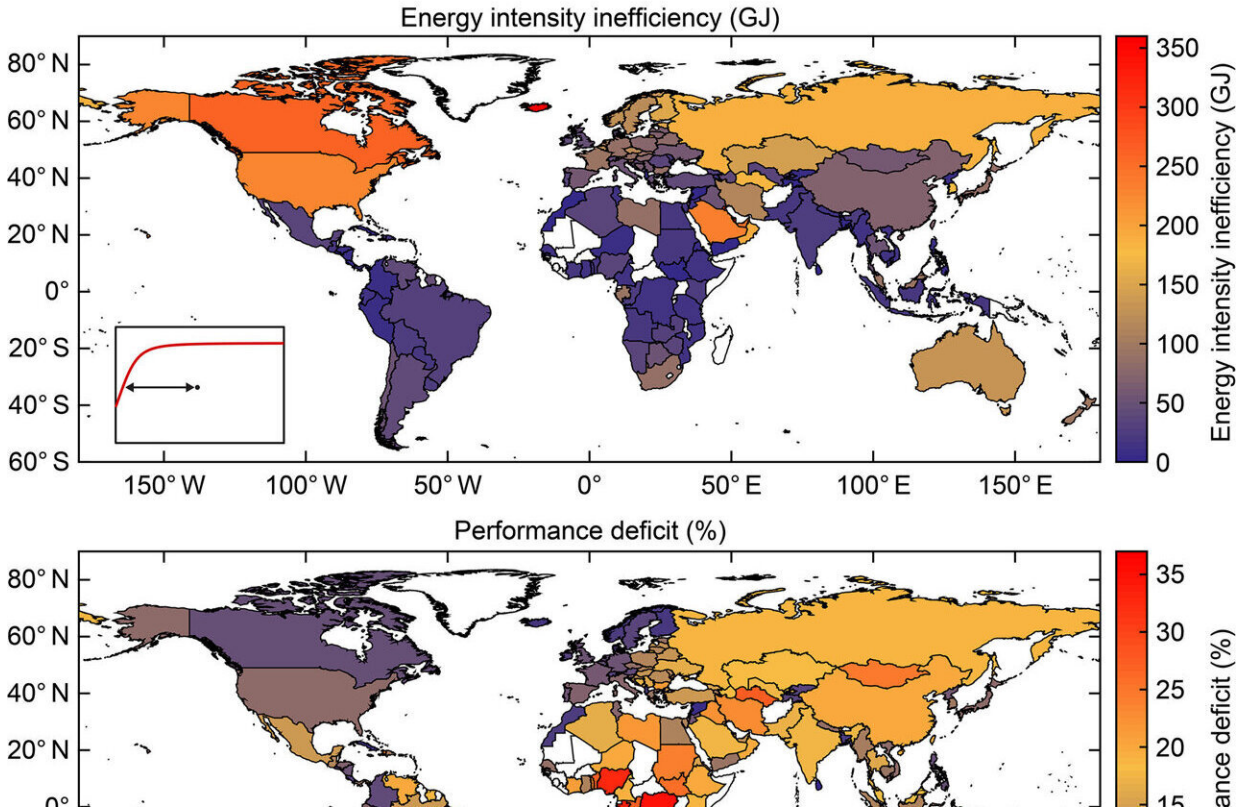
Study finds high energy use provides little benefit for health and well-being in richer nations

April 12 2022, by Josie Garthwaite



Top panel: Normalized scores by country averaged across nine metrics for countries individually and the maximum envelope fitted to them. Inset: Mean, range, and quantiles based on combining the nine maximum envelope functions in Figure 1. The two approaches estimate per capita energy thresholds of 74 and 58 GJ, respectively, at which 95% of maximum performance is observed. Middle panel: Energy intensity inefficiency, the horizontal difference between

the observed and minimum per capita energy consumption needed to obtain a given metric value. Bottom panel: Performance deficit, the vertical distance below the maximum potential for a given per capita energy use and a country's actual value. Credit: *Ecosphere* (2022). DOI: 10.1002/ecs2.3978

A good, long life requires energy: to illuminate hospitals, homes and schools, and make it possible to work, cook meals and study without inhaling toxic smoke or spending a full day collecting fuel. But at some point, energy stops being the limiting factor for well-being.

New research from Stanford University suggests that point—the threshold beyond which greater energy use loses its link to national-level improvements in measures of health, economy and environment—is surprisingly low.

The results, published April 12 in *Ecosphere*, suggest nations with high per capita energy use, such as the United States and Canada, could scale back consumption while maintaining or even improving well-being. Countries where energy poverty remains a challenge, meanwhile, may be able to maximize national health and prosperity with far less energy than scholars once thought.

The authors found today's average global energy consumption of 79 gigajoules per person could, in principle, allow everyone on Earth to approach the "maximum health, happiness and environmental well-being of the most prosperous countries today," if distributed equitably.

Finding the target

Other scholars have sought for decades to pin down the bare minimum of energy supply required per capita to achieve a decent quality of life.

Early estimates suggested a range of 10 to 65 gigajoules per person. "It's one thing to identify where people don't have enough energy; it's another to identify what our target might be," said lead study author Rob Jackson, professor of Earth system science at Stanford's School of Earth, Energy & Environmental Sciences (Stanford Earth). "How much additional energy needs to be provided?"

Answering this question is not just an academic exercise. It is central to mapping out how the world can achieve international climate goals while building out modern energy services for the 1.2 billion people who live without electricity and the 2.7 billion who cook on stoves linked to 3.5 million premature deaths each year from household air pollution.

"We need to address equity in energy use and greenhouse gas emissions. Among the least sustainable ways to do that would be to raise everyone to the levels of consumption we have in the United States," said Jackson, who is the Michelle and Kevin Douglas Provostial Professor at Stanford and a senior fellow at the Stanford Woods Institute for the Environment and at the Precourt Institute for Energy. "Even using renewables, that would have serious, possibly catastrophic consequences for the environment," because of the materials, land and resources required to supply hundreds of gigajoules per year for each of the 8.5 billion people projected to inhabit Earth in 2030.

Reducing global population size would also tamp down total energy and resource needs, Jackson said. But there are other ways to close the global energy gap with fewer emissions. The new research provides a gauge for measuring some of the human impacts of one of them: reducing per capita energy use in what Jackson called "energy profligate countries," while raising the rest of the world's energy supply to comparable levels.

Peak performance

The new conclusions derive from statistical analysis of energy-use data for 140 countries from 1971 to 2018, as well as global data for nine metrics related to human well-being. Many of those metrics align with the United Nations' Sustainable Development Goals, a set of objectives aimed at ending an array of inequities while taking the risks of climate change into account.

The researchers looked at the primary energy supply, which includes all energy production minus exports, international marine and aviation bunkers, and changes in the amount of fuel held in storage, for each of the 140 countries. They then separated out the total energy that goes into increasing well-being from the energy that is wasted or employed for other purposes, such as trade.

Recognizing that well-being is likely to be limited by multiple factors, including income and GDP, the authors examined whether per capita energy use could decline in some countries while maintaining quality of life.

Across most metrics, including life expectancy, infant mortality, happiness, food supply, access to basic sanitation services and access to electricity, the authors found performance improved steeply, then peaked with annual energy use averaging 10 to 75 gigajoules per person. That's less than the 2018 world average of 79 gigajoules per capita, and, at the higher end of the range, about a quarter of the U.S. average of 284 gigajoules per person.

U.S. energy use per capita has fallen slightly since the late 1970s, largely because of improvements in energy efficiency, but it remains high in part because of the nation's outsize demands for energy for transportation.

"In most countries that consume much more energy than the global

average, further increasing energy use per capita might only marginally improve human well-being," said coauthor Chenghao Wang, a postdoctoral scholar in Jackson's lab and also a research fellow at the Stanford Center for Longevity.

Return on excess

The new study reveals at least 10 countries punching above their weight, with greater well-being than most other countries using similar amounts of energy per capita. The high performers include Albania, Bangladesh, Cuba, Denmark, Finland, Iceland, Malta, Morocco, Norway and Sri Lanka.

Air quality stands apart from the other metrics examined by the authors, in that across 133 countries, it continued to improve with per capita energy use as high as 125 gigajoules. That's on par with the annual per capita energy use of Denmark in 2018, and slightly higher than that of China. One reason may be that the early stages of energy development have historically been dominated by dirtier fossil fuels.

In the U.S., energy use rose steeply after World War II—decades before federally imposed limits on pollution from tailpipes and smokestacks spurred improvements in the nation's air quality. "Wealthier countries like the U.S. tend to clean up their air only after they have built up wealth and the populace demands action," Jackson said.

Past research has shown that higher income "doesn't necessarily lead to better and happier lives," said study co-author Anders Ahlström, a climate scientist at Lund University who worked on the research as a postdoctoral scholar in Jackson's lab at Stanford. "Energy supply is similar to income in that way: Excess energy supply has marginal returns."

More information: Robert B. Jackson et al, Human well-being and per capita energy use, *Ecosphere* (2022). DOI: 10.1002/ecs2.3978