

Long-Term Energy Solutions: The Truth Behind the Silent Lie

The average reader of Albert Bartlett's article "Thoughts on Long-Term Energy Supplies: Scientists and the Silent Lie" (PHYSICS TODAY, July 2004, page 53) may not know that Thomas Robert Malthus anonymously published "An Essay on the Principle of Population as It Affects the Future Improvement of Society" in 1798. In it, he argued that population tends to increase faster than food supply and that, consequently, humanity should anticipate a future of subsistence living unless extraordinary measures are taken to control population growth. In a later revision of the essay, Malthus was somewhat more sanguine. Now, 200 years of history have certainly proven his thesis incorrect, at least in the context of market economies. Food has never grown scarce in modern market economies. Today, more people are fed more affordably and with larger varieties of food than ever before. Rather than starvation, the greatest food-related problem of modern societies is obesity!

It is therefore inexplicable that some people cling to the Malthusian logic when discussing modern economic issues. Bartlett argues that the conditions of the energy market call for a halt in population growth. Yet no economic data exist to support his claim. Although market dynamics occasionally impact the world economy otherwise, the downward overall trend in the real price of energy indicates faster growth in the supply curve than the demand curve.

In the past decade, energy has been cheaper than in previous decades even as total energy demand has grown to historic highs. Bartlett presents data indicating that world per capita petroleum consumption grew steadily through the period of US energy price regulation in the

1970s and has declined since the Carter administration's deregulation late in that decade. He incorrectly suggests that the data are evidence of production limitations "as production struggles to keep up with growing demand." However, his suggestion could only be supported if prices had been rising during the entire period. In fact, the declining price trend during that time is evidence that per capita demand for petroleum was slowing even while supplies were plentiful. Bartlett unwittingly contradicts his own thesis.

An important lesson following the deregulation policy of the late 1970s is that energy demand is quite elastic, meaning demand is flexible and responds readily to price (supply) change. Markets can accommodate limitations in energy resources without a halt in population growth. However, conventional fossil fuel resources are quite substantial: one hundred to several hundred years of current world consumption rates and growing, as technologies improve. Additionally, as Bartlett notes, unconventional fossil fuels, such as heavy oil, tar sands, shale oil, represent an even larger resource. Although those resources are accessible with modern technology, future prices and improved technology will dictate when they may be produced profitably. Nuclear fission technology brings another vast energy resource to market. The combined energy resources that are accessible with modern technologies, including breeder reactors, represent at least 1000 years of world energy demand, more than enough to accommodate market-controlled consumption growth for a long time.

Physicists and engineers continue to work on promising new energy technologies. Thermonuclear fusion technology will some day bring a well-known but presently inaccessible energy resource to market. The deuterium in the world's oceans represents an energy resource equal to 10 billion years of current world annual energy consumption.

Just as Malthus could not envision modern agricultural productivity, the most advanced scientists of his time couldn't possibly have been

cognizant of the vast energy resources available today, much less the concept of nuclear energy. It is superfluous to suppose a Malthusian thesis today in the case of energy resources and conclude that population growth must halt.

Nonetheless, market economies have a vital part in our avoiding the world that Malthus predicted. In the alternative—socialism—shortages can be expected regardless of population size; witness North Korea and the former Soviet Union. The tragedy of the periodic reemergence of the Malthusian thesis is that its advocates may have an impact on people unprepared to understand its flaws. The response can hamper liberal market economies and encourage socialist policies.

Mark Meier

(mameier@pdq.net)
Houston, Texas

Albert A. Bartlett claims that population growth is a major cause of societal problems. He goes on to state that physicists need to send the message to the public that solving the problems of carbon dioxide emissions and energy consumption requires the stopping of population growth. However, he fails to report that the world population growth rate is already falling. According to the US Census Bureau, the rate of world population growth peaked in 1963–64 at 2.2%; it is now around 1.3%. Even the absolute annual increase in population is declining, having peaked in 1989–90 at 87.4 million. Currently, world population is increasing by about 74 million people annually; the growth rate is expected to continue falling for the foreseeable future.

The Census Bureau also reports that some projections show world population hitting a peak of less than 10 billion at some point in the next century.¹ Moreover, Bartlett's figure of 1% growth for the US includes growth from immigration, which has no bearing on world population growth. When immigration is excluded, the US population growth rate is only about 0.54%, and it, too, is decreasing.² Although the consequences of "steady, exponential

Letters and opinions are encouraged and should be sent to Letters, PHYSICS TODAY, American Center for Physics, One Physics Ellipse, College Park, MD 20740-3842 or by e-mail to pletter@aip.org (using your surname as "Subject"). Please include your affiliation, mailing address, and daytime phone number. We reserve the right to edit submissions.

growth" are serious, that is not the type of growth displayed by the world population.

Population stabilization will not solve the problem of energy consumption, though. Bartlett reports that energy consumption will increase by 59% between 1999 and 2020; that percentage greatly exceeds the expected growth in population. As the developing world seeks economic growth, we can expect energy consumption to continue to increase at a huge rate.

Given the decreased population growth, it seems unlikely that we can solve the world's energy problems by blaming them on population pressure. In fact, it appears that only the most draconian population control measures could possibly make the supplies of fossil fuels last longer. We are guaranteed to run out of fossil fuels because their supply is finite and more countries want increased access to them. If economic growth is to continue, we need to encourage conservation of energy resources, make our energy use more efficient, and look for replacements for depleted fossil fuels.

References

1. US Census Bureau, *Global Population Growth*, available at <http://www.census.gov/ipc/prod/wp02/wp-02003.pdf>.
2. US Census Bureau, *Components of Change for the Total Resident Population: Middle Series, 1999 to 2100*, available at <http://www.census.gov/population/projections/nation/summary/np-t6-b.pdf>; *Projected Population Change in the United States, by Race and Hispanic Origin: 2000 to 2050*, available at <http://www.census.gov/ipc/www/usinterimproj/natprojtab01b.pdf>.

Douglas Davidson
(davidson@bhcc.edu)
Black Hawk College
Moline, Illinois

Albert Bartlett's emotional update of the 1798 essay by Thomas R. Malthus does not mention several contemporary facts.

Recently I was studying some data on modern Russia. Now, after the breakup of the Soviet Union, the Russian Federation is experiencing the most massive population decline in recent centuries. Then I looked at Germany, now part of "old Europe." Particularly in the east, the government is quietly tearing down massive apartment complexes because there are no people to live in them or the people have moved west. And Japan is rapidly becoming the oldest population in the world because of the country's avoidance of fresh, young faces.

I began to wonder if Bartlett has ever paid attention to Charles Darwin. One of Darwin's great principles would seem to be that a species that fails to reproduce dies. Does Bartlett really want that to happen to us?

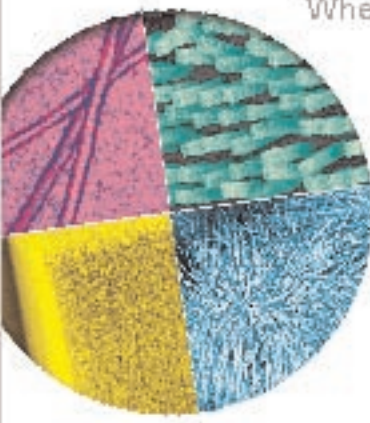
Frank R. Haig
(fhaig@loyola.edu)
Loyola College
Baltimore, Maryland

The article by Albert Bartlett causes me great concern. The suggestion that stopping population growth is necessary to address the

problem of finite resources seems intellectually irresponsible. Bartlett cites the ideas of mathematician Robert Malthus as obvious truth, but dismisses economist Julian Simon as a "nonscientist," even though Simon's field of study is precisely concerned with the way humans manage scarce resources. Mathematicians and physicists may be very good at applying mathematical models to situations controlled by predictable forces, but they should show some deference to "nonscientists" who have more experience

The EasyTube System

Where nanotechnology takes shape





We develop solutions for nanotube and nanowire synthesis. Our satisfied customers include many of the largest industry-leading companies and universities in the world.

- Achieve Control Over Nanotube and Nanowire Synthesis
- Intuitive Software Control
- Increase Productivity
- Repeatable Results
- Safe Operation
- Field Proven System Performance

First Nano's product line offers a new dimension to your choice in CVD equipment.

EasyTube™ 2000 – Platform architecture that allows for smooth integration of modular components for research and product development (pictured right)

EasyTube™ FED – Designed for Field Emission Display application development and substrate capacity up to 14 x 18 inch area

EasyTube™ System – The original turnkey CVD system for control over nanotube synthesis

EasyWire – Designed specifically for nanowire research and applications

EasyTube™ LT – A high quality tool for the budget-restricted lab.



FirstNano! 1015 Mark Ave. | Carpinteria, CA 93013 | Tel: 805.684.5111 | Fax: 805.684.5121
Toll-Free: 800.981.7008 | www.firstnano.com | Email: info@firstnano.com

dealing with the intelligent actions of humans.

Bartlett's attitude toward human freedom and human life is most disturbing. While chastising physicists for not telling people the truth about the need for population control, Bartlett is careful not to spell out exactly what population control entails. How does he intend to prevent too many children from being born? Will he ask people to please have only as many children as he tells them? Undoubtedly, some force from outside families would need to control their growth. Most likely, the government would have to impose penalties on individuals who have more than the allotted number of children. The idea of such a restriction on our freedom should make good Americans sick to the stomach.

Would Bartlett have the government throw the parents of "extra" children in jail? Should they pay a fine, so that the rich will pay money and the poor will pay Bartlett's inhumane cost? Perhaps the US should follow the lead of nations like China, where women have been forced to have abortions. Or maybe it should leave the children alone but kill the parents.

I suggest that consideration of the need for population control is more related to economics than to physics. In truth, however, it ranges even beyond that field: It calls into question the moral beauty of human life and the importance of human freedom. Let us keep this in mind as we ponder the wisdom of a vague notion of population control.

Gregory Weston
(gdweston@holycross.edu)
College of the Holy Cross
Worcester, Massachusetts

I commend Albert Bartlett for discussing the problem of overpopulation. In my experience, scientists almost universally agree that the problems of resource depletion and environmental degradation are intrinsically linked to population growth. And yet, more than 30 years after a US government report concluded that "no substantial benefits would result from continued growth of the nation's population,"¹ there is virtually no public discourse of the problem, at least in the US. The obvious reason for that lack is the rightward drift of the political center of mass over the past few decades, which has led to equating family planning with abortion.

The concept of family planning

has broad general approval in the US. This is evident in that 90% of women in this country give birth to three or fewer children in their lifetimes. The vast majority of Americans are exercising birth control, be it by abstinence, contraception, or abortion. They are asking, "What is the optimal number of people for my family?" And once they have an answer, they're taking steps to reach that goal. The goal of concerned scientists should be to persuade Americans to ask the same question, not just for their families but for the nation and the world. Breaking the silence on overpopulation will no doubt draw attacks from a vocal minority, but if there is one thing science should stand for, it is open debate of the facts. To remain silent is to abandon our responsibility to future generations.

Reference

1. Commission on Population Growth and the American Future, *Population and the American Future*, rep. commissioned by President Richard M. Nixon on 18 July 1969, US Government Printing Office, Washington, DC (1972). Available at http://www.population-security.org/rockefeller/001_population_growth_and_the_american_future.htm.

Brian Cluggish
(cluggish@at-sd.com)
Archimedes Technology Group
San Diego, California

Will unchecked population growth catastrophically exhaust fossil fuels? France generates 77% of its electricity from nuclear power plants, while the US generates only 20%. Why? Because France has severely limited fossil fuel resources. The US has 5% of the world's population but consumes 40% of fossil fuels. Working on the numerator rather than the denominator of per capita fossil fuel consumption seems more humane and practical. More important, there is no compelling reason to sustain such a heavy reliance on a power source that has devastating health, safety, environmental, and geopolitical impacts.

Nuclear, solar, and wind energy are far safer and cleaner than, and economically competitive with, fossil fuels for electricity production. The existing power grid might allow local hydrogen generation by electrolysis for use as a transportation fuel along with biofuels. Legislation and tax policies could easily and gradually be initiated to encourage clean and carbon dioxide-neutral electricity and

transportation fuel production and discourage fossil fuel consumption. Making these energy sources even safer and more economical would seem a better thing for physicists to set their minds to than playing God with world populations. There is also much to do in educating the public about the relative risks of various energy sources.

David J. Wesolowski
(wesolowskid@ornl.gov)
Oak Ridge National Laboratory
Oak Ridge, Tennessee

It is surprising and distressing that both Albert Bartlett's article and "Basic Choices and Constraints on Long-Term Energy Supplies" (PHYSICS TODAY, July 2004, page 47) by Paul B. Weisz completely ignore energy efficiency as a factor in long-term energy supply needs, and that the reviewers of these articles apparently did not point out this omission.

Failure to account for energy efficiency in a meaningful way renders the rest of both articles virtually irrelevant. The Bush administration's National Energy Plan states that energy use per gross domestic product declined 42% from 1973 and argues that about two-thirds of the reduction is due to energy efficiency. Other estimates give a larger percentage. Thus, energy efficiency has been the largest new energy source in the US, even without much attention from national policymakers.

If energy consumption continues to grow parallel to population or to the economy as the Energy Information Administration (EIA) forecasts suggest, then the tradeoffs and scenarios presented in both articles could have some validity. However, if energy consumption in the US or the world levels off or declines, either absolutely or relative to population, the results will be drastically different.

Several studies, including the very detailed *America's Energy Choices*,¹ show that declining energy demands are consistent with, and supportive of, continued economic growth. Witness the history of energy consumption in refrigerators: In 1973, they were the largest user of household electricity in the US, but their absolute use of electricity has declined as a result of a more than fourfold efficiency increase. (The price of a refrigerator dropped twofold during that period as well.) This example shows how large an error one would make ignoring efficiency or treating it as a 20% effect, as Weisz offhandedly suggests. If re-

Readings on Energy Efficiency

- ▶ Solar Energy Research Institute, *A New Prosperity: Building a Sustainable Energy Future—The SERI Solar/Conservation Study*, Brickhouse, Hanover, MA (1981).
- ▶ S. Bernow et al., *Energy Innovations: A Prosperous Path to a Clean Environment*, Alliance to Save Energy, American Council for an Energy Efficient Economy, Natural Resources Defense Council, Tellus Institute, Union of Concerned Scientists, Washington, DC (1997).
- ▶ Inter-Laboratory Working Group on Energy Efficient and Low-Carbon Technologies, *Potential Impacts of Energy Efficient and Low-Carbon Technologies by 2010 and Beyond*, US Department of Energy, Washington, DC (September 1997).
- ▶ Inter-Laboratory Working Group, *Scenarios for a Clean Energy Future*, Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory (2000).

frigerator energy use had followed pre-1973 trends and forecasts by EIA's predecessor agencies until now, the appliances would be consuming 150 gigawatts of peak power nationwide compared to the actual value of less than 30 GW. If similar policy attention were applied to the other uses of energy, similar results would be obtained.

The implicit assumption behind these articles is that the choice of energy production is of policy interest, but the choice of energy consumption is beyond policymakers' control. If anything, in the globalized market economy of the 21st century, the reverse is true: Governments have demonstrated their ability to cause dramatic reductions in energy demand without economic sacrifice. For example, California has held its per capita electricity consumption stable or at a slight decline for the past 30 years, under both Republican and Democratic leadership, while in the rest of the US, with slower economic growth, consumption per capita has increased 50%. In contrast, markets, and not government policies, have had a bigger say in determining the sources of energy supply.

As physicists, we pride ourselves on our ability to solve problems by first asking the right question and then seeking answers. Both articles fail primarily by asking the wrong question, namely, What can we, the government, do about energy use that rises inexorably with population (or

with economic growth)? But a broader and more effective reframing of the question is, How can policymakers provide for the level of energy services that the market demands at the lowest cost? Studies that attempt to answer the first question arrive at substantially more pessimistic answers than those that attempt to answer the second. The reframing provides more degrees of freedom in which to search for good results.

Enlightened energy efficiency policy can have much greater effects on the problems addressed in these articles than any of the solutions or scenarios that the authors presented. It is sad to see how efficiency issues were ignored.

Reference

1. A. Meyer et al., *America's Energy Choices*, Union of Concerned Scientists, Cambridge, MA (1991).

David B. Goldstein
(dgoldstein@nrdc.org)

*Natural Resources Defense Council
San Francisco, California*

Paul Weisz's article on long-term energy supplies (PHYSICS TODAY, July 2004, page 47) states that uranium resources with breeder reactors could provide the world's energy needs for "hundreds of years." That is a gross underestimate. The world's energy needs could be provided by uranium-fueled breeder reactors for the full billion years that life on Earth will be sustainable, without the price of electricity increasing by more than a small fraction of 1% due to raw fuel costs.¹

The error in Weisz's calculation is that he is referring to uranium available at its present price, \$10–20 per pound. But in breeder reactors, 100 times as much energy is derived from a pound of uranium as in present-day light water reactors, so we could afford to use uranium that is 100 times as expensive.

The cost of extracting uranium from its most plentiful source, seawater, is about \$250 per pound—the energy equivalent of gasoline at 0.13 cent per gallon! The uranium now in the oceans could provide the world's current electricity usage for 7 million years. But seawater uranium levels are constantly being replenished, by rivers that carry uranium dissolved out of rock, at a rate sufficient to provide 20 times the world's current total electricity usage. In view of the geological cycles of erosion, subduction, and land uplift, this process could continue for a billion years with no appreciable reduction of the ura-

nium concentration in seawater and hence no increase in extraction costs.

Reference

1. B. L. Cohen, *Am. J. Phys.* **51**, 75 (1983).

Bernard L. Cohen
(blc@pitt.edu)

*University of Pittsburgh
Pittsburgh, Pennsylvania*

The articles dealing with population growth and energy make claims that are sadly pessimistic, but fortunately wrong. Albert Bartlett takes issue with economist Julian Simon while fawning over Malthus. Readers should recall Paul Ehrlich's book *The Population Bomb* (Ballantine, 1968; Buccaneer Books, 1995). Thirty years ago, Ehrlich made many of the same arguments as Paul Weisz and Bartlett. Julian Simon made a now-famous wager with Ehrlich regarding the prices of five commodities in the future. According to basic economic theory, the price of goods will increase as the available supply decreases. Ehrlich predicted severe shortages and cost increases. Simon claimed that technology and efficiency would more than make up for increased population and that prices would fall. Ehrlich was wrong; Simon was right. Today, the cost of energy in constant dollars is less, not more, than it was 20 years ago. Throughout the past three decades, it has been Malthusian theory that is in error. Calling Simon "egregious" in his correct prediction does not erase the facts about energy efficiency.

What amazes me is the small scope in which Weisz and Bartlett limit analysis. As physicists, we should be touting the long-term potential for nuclear energy. However, Bartlett restricts his analysis to fossil fuels and Weisz writes only two sentences about US uranium—less than 3% of total world production. Bartlett complains about "nonscientists with academic credentials," but it appears that he is a noneconomist with physics credentials. By looking at people and energy as some sort of equation to be balanced, the authors ignore the social and economic incentives that cause humanity to become more innovative and efficient as needs and supplies dictate. We should embrace future growth with optimism.

Eric Swager
(eswager1@go.com)
*Chelsea High School
Chelsea, Michigan*



Vacuum Angle Valves

Series 26.4 with bellows feedthrough



More value
for less money

- Low cost
- Reliable simple design
- Short lead time

Swiss Headquarters
Tel ++41 61 771 61 61
reception@vat.ch

VAT Japan
Tel (045) 339 11 44
sales@vat.co.jp

VAT Taiwan
Tel 03 516 9066
taiwan@vatvalve.com

VAT France
Tel 01 69 20 6911
france@vatvalve.com

VAT U.K.
Tel 01 926 4527 59
uk@vatvalve.com

VAT USA
Tel (781) 335 1445
usa@vatvalve.com

VAT Korea
Tel 081 704 66 57
korea@vatvalve.com

VAT Benelux
Tel ++31 (30) 601 6251
benelux@vatvalve.com

VAT Germany
Tel (089) 46 501 5
deutschland@vatvalve.com

www.vatvalve.com



Circle number 10 on Reader Service Card

Our present energy situation has a much more pressing aspect than those considerations presented by Paul Weisz and Albert Bartlett. By the end of this century, fossil fuels will likely be gone. Making the transition from our overwhelming dependence on oil will be a wrenching adjustment for our civilization.

The current emphasis on economic globalization, though, will unnecessarily and dangerously exacerbate that transition. That globalization depends on inexpensive transport and will require massive amounts of transportation fuels; its promotion at a time when we are already facing a worldwide energy crisis is irresponsible. We must consider how to limit the process of economic globalization to avoid making the transition at the end of the oil age even more horrendous.

Caroline L. Herzenberg
(carol@herzenberg.net)
Chicago, Illinois

Something unanticipated and quite remarkable happened in England in the second half of the 20th century: People began getting married later in life and having

fewer children. The population growth rate in Western Europe is now close to zero; any increase in population comes from immigration. We in the US are approaching the same situation.

Social scientists who study population growth believe the remarkably low birthrate is most closely correlated with increased education level—especially that of women. We are not left with the Dismal or the Utterly Dismal Theorem, but with the Moderately Cheerful Form: Something other than misery and starvation has been found that will keep a prosperous population in check.

Paul Weisz concludes that an urgent commitment to solar and nuclear energy technology is needed. I certainly agree, not because fossil fuels will run out eventually, but because the level of air pollution is now simply unacceptable. In the 1980s, the US closed down a nuclear power plant on Long Island, New York. It cost billions to build and was never allowed to generate power. When a Long Island politician was asked about this, he replied, “If we save one life, it is worth the money.” A

year later, an explosion at a natural gas power plant in Manhattan killed two people, and the Upper East Side was without power for 10 hours. The headlines, of course, decried the power outage, not the loss of life.

If people are told that they must either allow construction of a nuclear power plant or turn off their air conditioners, the political movement to build nuclear power plants will be swift and vast. Until then, we on Long Island will generate power with fossil fuels.

William Morse
(morse@bnl.gov)

Brookhaven National Laboratory
Upton, New York

Bartlett replies: The appealing assertion that Thomas Robert Malthus has been proven wrong denies a fundamental mathematical truth. Malthus recognized that the growth potential of population is greater than that of food production; that realization led him to predict widespread starvation. Mark Meier writes that Malthus has been proven wrong because “food has never grown scarce . . . [and] today, more people are fed more affordably and

with larger varieties of food than ever before.” However, global agricultural scientists report that, despite all manner of scientific and technological advances in agriculture,

increases in food production, per hectare of land, have not kept pace with increases in population, and the planet has virtually no more arable land or fresh water to spare. As a result, per-capita cropland has fallen by more than half since 1960, and per capita production of grains, the basic food, has been falling worldwide for 20 years. . . . The World Health Organization estimates that more than 3 billion people are malnourished. . . . This is the largest number . . . of malnourished people ever reported.¹

Malthus’s prediction is now becoming reality. In addition, the observations of those agricultural scientists bear out Kenneth Boulding’s elaboration of Malthus’s idea: “The final result of [technical] improvements . . . is to increase the equilibrium population, which is to increase the sum total of human misery.”²

A similar thing seems to be happening in petroleum production. My graph (page 54 of the July article) showed that world per capita petroleum production has declined significantly since it peaked in the 1970s at about 2.2 liters per person-day. That decline is clear evidence that the numerator, production, is growing less rapidly than the denominator, population; and as Douglas Davidson reports, the growth rate of the denominator is decreasing significantly.

Two possible explanations come to mind for such a drop in the growth rate of petroleum production: either declining demand “while supplies were plentiful,” as Meier suggests, or declining growth in production that is expected as production approaches the top of the Hubbert peak, the point at which world oil production reaches its maximum and starts its inevitable long-term downward trend. Many scientific analyses suggest that the peak will occur within the next decade or two,³ which is consistent with my interpretation that the observed decline in the growth of world per capita petroleum production is mainly due to the approaching maximum of world petroleum production.

These observations are reflected in news stories such as one from a Boulder, Colorado, newspaper in

mid-September: “Oil prices have soared in recent months because of the extremely thin margin of spare output capacity worldwide and fears of supply disruptions around the globe.”⁴ I can’t see that this “unwittingly contradicts” my thesis, as Meier says. These food and petroleum data combine to exacerbate the Malthusian picture. Note that modern agriculture has been referred to as the use of land to convert petroleum into food.

The tragedy is not a periodic re-emergence of the Malthusian mathematical truth. The tragedy is our continued eagerness to ignore that truth. We do so at great peril.

It is irresponsible for scientists to suggest that the large tabulated total energy content of biomass, oil shale, oil sands, heavy oil, and nuclear fission can cover world energy demand for the long-term future. Meier suggests that these sources “represent at least a thousand years of world energy demand.” Such suggestions should not be made until the public is aware of thoughtful estimates of the net energy gained in extracting and consuming each of these resources, the necessary costs, in time and dollars, to develop them on a scale sufficient to affect global energy needs, the environmental and human costs of their development and use, and the secondary human and systemic problems that will predictably result when the enormous capital resources needed for development are diverted from traditional investment channels.

Douglas Davidson is correct that the “world population growth rate is already falling.” However, current projections suggest that world population will grow from the present 6.3 billion to between 9 billion and 11 billion before it stabilizes late in this century. Does anyone think that a world of even 9 billion people will be a better, more just, or more peaceful world? And Frank Haig is ahead of his time, worrying about extinction when the world population is growing by about 75 million people per year.

As David Goldstein observes, the technological potential for improved efficiency of energy use is enormous. But technology brings new ways to consume energy as well as to conserve it. If we are going to stretch the lifetimes of fossil fuels “consistent with geophysical constraints,” we must recognize the constraints and then combine the effects of technology and population growth so that there is a decline in total annual energy

use;⁵ that achievement will almost certainly require stabilizing population at the earliest possible date.

Much has been published about the growing problems associated with global warming. The following truth is self-evident: If any fraction of the observed global warming is due to human activities, then this constitutes positive proof that the human population, living as it does, has exceeded Earth’s carrying capacity—a situation that is not sustainable.

In his 1966 acceptance speech for the Planned Parenthood Federation of America’s Margaret Sanger Award, the great humanitarian Martin Luther King Jr spoke about the population problem:

Unlike plagues of the dark ages or contemporary diseases we do not yet understand, the modern plague of overpopulation is soluble by means we have discovered and with resources we possess.

What is lacking is not sufficient knowledge of the solution, but universal consciousness of the gravity of the problem and education of the billions who are its victims.

When scientists seek solutions to problems caused by population growth, it is professionally unethical not to list stopping population growth as a central part of the solutions. If scientists don’t speak out, who will?

References

1. D. Pimentel, A. Wilson, in special issue on population, *World Watch*, September/October 2004, p. 22.
2. K. E. Boulding in *Collected Papers [by] Kenneth E. Boulding*, vol. 2, Colorado Associated U. Press, Boulder (1971), p. 137.
3. A. M. S. Bakhtiari, *Oil Gas J.* **102**(16), 18 (2004); A. A. Bartlett, *Math. Geol.* **32**, 1 (2000); K. S. Deffeyes, *Hubbert’s Peak: The Impending World Oil Shortage*, Princeton U. Press, Princeton, NJ (2001); J. D. Edwards, *Am. Assoc. Pet. Geol. Bull.* **81**, 1292 (1997); W. Youngquist, R. C. Duncan, *Nat. Resour. Res.* **12**, 229 (2003).
4. M. Moore for Associated Press, “Ivan Pushing Oil Prices Up,” *Daily Camera*, Boulder, CO, 15 September 2004, p. 1D.
5. A. A. Bartlett, *Am. J. Phys.* **54**, 398 (1986).

Albert A. Bartlett
(albert.bartlett@colorado.edu)
University of Colorado
Boulder

Weisz replies: My article examines the magnitude of available energy sources for the support of the growing human population. Express-

ing that magnitude in terms of human lifetimes indicates the urgency for remedial actions in technology and social behavior, since those actions themselves take a matter of lifetimes to accomplish.

Bernard Cohen and Eric Swager both point to the large potentials of nuclear energy. My article points out the large potential longevity capabilities of nuclear fission energy for "hundreds of years," and leaves the number of hundreds unspecifically large!

Cohen also mentions the potential of harvesting uranium from the ocean, where it is present in a few parts per billion concentration. However, important basic thermodynamic and mass transport rate constraints limit the economics and feasibility of concentrating highly dispersed matter. I have discussed those constraints relative to the analogous proposal by Fritz Haber, inventor of ammonia synthesis, for harvesting gold from the oceans to pay Germany's World War I debts.¹

An energy unit—be it an erg, joule, BTU, or other—describes a definitive amount of energy. Many discussions concerning future energy alternatives predict their energy costs in currency units, that is, dollars.

Unfortunately, the value of the dollar itself depends on many factors: human choices, accounting procedures, economic policies, and, most importantly, the then prevailing energy availability.

David Goldstein discusses an energy efficiency defined by the ratio of the economic parameter gross domestic product to the amount of energy consumed. GDP is measured in currency units. It adds the dollars transacted in the goods sector, which includes agriculture, mining, and manufacturing, and those in the service sector—for example, informational, financial, and insurance services and entertainment. Energy consumption for services is lower than for goods. Thus, as long as I have adequate per capita energy for my food, housing, and other essential goods, I can spend many more dollars on services and entertainment, which results in a higher GDP-to-energy ratio. Current per capita energy availability is adequate, with the US having the highest availability; thus people are free to expend currency for many activities beyond necessities.

My analysis deals with the basic scientific and arithmetic choices and limitations of energy resource supply

alternatives that are available to sustain the prevailing course of energy demands and the conceivable lengths of time. It serves as a basic guide to understanding the existing challenge of providing for humanity's future energy supply.

It is extremely unlikely that the long prevailing trend of increasing energy demand will be voluntarily modified to substantially impact the adequacy or lifetime of current energy supplies. By way of example, just halting the growing rate in energy demand due to population growth alone would require a 20% reduction in total energy use—that is, in all energy-consuming technologies and human activities—to be continually repeated in less than 20-year intervals.

Refrigerators are an example of greatly improved energy efficiency. However, the technological capabilities of efficient heat removal have also created broad demand for air-conditioning, which has become a "necessity" humans are unlikely to give up.

David Goldstein is engaged in some important activities in both the energy efficiency and human behavior categories; he has my enthusiastic support. Like him, I also have experienced

It's Time for Luminescence!

Whether it's fluorescence, phosphorescence, or any other photoluminescence dynamic characterization, you'll find the components you need to build a system custom tailored to your research that takes advantage of the ultimate sensitivity of Time Correlated Single Photon Counting (TCSPC).

- Pulsed LED and Laser Diodes,
- Flashlamps
- Pico-second Detector Modules and MCP's
- TCSPC electronics
- Power Supplies...

All you need and More!

And All these components are time, quality and performance perfected since they are components of our state-of-the art, 18H lifetime systems. Call us now or browse our website to make your research faster and more accurate.

HORIBA PHOTO-MEASUREMENTS

Let's go to LAURE

HORIBA

Circle number 11 on Reader Service Card

RGA+Ion Gauge+Pirani *Extorr*

Residual Gas Analyzer Plus.....



- *Three gauges on a single probe with a 2.34" range.
- *A small, powerful control package drives the probe.
- *RS232 connection to your computer.
- *Complete operation under Extorr windows software.
- *Immediate startup using the built in Pirani gauge.
- *Automatic ion gauge operation.
- *Automatic residual gas analyzer operation.
- *Continuous monitoring protects the filament.
- *All is recorded - All is protected - All is monitored.
- *Autorangeing, high stability, and high sensitivity.

Three gauges in one extraordinary package.
Extorr is an outstanding vacuum measurement value.

100 amu for \$3450 (U.S. list)

Extorr Inc.
387 Columbia Road
New Kensington, PA 15068
Tel: (24-33)-8000 Fax: (24-33)-8322

Our Website is
www.extorr.com

Circle number 12 on Reader Service Card

As to policy and governments, the most important current need is education of all citizens and policymakers (which, in a democracy, should be synonymous). That education must include the most basic ingredients of the physical sciences and arithmetic and their relevance to society's functioning and survival.

1. P. B. Weisz, *ChemTech* **10**, 207 (1980).
Paul Weisz
 (pbweisz@mailaps.org)
 Pennsylvania State University
 University Park

I think it might be more difficult than is supposed in King Wiemann's letter (PHYSICS TODAY, May

Brian Sutcliffe
(bsutclif@ulb.ac.be)
Université Libre de Bruxelles
Brussels, Belgium

All the property that is necessary to a man for the conservation of the individual and the propagation of the species is his natural right,

In his will in 1790, explaining why he established a trust to encourage public service, Franklin wrote, “I wish to be useful even after my death, if possible, in forming and advancing other young men that may be serviceable to their country.”

Dudley Herschbach
(herschbach@chemistry.harvard.edu)
Harvard University
Cambridge, Massachusetts

August 2004, page 31—The caption for the bottom left picture has the names reversed. Juan Guillermo Diaz Ochoa, a Colombian student at the University of Mainz in Germany, is on the right and Kamran-ul-Hasan of Pakistan's Ghulam Ishaq Khan Institute of Engineering Sciences and Technology is on the left. ■

Circle number 13 on Reader Service Card