

The only sustainable exponential has a negative exponent

The sustainable use of resources is becoming an even more pressing question in these days of dwindling supplies of oil, natural gas, and other nonrenewable resources on which we have grown too reliant through the years. It was therefore of great interest to see Al Bartlett, who has warned for years about the dangers of any exponential growth and the nonsense underlying the term "sustainable development," both in the pages of this *Newsletter* and at meetings of the American Association of Physics Teachers (AAPT), offer a talk on "Sustainability and Use of Resources at Present Rates of Production" at the AAPT meeting in Syracuse on 26 July.

The reserves/production rate ratio is often used to indicate the "lifetime" of a resource, Bartlett opened, noting that this assumes a model of constant use of the resource until it is used up. But Bartlett noted that this model is somewhat naïve, neglecting the gradual decline in resource production rate as it becomes more and more costly to extract the remaining amounts from the Earth. He then cited the Gaussian curve of production rate versus time as the more realistic model proposed by (M. King) Hubbert, and looked at several Gaussians that could describe the resource production rate in time that matched the known reserves. The envelope of all these Gaussian curves denoted maximum production rates, so he characterized the part of the graph above this envelope as "forbidden."

The higher the near-term production rate, the more quickly the Gaussian approached zero in time -- and no Gaussian avoided reaching a zero limit eventually. Then Bartlett displayed the equation for exponential decay, which models the amount remaining of a radioactive isotope. Unless the number of atoms remaining becomes so small that statistics cannot be applied to them, there is always a remaining residue of the radioactive isotope -- and Bartlett proposed this as a mathematical model of sustainable use of resources. As one member of the audience suggested at the end, mindful of Bartlett's expertise on the effect of exponential growth, "the only sustainable exponential is one with a negative exponent."