



Short communication

Creating a new conceptual framework: environment power and society

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In 1972, when I ran across a copy of Howard T. Odum's book, *Environment Power and Society*, I had already acquired a degree in engineering and was working on a Masters degree at the LBJ School of Public Affairs. I was also an intern for the Texas Governor's Energy Advisory Council; that year Texas production of oil peaked and began its historic decline, an event that struck at the heart of the Texan economy. Then the OPEC embargo, which came in 1973, focused the attention of the entire country on energy issues. Already I knew in an intuitive way that energy was somehow important to everything we did and everything we had become as a society. But it was this book, H.T.'s first widely published work, which suddenly gave me a new conceptual framework for understanding how everything tied together.

And, I mean everything. Even the title, *Environment Power and Society*, seemed to promise a great deal to the reader. But H.T. exceeded all expectations. By sharing his perspective on the overarching laws of the physical world, and the way they permeate and constrain all that we do, he changed the way I viewed the world forever.

The book begins with an historical perspective of the changing role of humans in the larger ecosystem.

It explained how primitive people were able to glean a living from the production of the earth's environmental systems in a sustainable way. In reading it over again, I was reminded of one of the things that H.T. often said to me. You cannot understand a system without understanding the next larger and next smaller systems. "Large and small parts operate on their budgets of energy, and what can and cannot be done is determined by the simple laws that govern the system. Any phenomenon is controlled both by the working of its smaller parts and by its role in the larger system of which it is a division," (Odum, 1971, p. 11).

The book gives a macro discussion of how solar energy drives the earth's "heat engine" bringing rains and winds to the continents, and of the "living fires of earth" which photosynthesis and respiration represent. What we view as the progress of man, according to H.T., is largely the injection of the ancient stored energies of fossil fuels to vastly increase the work that man, through machines, was able to accomplish. As OPEC formed in late 1972, I read, "If his [man's] energy sources begin to decline, can he return to a minor energetic position in the earth system without a collapse and extinction of culture as we now know it?" (Odum, 1971, p. 7).

But the book does not lead only toward a dire warning about the consequences of rising fuel consumption or environmental degradation. H.T. continued, "The action programs needed on such public issues as birth control, land ownership, man in space, war prevention costs, nuclear power, zoning of land space, human

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medical maintenance and world economics must each be limited and fitted into the overall energetic budget for a successful system of nature,” (Odum, 1971, p. 11). As a young engineer in public policy school studying energy, it seemed as if this book was written for me personally, and I spent the next decade pursuing energy policy, and particularly solar or renewable energy policy, with these ideas of Odum’s in the back of my mind.

Despite my excitement about discovering this book, I have to admit that I couldn’t fully appreciate its value back then. In fact, when I reread the book this past weekend, I realized there is *still* more there than I can fully grasp without much more work on my part. But, it was interesting to read it now as a historical document and to realize that, after the publication of that work—as I was trying to learn more about energy in my own way—Odum also continued to develop his understanding of energetic systems and their properties. For example, it was after the publication of *Environment Power and Society* that Odum began to talk more about the importance of energy as a unifying indicator, leading eventually to the concept of transformity, or a quantitative measure of energy quality. This in turn led to his development in the 1980s of the term *Emergy* to mean the value of a thing, measured as the quantity and quality of the energy required to replace it, or bring it into being and sustain it.² It wasn’t until 1984, when I was lucky enough to study under H.T. and Betty Odum, when they were visiting lecturers at the LBJ School of Public Affairs in Austin, that I would more fully understand the importance of quantifying these elements—why, for example, solar energy systems were not being widely adopted despite popular interest, and could not simply replace subsidies we relied upon from more concentrated forms of energy.

Still, in *Environment Power and Society* H.T. Odum shared with anyone who cared to read it, the essentials

of a powerful conceptual framework for understanding the working of nature, and its relation to the affairs of man. In this book, H.T. says that many professionals in natural resources studies had already learned to trace the movement of minerals or nutrients, such as nitrogen or carbon, through the environment. But he also noted that this effort only explains one element of a whole environmental system at a time, and only the processes affecting that isolated material would be involved. This apparently is what led him to what may be his most fundamental contribution: “To understand a whole system and the full interaction of the parts, we must use a common denominator that expresses all the flows and processes together. Power is a common denominator to all processes and materials,” (Odum, H.T., *Environment Power and Society*, 1971, p. 21). Thus, the essence of what H.T. brought us is the understanding that we can use energetic analysis within a systems perspective to understand how things really work. This is seen most clearly in what was a revolutionary concept at the time. In Chapter 4, in a subsection labeled “Potatoes Made Partly from Oil,” he showed clearly how fossil energy was essential for the production (and distribution) of food in today’s agricultural system. Other investigators such as Steinhart, Pimentel and Smil wrote with great sophistication about this issue later, but H.T. was the first to write about the fundamental importance of this issue. (The President’s Food Report, 1967, included reference to this issue, as a result of Odum’s early writings.)

In 1972 I knew in some manner that everything is energy in various forms. But as an engineer, it surprised me when H.T. wrote, “We are not used to thinking of water, fertilizer, and air as fuels, but they are as much chemical reactants as oil,” (Odum, 1971, p. 45). I understood the potential energy of elevated water supplies (hydro power potential), for example, but not being a biologist, it didn’t occur to me that fresh water embodied another form of energy in its potential to absorb salts. I didn’t think of clean air as stored “energy” that contribute to the productive capacity of the environment and of human society. Nor did I think that the energy of each of these could be represented by a single comparable unit. He was providing a unifying set of ideas that made it possible for me to see the entire world as a set of simultaneous energy transformations.

² One of the leaps it took me a while to make in understanding Odum’s systems was this: If one considered systems that had been in place for many, many years, and the fact that systems tend to reinforce and sustain their parts in proportion to the value they add, then actually, the energy required to create and maintain a component of a sustainable living system is a measure of its value. Naturally, one has to be careful in assuming that something we have recently conceived, and sustained with fossil subsidies, can be valued in this same way.

Another observation in the book, which was important to me, is that while minerals and nutrients cycle through the environment by a number of processes, energy, the common denominator, flows through the process in one direction. Energy must be degraded in the process of doing work, and its one-time use is irreversible. I understood the first and second law of conservation, and what I remembered of high school biology confirmed this fact, although the simplicity of his portrayal of such processes is always enlightening. But what completely blew my young mind was that H.T. could see the larger ecological and economic systems so clearly that he could make an analogy between minerals cycling and currency in man's economy. "Some authors have compared money to energy, but the two are not the same and they flow in opposite directions . . . Money circulates, whereas energy flows are unidirectional."

Expanding on this creative view of the role of money, leads to other conclusions of some consequence. Because money is paid to people (in general) only for useful work performed, it is an incomplete tool for understanding the nature of environmental or human processes, and purely economic evaluations will often be misleading when trying to predict what works over time. The price of a thing may have nothing to do with its real value; in fact the reverse is often true. What is most valuable is highly concentrated resources at low prices; that is, high energy resources that do not require much in the way of human labor to harvest or obtain. At the same time, if people consider that low cost resources don't have much value, policies might be adopted that do not value important resources such as clean water, natural timber stands and so forth. For example, wild Atlantic Salmon were once incredibly cheap in New England, and as such they were an extremely valuable resource to the people there before they were extirpated. Their price was low but their value was high. Now the price of salmon (for example in a delicatessen in New York City or Boston) is extremely high, but it adds little to the nutrition, or well being of these cities today. Odum notes that unless the real value is recognized and human effort is made to feedback constructive work to maintain these resources, we will some day find their services unavailable or increasingly costly to our economy, although they may seem infinite, as the salmon once did, with dire consequences for our

well being. He also urges that if we plan to continue to consume all our stores of fossil fuels, that we invest a portion of these energies to evolve more sustainable systems for our survival in the future.

Furthermore, H.T. draws upon his understanding of nature to note that we have so successfully enlisted the work of fossil fuel-based machines to perform work, that machines easily out compete man for provision of simple labor. "The increased total work done increases the standard of living but only to those who can plug into the economy with a service that has an amplification value greater than the machines," (Odum, 1971, p. 185). He discusses the implications of this for the problem of poverty and the need for education, but also explores the difficulties of this for relations between more and lesser developed nations.

This book really did announce to the world that H.T. Odum was a new force in the universe, in his own right. It demonstrates an uncanny breadth of knowledge of chemical, electrical, biological, geological and ecological systems sciences, which would have been impressive enough by itself. The book brings all these subjects together in a way that made the big ideas from each tradition available to a generalist like me. But he goes further too. The book launches right into implications for world agriculture, economics and public policy, applying his tools of analysis to completely new subject matter in each chapter. This is another of the primary values of his work, which he acknowledges—the stepping outside of traditional disciplines. Before the book is over, H.T. lectures on the development of religions as a means to guide multiple pathways (humans in social groups) toward behaviors that were self sustaining or reinforcing historically. "In the ecological systems the behavior pattern of the large animals serve as power switches and transformers," (Odum, 1971, p. 204), he says. "Evolving with primitive man are many institutions stemming from his social psychology—his religion, his group nationalisms, his loyalties, and his loves. As partly inherited and partly learned pre-programs, these motivations are power-switching and power-concentrating mechanisms. They are means by which the resources and action of vast numbers of people can become directed into one combined focus, resulting in the kind of power delivery that has been deterministic in the great wars, emigrations, social upheavals and change," (Odum, 1971, p. 204).

This is typical of H.T.'s wide ranging application of ecological systems theory to completely new turf. He even provides a systems diagram of the "common abstractions of energetics and religious teaching showing the angelic operations of order, evolution and selection of information, and the evil processes of disorder, dissipation, and heat death," (Odum, 1971, p. 252). While it is not clear to most of us that H.T. was conventionally religious, it is clear that he felt that religions were an extremely useful way to organize and guide human behavior, even to the degree that he felt we should consider how the environmental-energy message could be spread through churches!

At the same time that the book definitely serves as a warning—that unwise use of our stores of resources will have serious consequences on our subsequent standard of living and so on—it is also ultimately hopeful. On page 244, H.T. provides Ten Commandments of the Energy Ethic for Survival of Man in Nature. And in the final chapter, Partnership with Nature, H.T. provides a five phase process for man to further expand his understanding of the natural systems in which we find ourselves embedded, reflecting H.T.'s own optimism. (See also the cartoon view, page 10, of Odum's overview of the role of study, and man, in the wise management of natural systems.)

That Howard T. Odum was a teacher is clear from this incredible book. He liked to teach and he was a wonderful teacher. But he was also driven. "Man's survival will probably depend on his being able to see what his vast human system has become in relation to preceding and possible earth systems. And he must acquire the necessary understanding rapidly enough to adopt his opinions, folkways, mores, and action programs to the great new systems and provide a continuing survival path for them. Since decisions on such matters in the arena of public affairs are ultimately made according to the beliefs of the citizens, it is the citizens who must somehow include the energetics of systems in their education," (Odum, 1971, p. 6).

H.T. did his best to educate us, and has left behind a legacy of knowledge in publications and student disciples as a result of his legendary work efforts. The last intellectual energy of his life was spent updating and revising this great book, which was published in 2003 by Columbia University Press, and I hope you will read it.

References

- Odum, H.T., 1971. *Environment Power and Society*. John Wiley and Sons, New York.