Energy governed by the laws of physics

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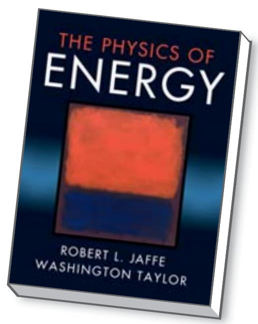

The Physics of Energy
Robert L. Jaffe and Washington Taylor
Cambridge U. Press, 2018. $81.99

Robert Jaffe and Washington Taylor's long-needed guide to the fundamentals of energy conversion contains an abundance of knowledge. Energy is an overwhelmingly sophisticated subject. Describing it in both depth and breadth is a Herculean task. The majority of introductory textbooks therefore offer generic, high-level overviews. But the devil is in the details; nuances are important to understanding the big picture and often dictate the feasibility of energy technologies.

As an instructor for an undergraduate course on sustainable energy in a school of engineering and applied sciences, I have had to rely on many texts to cover the subject. I have long wished for a single textbook that could explain energy conversion as it occurs in nature and is utilized in our industrial and digital world in a comprehensive, accurate, and engaging way. *The Physics of Energy* is that book. It covers its subject matter with depth, breadth, care for precision, and clarity.

Jaffe and Taylor have written a textbook made for learning. *The Physics of Energy* emerged from the authors' one-semester course at MIT, which they have taught for more than a decade. Although the book is designed for classroom use, its audience is not limited to engineering and physics students. Sustainable energy sources are receiving enormous societal interest because of the high rate of current energy use and exponentially growing demands, society's heavy dependence on exhaustible fossil fuels, and increased concerns about climate change and the safety of nuclear power. Anyone with an interest in energy will find this book enlightening and informative. It would make a great desk reference for policymakers, as understanding the physical limits of energy use ought to precede any attempt to formulate new energy policies.

The book contains three logically evolving parts, focused on basic energy physics, sources of energy, and energy system issues and externalities. Energy conversion processes and the physical mechanisms behind them are covered entirely and without redundancies in 874 pages. Jaffe and Taylor artfully connect theory with real-life examples. Have you ever thought of why electric power lines are put underground in most places in Europe but run overhead in North America? Are there any physical limits behind those differences in electric distribution systems? If you are curious, the answer is on page 820. Do you know how important the phase transitions between states of matter are for the functionality of a steam turbine? Chapter 12 explains the physics of phase-change energy conversion and its application to practical devices. The consistent attention to detail is a particularly beautiful aspect of the book.

One of Jaffe and Taylor's greatest contributions is in bridging physics and engineering. *The Physics of Energy* introduces readers to cosmological dark energy, unveils the history of energy in the universe, and covers the most important aspects of sustainable energy technologies. Most textbooks on the subject neglect or deliberately avoid discussing the fundamental meaning of energy and usually rely on a shaky, circular definition of energy as an ability to do work. Those definitions often remind me of Richard Feynman's remark in *Lectures on Physics* that "in physics today, we have no knowledge of what energy is." In contrast, chapter 21 of *The Physics of Energy* includes a comprehensive discussion on the physical meaning of energy and thus gives readers ground beneath their feet in an ocean of energy-related information.

The book also touches on energy efficiency, storage, and challenges of sustainable development. In that context, the one topic that deserved a brighter spotlight is the present and future challenges of solar and wind energy technologies. We will have to contend with the high variability of those energy sources, their inability to provide baseload power, and their low areal power density. All those concerns are especially important in view of rapid urbanization and increased electricity demand for computing, electronic controls, monitoring, artificial intelligence, and other uses of electric power.

To quote Feynman once again, "it is up to the physicist to figure out how to liberate us from the need for having energy. It can be done." Anyone looking for practical recipes on how to create that freedom should keep *The Physics of Energy* at hand.

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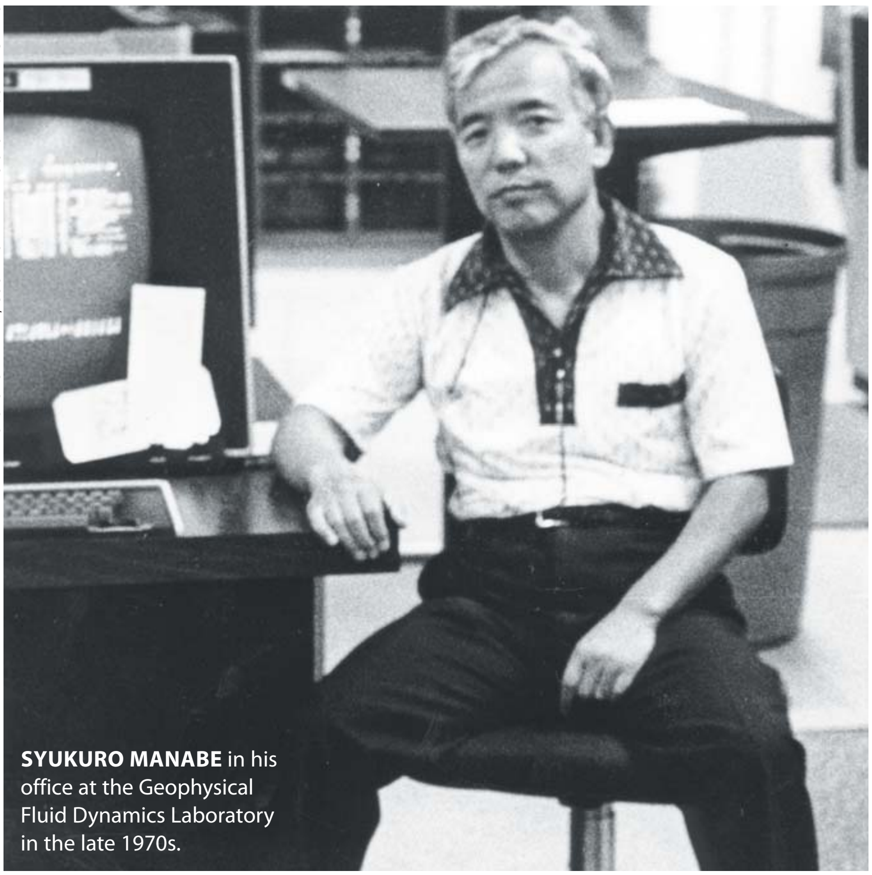
SYUKURO MANABE, COURTESY AIP EMILIO SEGRÈ VISUAL ARCHIVES

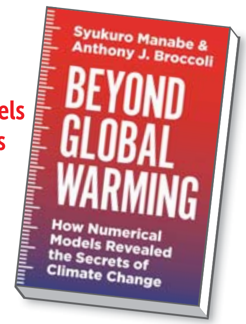


SYUKURO MANABE in his office at the Geophysical Fluid Dynamics Laboratory in the late 1970s.

Modeling the future of Earth's climate

Beyond Global Warming
How Numerical Models Revealed the Secrets of Climate Change

Syukuro Manabe and Anthony J. Broccoli
Princeton U. Press, 2020. $35.00



Syukuro Manabe arrived in Washington, DC, in the fall of 1958. He had just finished a PhD at the University of Tokyo and had been invited to work on climate models at the US Weather Bureau. He worked there until 1963, when he moved to Princeton's newly founded Geophysical Fluid Dynamics Laboratory (GFDL), where he spent the rest of his career. He and his colleagues built the first climate model in the US, and Manabe is now regarded as the leading figure in climate model development in this country. Anthony Broccoli worked with Manabe in the 1980s. Together they applied the climate model to various paleoclimate epochs, such as the Last Glacial Maximum. Broccoli then moved to Rutgers University, where he is a professor of environmental sciences. Their new book, *Beyond Global Warming: How Numerical Models Revealed the Secrets of Climate Change*, is a summary of the many major developments that Manabe pioneered, and it stands as a tribute to his career.

Beyond Global Warming begins with the history and basic science behind Manabe's work. The first chapters introduce us to the greenhouse effect and global warming, along with early studies of warming such as the pioneering work of Sweden's Svante Arrhenius in the late 19th century. Arrhenius was the first person to estimate the surface-temperature change resulting from a change in atmospheric carbon dioxide concentration. From there, the book moves on to focus on Manabe's career. It describes his work on one-dimensional models of radiative–convective equilibrium and the early development of global atmosphere general circulation models.

In chapter 5, Manabe and Broccoli describe Manabe's work using early GFDL atmosphere models, including the first computational experiment in which the atmospheric concentration of carbon dioxide was doubled; that experiment is still a standard for all today's climate models. Manabe was one of the first people to use a realistic distribution of land masses and a mixed-layer model of the very upper