Book Review - Energy Transitions: History, Requirements, Prospects

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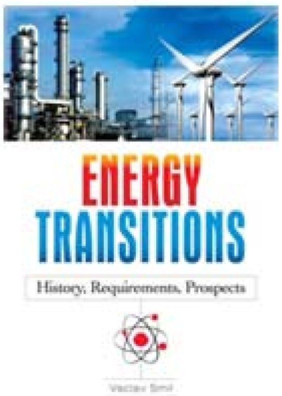

The discussion about our energy supply is full of extremely optimistic expectations. There are many people who believe that full replacement of fossil with renewable energy sources in an extremely short time span is possible. Such ideas have been publicly voiced in Al Gore's call for 100% renewable energy in the United States within 10 years, and Jacobson & Delucchi's plan to power 100 percent of the planet with renewable by 2030 published in Scientific American. Their optimism stems from ignoring the inherent gradual nature of energy transitions and the quality differences between energy sources.

Both issues are described in Vaclav Smil's new book, Energy Transitions: History, Requirements, Prospects. Vaclav Smil, a Professor at the University of Manitoba, has been writing about energy for more than two decades. This book is written in his usual clear descriptive style. He has an eye for detail as he quantifies many historical amounts, providing a much needed reality check for any energy transition scenario under consideration. He concludes that energy transitions are a generations-long process. To increase the likelihood of success of the coming energy transition, it would be wise for affluent nations to introduce policy targets to reduce absolute energy usage per capita.

"The scale of the coming energy transition is best illustrated by comparing the future demand for non-fossil fuels and primary electricity with the past demand for fossil energies that were needed to complete the epochal shift from biomass to coal and hydrocarbons. By the late 1890s, when the share of biomass energies slipped just below 50% of the world's total primary energy supply, less than 20 ExaJoules (EJ) of additional fossil fuel supply were needed to substitute all of the remaining biomass energy consumption. By 2010 the global use of fossil energies runs at the annual rate of roughly 400 EJ, which means that the need for new non-fossil energy supply to displace coal and hydrocarbons is 20 times greater in overall energy terms than was the need for fossil energies during the 1890s."

The book is divided in four parts. The **first chapter** describes the basic science behind energy systems, talking about the many energy sources and our means to convert these into usable energy. It is a dry concise overview of historic changes in global energy supply, the introduction and changing efficiency of various engines, and changes in energy infrastructure and prices. This part is required material for the uninformed reader, in order not to get lost in further chapters. For readers interested in a broader, more historic and more detailed coverage of these topics, I recommend reading Smil's earlier books Creating the twentieth Century, and Energy at the Crossroads.

The **second chapter** gives a description of global changes in energy consumption patterns: from biomass to coal and hydrocarbons (oil, gas, and coal), the use of electricity, and the history of prime movers from muscle power to machine power. The chapter ends with an insightful analysis of the speed of energy transitions of both fuel sources and prime movers. A comparison of time spans shows that once a fuel reached 5% of total global energy production, it still took 35, 40, and 55 years for coal, oil, and natural gas respectively to reach a 25% share of the energy market. There is no indication that later transitions will progress faster. In fact, the opposite is likely true, as the absolute quantities that need to be replaced have only become bigger.

"Globally, coal began to supply more than 5% of all fuel energies around 1840, more than 10% in the early 1850s, more than a quarter of the total by the late 1870s, and one half by the beginning of the twentieth century…"

The **third chapter** deals with energy transitions from a national perspective discussing changes in energy supply and conversion in Britain, France, the Netherlands, the United States, Japan, China, Russia, and Saudi Arabia.

The **fourth and last chapter** deals with coming transitions, providing an overview of the availability of non-fossil energy sources, and their constraints in conversion due to low power density and intermittency. A striking fact from Smil's calculations is only 30.000 km2 of area was used to extract, process, and transport fossil fuels and generate and transmit electricity in the early 21st century, a sum equal to the area of Belgium. As a comparison, he takes bio-energy as a replacement energy source assuming a plant energy intake of 1 watt/m2 from the sun. To replace the total of 12.5 TW (400 Exajoules) of fossil fuel supply today would require 400 times the current space needed for fossil fuel energy, a spatial requirement of 12,500,000 km2, equivalent to the territory of the United States and India.

Subsequently the speed at which infrastructure can be altered, the speed with which the cost of alternative energies can be reduced, and expectations for changes in electric engines in cars are discussed. The chapter ends by comparing a host of what Smil sees as too optimistic scenarios for renewable energy, including Al Gore's 100% renewable electricity plan and Google's clean energy 2030 vision.

Vaclav Smil concludes his book with advice that a shift away from fossil fuels is a generations-long process.

"The inertia of existing massive and expensive energy infrastructures and prime movers and the time and capital investment needed for putting in place new convertors and new networks make it inevitable that the primary energy supply of most modern nations will contain a significant component of fossil fuels for decades to come."

Therefore, from Smil's perspective, hoping for rapid technological development and increasingly better conversion efficiencies is insufficient. He believes that a precondition for a successful transition from fossil fuels is that all affluent nations take steps to reduce fossil fuel consumption, through conservation and increased energy efficiently. In this way, the amount of replacement fuel can be reduced.

“Difficult as it would be, reducing the energy use would be much more rewarding than deploying dubious energy conversions operating with marginal energy returns (fermentation of liquids from energy crops being an excellent example), sequestering the emissions of CO_2 (now seen as the best future choice by some industries), and making exaggerated claims for non-fossil electricity production (both in terms of their near-term contributions and eventual market shares). Or hoping for an early success of highly unconventional renewable conversions (jet stream winds, ocean thermal differences, deep geothermal). After all, a dedicated but entirely realistic pursuit of this goal could result in reductions on the order of 10% of the total primary energy consumption in a single generation, an achievement whose multiple benefits could not be matched by the opposite effort to increase the overall energy use.

Affluent countries should thus replace their traditional pursuit of higher energy output and increased conversion efficiency with a new approach that would combine aggressively improved efficiency of energy conversion with decreasing rates of per capita energy use. This combination would be the best enabler of the unfolding energy transition. Until we get such history-changing conversions as reliable, inexpensive PV cells generating electricity with 50% efficiency or genetically engineered bacteria exuding billions of liters of kerosene, it is the best way to ensure that new renewables will come as close to displacing fossil fuels as is economically advantageous and environmentally acceptable”