A SLAYER OF BULLSHIT

As a teenager in the 1950s, **Vaclav Smil** spent a lot of time chopping wood. He lived with his family in a remote town in what was then Czechoslovakia, nestled in the mountainous Bohemian Forest. On walks he could see the Hohenbogen, a high ridge in neighboring West Germany; less visible was the minefield designed to prevent Czechs from escaping across the border. Then it was back home, splitting logs every 4 hours to stoke the three stoves in his home, one downstairs and two up. Thunk. With each stroke his body, fueled by goulash and grain, helped free the sun's energy, transiently captured in the logs. Thunk. It was repetitive and tough work. Thunk. It was clear to Smil that this was hardly an efficient way to live.

Throughout his career, Smil, perhaps the world's foremost thinker on energy of all kinds, has sought clarity. From his home office near the University of Manitoba (UM) in Winnipeg, Canada, the 74-year-old academic has churned out dozens of books over the past 4 decades. They work through a host of topics, including China's environmental problems and Japan's dietary transition from plants to meat. The prose is dry, and they rarely sell more than a few thousand copies. But that has not prevented some of the books—particularly those exploring how societies have transitioned from relying on one source of energy, such as wood, to another, such as coal—from profoundly influencing generations of scientists, policymakers, executives, and philanthropists.

Now, as the world faces the daunting challenge of trying to curb climate change by weaning itself from fossil fuels, Smil's work on energy transitions is getting more attention than ever. But his message is not necessarily one of hope. Smil has forced climate advocates to reckon with the vast inertia sustaining the modern world's dependence on fossil fuels, and to question many of the rosy assumptions underlying scenarios for a rapid shift to alternatives. ***"He's a slayer of bullshit,"*** says David Keith, an energy and climate scientist at Harvard University.

Give Smil 5 minutes and he'll pick apart one cherished scenario after another. Germany's solar revolution as an example for the world to follow? An extraordinarily inefficient approach, given how little sunlight the country receives, that hasn't reduced that nation's reliance on fossil fuels. Electric semitrailers? Good for little more than hauling the weight of their own batteries. Wind turbines as the embodiment of a low-carbon future? Heavy equipment powered by oil had to dig their foundations, Smil notes, and kilns fired with natural gas baked the concrete. And their steel towers, gleaming in the sun? Forged with coal.

"There's a lot of hopey-feely going on in the energy policy community," says David Victor, an expert on international climate policy at the University of California, San Diego. And Smil ***"revels in the capability to show those falsehoods."***

But Smil is not simply a naysayer. He accepts the sobering reality of climate change—though he is dubious of much climate modeling—and believes we need to reduce our reliance on fossil fuels. He has tried to reduce his own carbon footprint, building an energy-efficient home and adopting a mostly vegetarian diet. He sees his academic work as offering a clear eyed, realistic assessment of the challenges ahead—not as a justification for inaction. And he says he has no ax to grind. "*I have never been wrong on these major energy and environmental issues,*" he says, "*because I have nothing to sell.*"

He was a regular in the nation's capital during the 1980s and '90s, consulting with the World Bank, the Central Intelligence Agency, and other government agencies. But the United States's security clampdown after 9/11—its the increasing political dysfunction—soured him on the country's leaders. "*This government is so inept,*" he said. "*It cannot even run itself in the most basic way.*"

Still, Smil can't shake his affection for the United States. It goes back to his childhood: During World War II, U.S. soldiers—not Soviet troops—liberated his region from the Nazis. And it was to the United States that Smil and his wife, Eva, fled in 1969, after the Soviets invaded Czechoslovakia to stymie a political uprising.

"I'm the creation of the communist state," he says, recalling how, as a child, he heard that the Soviet Union had increased production of passenger cars by 1000% in a single year. "*I looked at it and said, 'Yeah, but you started from nothing.*'" Officials would claim they had exceeded their food plan, yet oranges were never available. "*It was so unreal and fake,*" Smil says. "*They taught me to respect reality. I just don't stand for any nonsense.*"

The transition from wood ("traditional biofuels") to fossil fuels—first coal, then oil and natural gas—took more than a century. Today, fossil energy is dominant, with wind and solar making up a mere sliver of the mix. The pace of past energy transitions suggests that a full-scale shift to renewables will be slow.

Smil's writing career kicked off in the mid-1970s, just as an embargo on oil sales by Middle Eastern nations woke up developed nations to just how hooked they were on petroleum, for transportation, heating, farming, chemicals, even electricity. The jolt came just after the publication of ***The Limits to Growth***, an influential study that, using a simple computer model, warned of a pending depletion of the planet's resources.

Smil was intrigued and taught himself programming to re-create the model for himself. "I saw it was utter nonsense," he recalls; the model was far too simple and easily skewed by initial assumptions. He constructed a similar model of how carbon dioxide emissions affect climate and found it similarly wanting. He understood the physics of the greenhouse effect and the potential for a carbon dioxide buildup to warm Earth, but models seemed too dependent on assumptions about things like clouds. Ever since, he's held models of all kinds in contempt.

"I have too much respect for reality,"

Instead, he scoured the scientific literature and obscure government documents for data, seeking the big picture of how humanity generates and deploys energy. What ultimately emerged in several blandly titled books—including *General Energetics: Energy in the Biosphere and Civilization* (1991), *Energy in World History* (1994), and *Energy Transitions: History, Requirements, Prospects* (2010)—is an epic tale of innovation and transformation, worked through one calculation at a time.

That work has guided a generation to think about energy in the broadest sense, from antiquity to today, says Elizabeth Wilson, director of the Institute for Energy and Society at Dartmouth College. "*You could take a paragraph from one of his books and make a whole career out of it,*" she says. And yet Smil has avoided mental traps that could come with his energy-oriented view, she adds. "*[He] does a really good job of being nuanced.*"

In essence, Smil says, humanity has experienced three major energy transitions and is now struggling to kick off a fourth. First was the mastery of fire, which allowed us to liberate energy from the sun by burning plants. Second came farming, which converted and concentrated solar energy into food, freeing people for pursuits other than sustenance. During that second era, which ended just a few centuries ago, farm animals and larger human populations also supplied energy, in the form of muscle power. Third came industrialization and, with it, the rise of fossil fuels. Coal, oil, and natural gas each, in turn, rose to prominence, and energy production became the domain of machines, as such coal-fired power plants.

Now, Smil says, the world faces its fourth energy transition: a move to energy sources that do not emit carbon dioxide, and a return to relying on the sun's current energy flows, instead of those trapped millions of years ago in deposits of coal, oil, and natural gas.

The fourth transition is unlike the first three, however. Historically, Smil notes, humans have typically traded relatively weak, unwieldy energy sources for those that pack a more concentrated punch. The wood he cut to heat his boyhood home, for example, took a lot of land area to grow, and a single log produced relatively little energy when burned. Wood and other biomass fuels have relatively low **"power density,"** Smil says. In contrast, the coal and oil that heated his later dwellings have higher power densities, because they produce more energy per gram and are extracted from relatively compact deposits. But now, the world is seeking to climb back down the power density ladder, from highly concentrated fossil fuels to more dispersed renewable sources, such as biofuel crops, solar parks, and wind farms. (Smil notes that nuclear power, which he deems a **"successful failure"** after its rushed, and now stalled, deployment, is the exception walking down the density ladder: It is dense in power, yet often deemed too costly or risky in its current form.)

In the past, humanity has typically adopted energy sources that have greater "power density," packing more punch per gram and requiring less land to produce. Renewables, however, are lower in density than fossil fuels. That means a move to renewables could vastly increase the world's energy production footprint, barring a vast expansion of nuclear power.

One troubling implication of that density reversal, Smil notes, is that in a future powered by renewable energy, society might have to devote 100 or even 1000 times more land area to energy production than today. That shift, he says, could have enormous negative impacts on agriculture, biodiversity, and environmental quality.

To see other difficulties associated with that transition, Smil says, look no further than Germany. In 2000, fossil fuels provided 84% of Germany's energy. Then the country embarked on a historic campaign, building 90 gigawatts of renewable power capacity, enough to match its existing electricity generation. But because Germany sees the sun only 10% of the time, the country is as hooked as ever on fossil fuels: In 2017, they still supplied 80% of its energy. "*True German engineering,*" Smil says dryly. The nation doubled its hypothetical capacity to create electricity but has gotten minimal environmental benefit. Solar can work great, Smil says, but is best where the sun shines a great deal.

Perhaps the most depressing implication of Smil's work, however, is how long making the fourth transition might take. Time and again he points back to history to note that energy transitions are slow, painstaking, and hard to predict. And existing

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technologies have a lot of inertia. The first tractor appeared in the late 1800s, he might say, but the use of horses in U.S. farming didn't peak until 1915—and continued into the 1960s.

Fossil fuels have similar inertia, he argues. Today, coal, oil, and natural gas still supply 90% of the world's primary energy (a measure that includes electricity and other types of energy used in industry, transportation, farming, and much else). Smil notes that the share was actually lower in 2000, when hydropower and nuclear energy made up more of the mix. Since then, "we have been increasing our global dependence on fossil fuels. Not decreasing," he says.

A key factor has been the economic boom in China, a nation Smil has studied since the 1970s, and its burgeoning appetite for coal. Smil was among the first Western academics invited to study the Chinese energy system. He sounded early warnings about the nation's cooked farm statistics and perilous environmental state. Now, Smil is disheartened by China's consumer culture: Instead of aiming to live more modestly, he says the Chinese are ***"trying to out-America America."***

Meanwhile, despite years of promotion and hope, wind and solar account for just about 1% of the world's primary energy mix. In part, he notes, that's because some of the key technologies needed to deploy renewable energy on a massive scale—such as higher-capacity batteries and more efficient solar cells—have seen only slow improvements. The bottom line, he says, is that the world could take many decades to wean itself from fossil fuels.

"I'm a European pessimist."

Smil says that pessimism is rooted in his understanding of history. But even some of his fans say he puts too much stock in the lessons of the past.

Smil says he would be delighted to be proved wrong— In particular, a breakthrough in cheap energy storage would change the game. "*Give me mass-scale storage and I don't worry at all. With my wind and photovoltaics I can take care of everything.*" But "*we are nowhere close to it,*" he says.

Smil is not comfortable offering solutions. Any he suggests typically come down to encouraging individual action, not sweeping government policies or investment strategies. If we all cut consumption, lived more efficiently, and ate less meat, he suggested at one recent lecture, the biosphere would do fine. Fewer livestock, for instance, might mean farmers would stop over fertilizing soybeans to feed to animals. Less fertilizer, in turn, would drastically cut emissions of nitrous oxide, a powerful greenhouse gas, from the soil. "*Less pork and less beef, right? That's it,*" Smil says. "*Nobody is really talking about it.*"

For all his insistence on documenting reality, he accepts that many concepts cannot be defined. What does a healthy society look like, and how do you measure it? He abhors Gross Domestic Product, the traditional measure used by economists, because even horrendous events—natural disasters and shootings, for example—can prompt spending that makes it grow. But the alternatives don't look great, either. Happiness indexes? Some of "*the happiest nations on the planet are Colombia and the Philippines,*" Smil says. "*What does that tell you?*"

Lately, he's been thinking about growth, the obsession of modern, fossil-fueled economies and the antithesis of Smil's lifestyle of efficient, modest living. How do children grow? Energy systems? Cyanobacteria? Empires? His next book, in 195,000 words, will examine growth in all forms. "*I'm trying to find the patterns and the rules,*" he says. "*Everything ends. There is no hyperbolic growth.*"

Still, although Smil can see the present better than most, he is loath to predict the future. And has been wrong before- He could not have imagined, he says, how soon the Soviet Union would fall. Or how fast China would grow. And he is not about to say that a collapse is inevitable now—not even with humanity on a problematic course and unlikely to change direction soon. "You ask me, 'When will the collapse come?'" Smil says.

"Constantly we are collapsing. Constantly we are fixing."

Vaclav Smil's latest book is:
'How the World Really Works: The Science Behind How We Got Here and Where We're Going'

From an article by **Paul Voosen**
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