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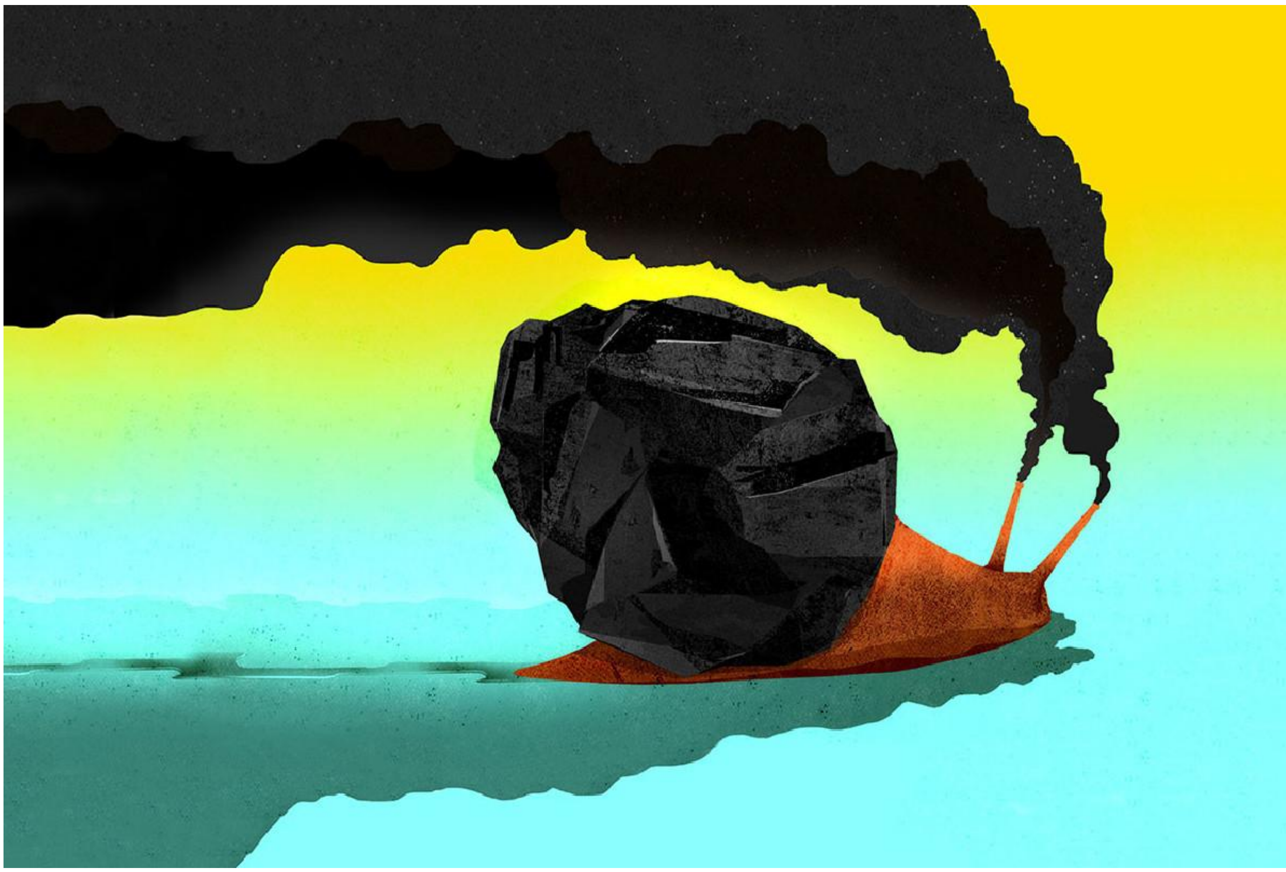

Brian Stauffer for POLITICO

The Agenda
FUTURE OF POWER

Revolution? More like a crawl

The energy visionary Vaclav Smil — Bill Gates's favorite author — says that when our leaders promise quick energy transformations, they're getting it very wrong.

By VACLAV SMIL | 05/26/2015 11:42 PM EDT

America in 2015 finds itself almost in a new energy reality. It recently became the world's second-largest extractor of crude oil, and since 2010 has been the leading producer of natural gas, whose abundant and inexpensive supply has been accelerating the retreat from coal as a national source of electric power.

Some see this as the beginning of an even bigger transition, one in which America's dominant status as a producer of hydrocarbons ends its allies' dependence on Russian gas and makes OPEC terminally irrelevant, while its entrepreneurial drive helps it quickly advance to harness renewables and reduce greenhouse gas emissions.

All of this sounds too good to be true — and it is. Indefensible claims of imminent transformative breakthroughs are an unfortunately chronic ingredient of American energy debates.

When American leaders talk about energy transitions, they tend to sell them as something that can be accomplished in a matter of years. Al Gore, perhaps the country's most prominent climate activist, proposed to "re-power" America, making its electricity carbon-free, within 10 years, calling the goal "achievable, affordable and transformative." That was in 2008, when fossil fuels produced 71 percent of American electricity; last year 67 percent still came from burning fossil fuels.

President Barack Obama, who has a strong rhetorical dislike of oil — although kerosene distilled from it fuels the 747 that carries him to play golf in Hawaii — promised in his 2011 State of the Union message that the country would have 1 million electric cars by 2015. That goal was abandoned by the Department of Energy just two years later.

For years, even decades, we have been on the verge of mass deployment of (take your pick) fast breeder reactors, of coal-fired electricity generating plants that capture and sequester all of their CO2, of fuel cell-powered cars running on hydrogen, if not a complete hydrogen economy. We've been promised electric cars that will not only cost nothing to run but will also power houses while sitting in garages; or microorganisms genetically engineered to ooze gasoline.

The reality of energy transitions is very different. Too many modern observers have become misled by the example of electronics, in which advances have followed Moore's law — the now 50-year-old prediction that the number of components on a microchip will double every 18 months. This has allowed exceptionally rapid progress. But the fundamental physical realities that determine progress of energy systems do not behave that way: they are improving steadily, but far more slowly. Moore's law implies an exponential growth rate of 46 percent a year. The analogues in energy are not even close: Since 1900, the efficiency of electricity generation in large power plants has been rising by less than 2 percent a year, advances in lighting have boosted its efficiency by less than 3 percent a year, and the energy cost of steel, our civilization's most essential metal, has been falling by less than 2 percent a year.

Moore's Law means performance doubles in a year and a half. Change at the rate of energy systems means doubling efficiencies, or halving the costs, in 35 years — a vastly longer timespan.

These things might sound technical. They are not. Accepting this reality is essential in order to chart a path for lasting progress: sensible policies cannot be built on mistaken beliefs or on wishful thinking. In the conversation about America's — and the world's — energy future, reality demands we keep a few important principles in mind.

Undoubtedly, the U.S. is experiencing two notable energy transitions, from coal to natural gas and from fossil fuels to new renewables in electricity generation. These shifts are welcome because they promise to bring cleaner and less carbon-intensive supplies. But they cannot be rapid, and they bring their own technical, economic and social challenges. Energy infrastructure is the world's most elaborate and expensive, and the longevity and inertia of many large energy enterprises make it impossible for any large, complex national system (to say nothing of the global level) to reconfigure itself even in three or four decades.

How slow are these transitions, really? To answer this question I recently undertook a comprehensive study of energy transitions –- both at the global level and for the world's major economies (U.S., China, Japan, Russia, U.K., France) — for a period of 150 years. Starting with the epochal move from wood to coal that defined the second half of the 19th century, through the more recent shifts from fossil fuels to renewables like wind turbines and solar cells, I measured how long it typically takes for a particular energy source to go from 5 percent of the market (that is, more than a negligible contribution) to claim large shares (25 percent to 30 percent) of total energy supply.

The repeated answer is that it takes decades of gradual penetration. After crude oil claimed 5 percent of the total American energy supply in 1905, it took 28 years to reach 25 percent, and the rise was even slower for natural gas, 33 years from 1924 to 1957. Today, despite the attention lavished on solar cells and wind, those up-and-coming renewables have yet to reach even the 5 percent mark.

Globally, energy transitions have been even slower than in the U.S., with crude oil taking 40 years to go from 5 percent to 25 percent of the global primary energy supply, and it looks as though natural gas will take 60 years to do the same.

Coal's decline from being the source of half of the U.S. electricity in 2005 to less than two-fifths in 2015 has been the result of an inevitable process of closing down coal-fired power plants (due to their age and new mercury and air toxics standards), accelerated by the availability of cheap natural gas. But this does not mean an imminent end of coal. In absolute terms, coal combustion in U.S. power plants will have declined by only 2 percent between 2013 and 2015, and it is projected to be down by another 0.6 percent by the end of 2016 — hardly a precipitous drop.

Electricity generation by new renewables has been growing fastest, but it is far from taking over: at 7 percent in 2014 it was still only about a third of all electricity generated by the aging nuclear stations. And because electricity is only a part of the overall energy supply, the contribution of new renewables (wind and solar) to the country's total primary energy consumption (including all industrial and transportation fuels) remains very modest: it rose from just 0.1 percent in the year 2000 to 1 percent in 2010 and to 2.2 percent in 2014.

The U.S. is still an overwhelmingly fossil-fueled society, albeit a bit less so than it was a generation ago. Even if the new renewables keep on advancing at the same rate as they have been so far — a rate hard to maintain as the aggregate solar and wind capacities to be installed every year get progressively larger — fossil fuels would be supplying 78 percent of the U.S. primary energy in 2030 and still about 75 percent by 2040.

Our increasingly electrified, electronic and data-driven society places steadily rising demand on reliable baseload power — that is, on electricity available 24/7/365. Servers never sleep, nor does air conditioning during hot nights, and in Asia's megacities subways and electric trains take only brief naps between midnight and 5 a.m.

Electricity generating plants burning coal or natural gas or fissioning uranium can be run all night, or all winter, to supply baseload power, with nuclear reactors operating about 90 percent of the time. Not so wind turbines: they generate electricity only while sufficiently strong wind is blowing (and hence work 25-35 percent of the hours available every year).

Photovoltaic solar generation peaks around noon under clear skies and stops later in the day. Both wind and sun experiences major seasonal downturns. For example, the northern Plains are America's windiest region, but in winter — when the electricity is needed most through cold and short days — the Arctic air forms semi-stationary high pressure cells that produce low temperatures and calm winds.

The only way to negate these longer-lasting wind and solar lows is to bank the electricity generated during sunny and windy days — and that means massive, grid-scale storage. Our batteries are getting better, but the only commercially available massive (gigawatt-scale) electricity storage is still a 19th-century technique first commercially deployed during the 1890s: pumping water up to a mountain reservoir with cheaper nighttime electricity, and then releasing it during the hours of high daily demand. (This practice results in a net energy loss of about 25 percent and, obviously, it cannot be used in flat regions.) More than anything else, electricity storage is the key technical breakthrough needed if the new renewables are to claim a substantial share of primary energy in modern electricity-intensive economies, but the progress will be, as it has been, slow and incremental.

America tends to assume Silicon Valley-style innovators can drive quick and transformative changes, but even Silicon Valley's would-be masters of the universe have discovered that energy transitions are subject to time spans and technical constraints that defy their reach. Google launched its "Clean Energy 2030" in October 2008, aiming to eliminate U.S. use of coal and oil for electricity generation by 2030, and cut oil use for cars by 44 percent. It was completely abandoned in November 2011.

Elon Musk, the entrepreneur some U.S. media have proclaimed to be a man more inventive than Edison, makes much-praised electric cars — but Tesla ended 2014 with another loss after selling only 17,300 vehicles in a market of 16.5 million units, claiming a share of 0.1 percent of the U.S. car market. Obviously, it will take many years before Tesla becomes anything but a market curiosity.

What then is the best course to follow? Not a single route, but a combination of advances.

First, even after more than a century of improvements, all fossil fuel conversions can be made substantially more efficient and work with reduced environmental impacts. But these solutions must go beyond the converters themselves: we already have 97-percent-efficient natural gas furnaces, but their full benefit can be realized only in superinsulated houses with triple windows; and the benefits of cleaner and more efficient car engines will be largely negated as long as people drive ever-more massive SUVs.

Second, the desirable development of new renewables should not be guided by wishful preferences and arbitrary targets (30 percent generated by wind by 2030), but it should proceed at a determined but measured pace that would ensure lasting benefits.

Third, beneath (or above) this all is the fundamental question of what is the energy use for. If it is to enable long, healthy and productive lives in safe and caring societies, then the U.S. has not done a very good job. America's per capita energy use is nearly twice as high as in Germany, France or Japan, but America's health care and educational achievements and subjective satisfaction with life are not twice the EU or Japanese level: indeed, in many of these measures the U.S. does not place even among the world's top 20 countries. Using more energy, albeit more efficiently and with lower specific environmental effects by deploying new conversion techniques, is unlikely to change the country's fortunes — but no serious consideration has been given to how to use less, much less. Indeed, such a suggestion seems to be entirely subversive, and quintessentially unAmerican.

Vaclav Smil is Distinguished Professor Emeritus at the University of Manitoba and author of numerous books on energy and the environment, most recently "Power Density: A Key to Understanding Energy Sources and Uses."

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By THE LAZER LAB

Data scientists graphed every word from members of Congress about coal. Here's what they found.

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