Energy transitions, renewables and rational energy use: A reality check

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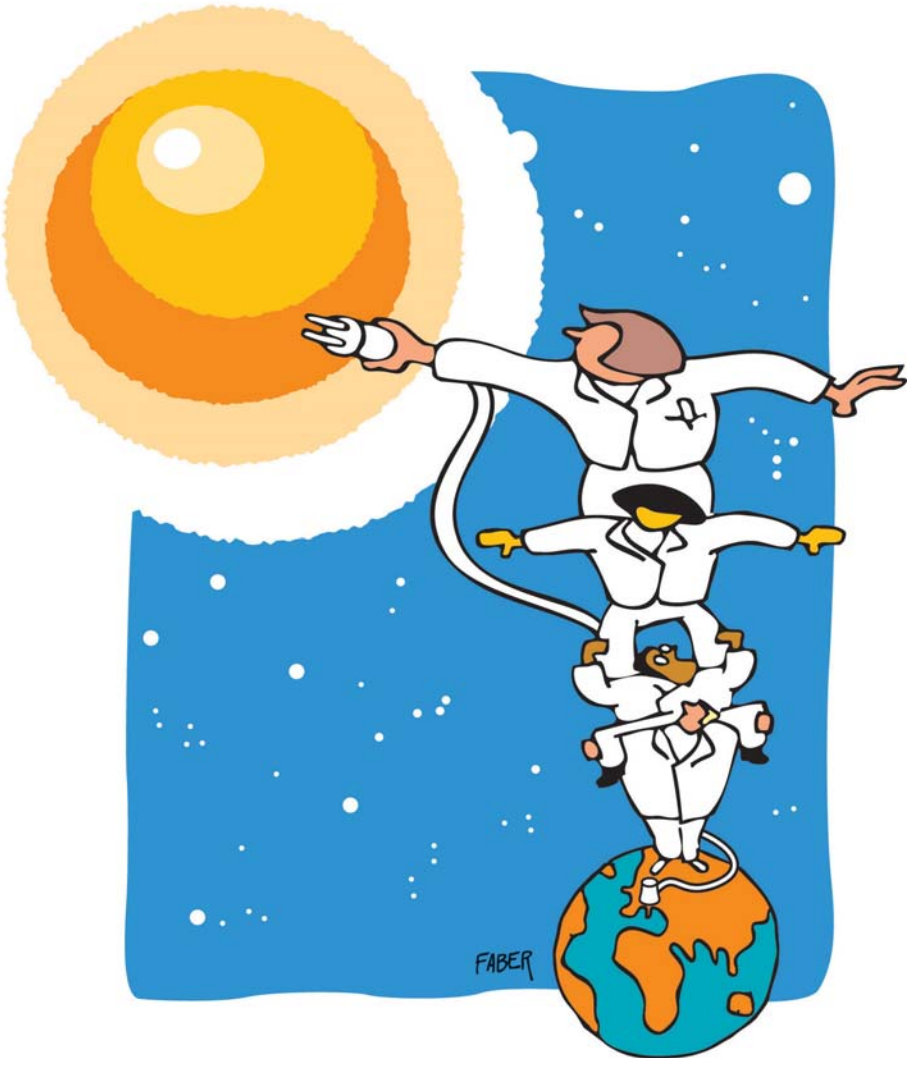

Is replacing fossil fuels with renewable sources such as solar and wind really feasible? A lot has to happen first, including a change in how we use energy.

There is nothing new about energy transitions, though until the 19th century they unfolded very slowly. With the exception of the UK (where coal had already become the dominant fuel by the mid-17th century) all major Western societies remained predominantly wood-fuelled economies energised by traditional biomass, until the latter half of the 19th century. Coal began to supply more than half of French energy by the early 1870s, and more than half of the US demand by the mid-1880s. But in global terms the 19th century was still dominated by wood and the world began to use more coal than wood only at the very beginning of the 20th century.

By 1950 traditional biomass fuels supplied about 27% of the world's energy (and most of the energy in both China and India), and fossil fuels (mainly coal) provided about 72%, with hydroelectricity delivering just over 1%. By the end of the 20th century modern civilisation became even more dependent on fossil fuels: in absolute terms their extraction had more than quadrupled between 1950 and 2000, and they delivered about 78% of the world's primary energy. But traditional biomass fuels still provided nearly 12%, so if we count only modern primary energies, then coal, crude oil and natural gas supplied 90% of the world's energy in the year 2000, declining to 86% by 2015. We have always known that our reliance on fossil fuels would be a temporary affair, and that long before we would exhaust their immense resources, coal recovery from deep and thin seams and oil and gas production from small fields in extreme environments would become too costly to handle. A shift to nuclear energy or to modern conversions of renewable energy flows was always inevitable. If fuel resources and technical abilities to recover them at affordable price were the only limitations, we could anticipate at least another century or more of coal, oil and gas. Global warming has made the transition to non-carbon energies a matter of some urgency, but we must nevertheless be realistic about the size and speed of such a shift.

> "Less is more" has never been more desirable than in the case of tackling climate change

By 2015, the largest non-fossil contribution came from hydroelectricity (about 6%), and while large-scale opportunities to develop water power are still available in parts of Asia, Africa and Latin America, resource limitations and environmental consideration dim the prospects of even a doubling of this contribution. Nuclear fission now supplies less than 5% of the world's primary energy and while there are some bold plans for its expansion in

Asia, its use in OECD countries has been stagnating or declining, making it highly improbable that it could become a leading source of non-carbon energy in the near future.

Solar, wind and modern biofuels now supply no more than 3% of the world's primary energy, and in 2014 China, which has seen years of record-setting additions of solar and wind capacities, derived less than 2% of its energy from these conversions. Wind and solar electricity are much more prominent in some EU countries, but even Germany, the country that forced an accelerated adoption of new renewables through its *Energiewende*, produced about 15% of all electricity from wind and solar, compared to about 55% from fossil fuels in 2014. Going further, say to 40-50%, will be challenging technically and cost-wise, since producing higher shares of intermittently available electricitzy will require higher reserve capacities for night-time demand, and for overcast and calm days; better high-voltage interconnections; and more extensive electricity storage, including for entire cities, now home to more than half of the world population.

However, generating higher shares of electricity from wind and solar conversions is less challenging than displacing fossil fuels for transportation. Biofuels are an obvious alternative but very few countries can afford to divert so much of their cropland to their cultivation as the US has done, where biofuel still only supplies less than 8% of all of its transportation energy. Global production of modern biofuels (ethanol and biodiesel) is now equivalent to just 3% of nearly 2.5 billion tonnes of oil equivalent used by land, water and air transport. Low power densities, low energy returns, water demand and environmental degradation are among the most obvious limits on biofuel production, and the much touted second generation of such fuels (converting waste phytomass) has yet to reach large-scale commercial stage.

Most importantly, there are large segments of modern energy consumption where we do not have any readily available alternatives of the required scales of billions or hundreds of millions of tonnes. Worldwide, about a billion tonnes of coal goes to make coke, the critical raw material for producing iron, while direct reduction of iron accounts for only 5% of the metal's total output (and it is mostly energised by another fossil fuel, natural gas). Non-energy uses of fossil fuels are also critical: more than half a billion tonnes of crude oil and natural gas are used as feedstocks to produce a wide array of plastics, fertilisers and other chemicals, and more than 100 million tonnes of crude oil end up as lubricants and paving materials (asphalt).

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Slim that waste line

So there is work to do. A combination of subsidy changes–removing them from fossil fuels, enhancing them for new renewables–mandated production targets and intensified R&D could accelerate the transition to renewables, but it is unlikely to displace all fossil fuels in a few decades, particularly as many low-income countries will rely on them for their development. While fossil fuels will still dominate the global energy supply by 2050, their absolute consumption should be steadily declining, particularly in OECD countries and if we commit ourselves to a more rational energy use.

Mass adoption of the best available conversion techniques is not enough: after all, we now use more fuel by flying more frequently in better airplanes and moving more goods in more efficient ships and trucks. High-income economies simply have to find ways to reduce their average per capita energy use, such as by cutting their extraordinarily high food losses (about 40%), and rationalise their wasteful transport. Such actions would increase well-being and improve trade balances as well, while steadily reducing CO_2 emissions.

We should not forget that the environmentally least disruptive action is not to turn to new technical solutions to produce more energy in different ways, but simply to do with less. "Less is more" has never been more desirable than in the case of tackling the rising levels of atmospheric CO_2.

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Smil, Vaclav (2006), "21st century energy: Some sobering thoughts", in *OECD Observer* No 258-259, December 2006, OECD Publishing.