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As a child of the 1950s I grew up immersed in a near-universal expectation of progress. Everybody expected a shiny new future; the only thing that might have prevented us from having it was nuclear war, and thankfully that hasn't happened (so far). But, in the intervening decades, progress has begun to lose its luster. Official agencies still project economic growth as far as the eye can see, but those forecasts of a better future now ring hollow.

Why? It's simple. We can't afford it.

To understand why, it's helpful to recall how the present got to be so much grander (in terms of economic activity) than the past. Much of that story has to do with fossil fuels. Everything we do requires energy, and coal, natural gas, and oil provided energy that was cheap, abundant, concentrated, and easily stored and transported. Once we figured out how to get these fuels out of the ground and use them, we went on history's biggest joy ride.

But fossil fuels are depleting non-renewable resources, and are therefore subject to declining resource quality. Oil is the most economically important of the fossil fuels, and depletion is already eating away at expectations of further petroleum-fed progress. During the past decade, production rates for conventional oil—the stuff that fueled the economic extravaganza of the 20th century—have stalled out and are set to drop (according to the IEA's [latest forecast](#)). Between 2004 and 2014, the oil industry's costs for exploration and production rose at [almost 11 percent per year](#). The main bright spot in the oil world has been growing production of unconventional oil—specifically tight oil in North America associated with the fracking boom. But now that boom is going bust.

It's true that boom and bust cycles have typified the oil and gas industry throughout its history, but this time it really does seem different. [Tight oil is expensive to produce](#), individual wells decline quickly, well quality varies greatly, and good drilling sites are limited in number. These problems didn't seem to be an issue at first. During the boom years money was cheap and investors were easily conned. The frackers had every incentive to lease as much land as they could borrow money for, drill the best sites as quickly as possible, and leave the leftovers for laggards. This mentality led them to over-produce over the short run, driving oil prices down far below the cost of doing business. Now drilling rigs are idled and production is headed south, leaving fracking companies' high-priced PR

spokescritters to whine that surely production will pick up again when prices eventually recover. Will it? Only if new cadres of investors (read: "suckers") can be found, and even then only briefly. Overall, the oil industry is in treacherous waters and headed for worse.

This is part of a general trend. Extractive industries are always ruled by the imperative to target highest-quality resources first and leave the crappy stuff for later. After decades of extracting oil, coal, and natural gas, the fossil fuel industry is increasingly faced with unpalatable future prospects (unconventional oil and gas, lower grades of coal) that are more expensive to extract and that entail higher environmental risks and costs.

So the fossil-fueled future will be more expensive. But if we want to tally its real cost, we must add the also soaring "external" costs of burning fossil fuels. Over the short run, the biggest of those costs may simply be the health impacts from breathing coal smoke and dust: [a study I co-authored in 2011](#) calculated that coal use costs the U.S. between a third and over half a trillion dollars each year in health, economic, and environmental impacts. The costs for China, [where 670,000 people die each year of coal-related diseases](#), is no doubt far higher. Now add the bills for cleaning up oil spills, for the health impacts of fracking, and for the potential health costs of environmentally dispersed petrochemical-based hormone disrupters, and we're talking real money.

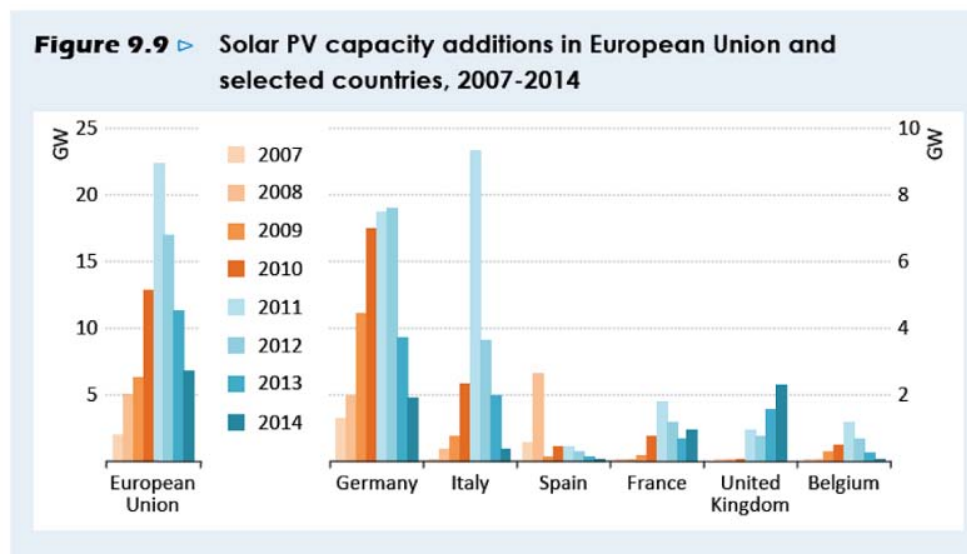
On top of all that, add the costs of climate change. They're relatively modest now, but set to explode. What would be the cost the U.S., for example, of having to largely abandon one major coastal city (Miami or New Orleans)? How about a dozen (possibly including New York)? What would be the cost from death and illness due to an unprecedented heat wave? What would be the cost of the nearly complete loss of agricultural production in California's Central Valley due to drought? The answer: it's probably incalculable. But that's all just the tip of the proverbial (and quickly melting) iceberg, and it's all just a matter of time. It should be clear by now that we really can't afford a fossil-fueled future.

Well then, how about a renewable energy future? I must start by noting my own view that a transition to renewable energy is necessary and inevitable, and that we must organize and pursue that effort as a top societal priority. But that doesn't mean we can just unplug coal power plants, plug in solar panels, and continue living essentially as we do now. True, solar and wind are getting cheaper. [A lot cheaper](#). Which is a good thing, because until recently they required subsidies for any substantial growth. They still do, in many situations. But even assuming further cost reductions, the fact is that an energy transition is a big deal. It takes time and the replacement of an extraordinary amount of infrastructure. Solar and wind energy production is greatly expandable, but these energy sources have some drawbacks: they produce energy intermittently and uncontrollably. It takes additional technology to adapt these sources to our 24/7 energy demand patterns.

In recent studies, Mark Jacobson of Stanford University and his co-authors [have concluded that a full transition to renewable energy would be affordable](#). Their conclusion depends on counting savings

from the avoided costs of climate change and health damage from fossil fuel use. However, subtracting these avoided costs tells us only that a transition to renewables would be more affordable than maintaining our status quo reliance on fossil fuels; it does not necessarily mean that the transition would be affordable on its own terms.

Estimating how much a total energy transition would cost is difficult. The problem can be simplified greatly by including only the direct cost of solar panels and wind turbines, but doing so is unrealistic. Better estimates would include the costs of energy storage, grid redesign, and redundant capacity; plus required investments in new technology for the transportation, agriculture, and manufacturing sectors; in new equipment for building operations; and in energy efficiency retrofits to nearly every existing structure. Just one example: we currently make cement (which is used in nearly all construction projects) using high heat from fossil fuels; we could get that heat from sunlight, hydrogen, or electricity, but that would require a complete redesign of the process, and it's unclear how much cement made with renewable energy would cost relative to cement made with fossil fuels. Altogether, the cost of a full global renewable energy transition would certainly run into the many tens of trillions of dollars—if (and this is crucial) our goal is to produce enough energy to maintain current levels of mobility and amenity.



Source: IEA, *World Energy Outlook 2015*

Actual rates of investment in renewable energy globally have leveled off in the past four years, with investment rates in Europe shrinking while China continues to surge ahead.

Wait, I'm not finished. This isn't all about energy, though energy is probably the single greatest factor determining whether we can afford our assumed future of further material progress. Ask any civil engineer and they will tell you the United States is [literally falling apart](#). Roads, bridges, water mains, airports, rails, and power grids were built during the last century in an orgy of construction such as the world had never seen. Today that infrastructure is aging, and we can't seem to find the money with which to repair or replace it.

Finally we come to the financial tool inevitably used to deal with all such costs—debt. Credit (the other side of the debt coin) is wonderful: it enables us to spend now but pay later. We've exploited this tool ruthlessly over the past few decades, and as a result today's household debt, corporate debt, and government debt are all at or near record levels. The financial crisis of 2008 is widely regarded as having been triggered by too much unserviceable debt; nevertheless, global debt has actually increased by \$57 Trillion since then. Greece's debt crisis still threatens the economic stability of the European continent. [Global debt now stands at 286 percent of GDP](#), a level that many economists believe is unsustainable and must eventually lead to a deleveraging event perhaps comparable to, or worse than, the Great Depression. But how are we to pay for our energy future (fossil fueled or renewable), and needed infrastructure repair, without still more debt? It doesn't look as though we'll be able to do all that spending using current account surpluses, as [world GDP growth is slowing rather than accelerating](#).

Some readers may assume that I just got up on the wrong side of the bed, and that this is all just too pessimistic. Surely we will muddle through, with new technology making further progress affordable. I must be cherry-picking a worst-case scenario, right? No, in my view there is no exaggeration here. The evidence as I see it is stacked almost entirely on the side of my thesis: we (as a nation, or as a global civilization, take your pick) really and truly cannot afford much more of the kind of progress—defined in terms of increases in energy and material consumption—that we got used to during the last century.

That means that if we don't start planning for whatever kind of future we can afford (in both dollar and energy terms), we'll end up broke, foreclosed, and without much of a future worth living in.

Clearly, the affordable future will be slower, simpler, and less mobile than Futurama daydreams of the 1960s. It will entail living closer to the land and using much less in the way of energy and materials than folks in wealthy industrial nations currently are accustomed to using. If we're dropped headlong into that future with no preparation, we're likely to see it as—and turn it into—a dystopian, post-apocalyptic nightmare. However, if we plan and prepare, our affordable future could actually be an improvement over the soul-destroying existence that pervades so much of urban and suburban America these days. [Permaculturists](#), [organizations of idealistic young organic farmers](#), eco-villages like [Dancing Rabbit](#) and [The Farm](#), and [Transition Initiatives](#) represent what appear currently to be barely visible fringe phenomena. But the folks pursuing these road-less-traveled deserve our attention and help, because they're about the only people in the industrialized world who are preparing for the kind of future that's actually within our means.