The Trump Administration is trying to save coal and stop the growth of renewables. Just this week Scott Pruitt issued a proposed repeal of Obama's Clean Power Plan. Whether or not the repeal succeeds, Pruitt & Co. are fighting against the economic tide. If the price of renewables continues to fall, it will be harder and harder to maintain the use of the high-pollution fuels they favor. Fortunately, there are strong reasons to think that the downward price trend will continue.

I've read about a million times that renewables are getting cheaper, but no one ever seems to explain why. I decided to dig into that a bit, in the hope of finding out whether the trend will continue. In the U.S., the Trump Administration may try to buck the trend through tariffs or other market interventions to protect polluting coal plants from cheaper, cleaner alternatives. But it looks like the economic and technological fundamentals favor a continuing global trend toward cheaper renewables.

Wind. According to the American Wind Energy Association, wind turbines represent about 70% of the capital cost of a wind project. Technological improvements have made wind turbines more efficient, producing more energy per dollar of investment. Blades have gotten lighter and longer, while towers have gotten higher (allowing access to higher wind speeds). Increased rotor diameters have also increased efficiency, according to **experts**. My initial thought was that these improvements were due to improvements in materials science, but it appears that improvements in the digital realm have more to do with it. Better computer modeling allows improvements in blade design (including potentially site-specific design) and also in operation – apparently the blades develop thrust which is hard to control in real time, but computers have helped address this problem substantially.

Since it has no fuel costs, wind also has value as a hedge in price fluctuations for other energy sources such as natural gas, which could be considered an offset against the capital costs.

What about the future? One **study** projected that wind costs will fall by an additional 20% by 2030, based on the learning curve to date. Other **experts** predict decreases of 25-30% or more. Offshore wind could involve even greater efficiencies if the barriers to those projects could be lowered.

The use of wind to generate electricity goes back to the late 19th century. That's about the same time that cars were invented. It seems to me that the analogy is a good one. Today's cars are far more efficient than the cars of the past, but it's not due to any huge conceptual breakthrough.. It's due to thousands of incremental improvements over time, incorporating new technologies such as computers and carbon fiber materials. We can expect to see very

similar developments with wind.

Solar. The cost of solar dropped about 25% from 2010 to 2015 (measured by generating capacity). Interestingly, as Scientific American explained, this took place even though the price of panels was flat during this time period – meaning that it was "largely caused by a decline in the cost of the inverters that convert the DC power produced by solar panels to AC power for the grid, along with other "soft" costs such as customer acquisition, system design, installation, and permitting."

An article published in ***Science*** last April projects that further price decreases are likely, given plausible technological developments. According to the researchers from DOE's National Renewable Energy Laboratory:

> "Recent technoeconomic analysis has mapped potential paths to a levelized cost of electricity of $0.03/kWh that could be achieved in the United States by lowering the module price to $0.30/W, increasing module efficiency to 25%, decreasing the balance of systems costs (all components other than the PV panels) [photovoltaic] to $0.35/W, and improving reliability."

The projected cost of $.03/kWh is about one-fourth of current prices, so this would be a very promising price drop. In terms of the intermittency problem, these researchers contend that "dispatchable solar electricity (PVs at $0.03/kWh plus storage at $0.05/kWh) could be economically competitive for a range of markets by 2030."

Economies of scale or learning by doing could also help bring down other costs such as installation and permitting. In addition, like wind, solar power has hedging value against future price increases for other fuels and tighter environmental regulation.

If Trump slaps prohibitive tariffs on imports of solar panels, that will throw some temporary shade on the expansion of solar. This effect will ease at least somewhat as the domestic industry expands but could still create a damping effect for some period of time. Historically, such trade barriers have proved prone to leakiness as companies learn how to evade the rules, and of course a future president could very well lift the trade sanctions. In any event, regardless of Trump, countries like China are turning toward renewables, which will choke off the export market for U.S. coal.

The Future. There is every reason to think that renewable prices will continue to fall in the long run. Just how much is hard to know because that depends on engineering

developments. There are also potential cost decreases on the human systems side – faster land acquisition and permitting, plus quicker installation. By **some accounts**, renewables are already cost-competitive with fossil fuels. The economics seem likely to shift even more toward renewables going forward. This may be even more true in developing countries, since labor costs for installation are a significant factor, and labor is cheaper there. And of course, Trump can't stop people in other countries from going renewable.