The true feasibility of moving away from fossil fuels

One of the great misconceptions of our time is the belief that we can move away from fossil fuels if we make suitable choices on fuels. In one view, we can make the transition to a low-energy economy powered by wind, water, and solar. In other versions, we might include some other energy sources, such as biofuels or nuclear, but the story is not very different.

The problem is the same regardless of what lower bound a person chooses: our economy is way too dependent on consuming an amount of energy that grows with each added human participant in the economy. This added energy is necessary because each person needs food, transportation, housing, and clothing, all of which are dependent upon energy consumption. The economy operates under the laws of physics, and history shows disturbing outcomes if energy consumption per capita declines.

There are a number of issues:

- The impact of alternative energy sources is smaller than commonly believed.
- When countries have reduced their energy consumption per capita by significant amounts, the results have been very unsatisfactory.
- Energy consumption plays a bigger role in our lives than most of us imagine.
- It seems likely that fossil fuels will leave us before we can leave them.
- The timing of when fossil fuels will leave us seems to depend on when central banks lose their ability to stimulate the economy through lower interest rates.
- If fossil fuels leave us, the result could be the collapse of financial systems and governments.

[1] Wind, water and solar provide only a small share of energy consumption today; any transition to the use of renewables alone would have huge repercussions.

According to BP 2018 Statistical Review of World Energy data, wind, water and solar only accounted for 9.4% of total energy consumption in 2017.
Even if we make the assumption that these types of energy consumption will continue to achieve the same percentage increases as they have achieved in the last 10 years, it will still take 20 more years for wind, water, and solar to reach 20% of total energy consumption.

Thus, even in 20 years, the world would need to reduce energy consumption by 80% in order to operate the economy on wind, water and solar alone. To get down to today’s level of energy production provided by wind, water and solar, we would need to reduce energy consumption by 90%.

[2] Venezuela’s example (Figure 1, above) illustrates that even if a country has an above average contribution of renewables, plus significant oil reserves, it can still have major problems.

One point people miss is that having a large share of renewables doesn’t necessarily mean that the lights will stay on. A major issue is the need for long distance transmission lines to transport the renewable electricity from where it is generated to where it is to be used. These lines must constantly be maintained. Maintenance of electrical transmission lines has been an issue in both Venezuela’s electrical outages and in California’s recent fires attributed to the utility PG&E.

There is also the issue of variability of wind, water and solar energy. (Note the year-to-year variability indicated in the Venezuela line in Figure 1.) A country cannot really depend on its full amount of wind, water, and solar unless it has a truly huge amount of electrical storage: enough to last from season-to-season and year-to-year. Alternatively, an extraordinarily large quantity of long-distance transmission lines, plus the ability to maintain these lines for the long term, would seem to be required.

[3] When individual countries have experienced cutbacks in their energy consumption per capita, the effects have generally been extremely disruptive, even with cutbacks far more modest than the target level of 80% to 90% that we would need to get off fossil fuels.
Notice that in these analyses, we are looking at “energy consumption per capita.” This calculation takes the total consumption of all kinds of energy (including oil, coal, natural gas, biofuels, nuclear, hydroelectric, and renewables) and divides it by the population.

**Energy consumption per capita depends to a significant extent on what citizens within a given economy can afford.** It also depends on the extent of industrialization of an economy. If a major portion of industrial jobs are sent to China and India and only service jobs are retained, energy consumption per capita can be expected to fall. This happens partly because local companies no longer need to use as many energy products. Additionally, workers find mostly service jobs available; these jobs pay enough less that workers must cut back on buying goods such as homes and cars, reducing their energy consumption.

**Example 1. Spain and Greece Between 2007-2014**

The period between 2007 and 2014 was a period when oil prices tended to be very high. Both Greece and Spain are very dependent on oil because of their sizable tourist industries. Higher oil prices made the tourism services these countries sold more expensive for their consumers. In both countries, energy consumption per capita started falling in 2008 and continued to fall until 2014, when oil prices began falling. Spain’s energy consumption per capita fell by 18% between 2007 and 2014; Greece’s fell by 24% over the same period.

Both Greece and Spain experienced high unemployment rates, and both have needed debt bailouts to keep their financial systems operating. **Austerity measures** were forced on Greece. The effects on the economies of these countries were severe. Regarding Spain, Wikipedia has a section called, “**2008 to 2014 Spanish financial crisis.**” suggesting that the loss of energy consumption per capita was highly correlated with the country’s financial crisis.

**Example 2: France and the UK, 2004 – 2017**
Both France and the UK have experienced falling energy consumption per capita since 2004, as oil production dropped (UK) and as industrialization was shifted to countries with a cheaper total cost of labor and fuel. Immigrant labor was added, as well, to better compete with the cost structures of the countries that France and the UK were competing against. With the new mix of workers and jobs, the quantity of goods and services that these workers could afford (per capita) has been falling.

Comparing 2017 to 2004, energy consumption per capita is down 16% for France and 25% in the UK. Many UK citizens have been very unhappy, wanting to leave the European Union.

France recently has been experiencing “Yellow Vest” protests, at least partly related to an increase in carbon taxes. Higher carbon taxes would make energy-based goods and services less affordable. This would likely reduce France’s energy consumption per capita even further. French citizens with their protests are clearly not happy about how they are being affected by these changes.

Example 3: Syria (2006-2016) and Yemen (2009-2016)

Both Syria and Yemen are examples of formerly oil-exporting countries that are far past their peak production. Declining energy consumption per capita has been forced on both countries because, with their oil exports falling, the countries can no longer afford to use as much energy as they did in the past for previous uses, such as irrigation. If less irrigation is used, food production and jobs are lost. (Syria and Yemen)
Between Yemen’s peak year in energy consumption per capita (2009) and the last year shown (2016), its energy consumption per capita dropped by 66%. Yemen has been named by the United Nations as the country with the “world’s worst humanitarian crisis.” Yemen cannot provide adequate food and water for its citizens. Yemen is involved in a civil war that others have entered into as well. I would describe the war as being at least partly a resource war.

The situation with Syria is similar. Syria’s energy consumption per capita declined 55% between its peak year (2006) and the last year available (2016). Syria is also involved in a civil war that has been entered into by others. Here again, the issue seems to be inadequate resources per capita; war participants are to some extent fighting over the limited resources that are available.

Between 2008 and 2017, energy consumption per capita in Venezuela declined by 23%. This is a little less than the decreases experienced by the UK and Greece during their periods of decline.

Even with this level of decline, Venezuela has been having difficulty providing adequate services to its citizens. There have been reports of empty supermarket shelves. Venezuela has not been able to maintain its electrical system properly, leading to many outages.

[4] Most people are surprised to learn that energy is required for every part of the economy. When adequate energy is not available, an economy is likely to first shrink back in recession; eventually, it may collapse entirely.

Physics tells us that energy consumption in a thermodynamically open system enables all kinds of “complexity.” Energy consumption enables specialization and hierarchical organizations. For example, growing energy consumption enables the organizations and supply lines needed to manufacture computers and other high-tech goods. Of course, energy consumption also enables what we think of as typical energy uses: the transportation of goods, the smelting of metals, the heating and air-conditioning of buildings, and the construction of roads. Energy is even required to allow pixels to appear on a computer screen.

Pre-humans learned to control fire over one million years ago. The burning of biomass was a tool that could be used for many purposes, including keeping warm in colder climates, frightening away predators, and creating better tools. Perhaps its most important use was to permit food to be cooked, because cooking increases food’s nutritional availability. Cooked food seems to have been important in allowing the brains of humans to grow bigger at the same time that teeth, jaws and guts could shrink compared to those of ancestors. Humans today need to be able to continue to cook part of their food to have a reasonable chance of survival.

Any kind of governmental organization requires energy. Having a single leader takes the least energy, especially if the leader can continue to perform his non-leadership duties. Any kind of added governmental service (such as roads or schools) requires energy. Having elected leaders who vote on decisions takes more energy than having a king with a few high-level aides. Having multiple layers of government takes energy. Each new intergovernmental organization requires energy to fly its officials around and implement its programs.

International trade clearly requires energy consumption. In fact, pretty much every activity of businesses requires energy consumption.

Needless to say, the study of science or of medicine requires energy consumption, because without significant energy consumption to leverage human energy, nearly every person must be a subsistence level farmer, with little time to study or to take time off from farming to write (or even read) books. Of course, manufacturing medicines and test tubes requires energy, as does creating sterile environments.

We think of the many parts of the economy as requiring money, but it is really the physical goods and services that money can buy, and the energy that makes these goods and services possible, that are important. These goods and services depend to a very large extent on the supply of energy being
consumed at a given point in time—for example, the amount of electricity being delivered to customers and the amount of gasoline and diesel being sold. Supply chains are very dependent on each part of the system being available when needed. If one part is missing, long delays and eventually collapse can occur.

[5] If the supply of energy to an economy is reduced for any reason, the result tends to be very disruptive, as shown in the examples given in Section [3], above.

When an economy doesn’t have enough energy, its self-organizing feature starts eliminating pieces of the economic system that it cannot support. The financial system tends to be very vulnerable because without adequate economic growth, it becomes very difficult for borrowers to repay debt with interest. This was part of the problem that Greece and Spain had in the period when their energy consumption per capita declined. A person wonders what would have happened to these countries without bailouts from the European Union and others.

Another part that is very vulnerable is governmental organizations, especially the higher layers of government that were added last. In 1991, the Soviet Union’s central government was lost, leaving the governments of the 15 republics that were part of the Soviet Union. As energy consumption per capita declines, the European Union would seem to be very vulnerable. Other international organizations, such as the World Trade Organization and the International Monetary Fund, would seem to be vulnerable, as well.

The electrical system is very complex. It seems to be easily disrupted if there is a material decrease in energy consumption per capita because maintenance of the system becomes difficult.

If energy consumption per capita falls dramatically, many changes that don’t seem directly energy-related can be expected. For example, the roles of men and women are likely to change. Without modern medical care, women will likely need to become the mothers of several children in order that an average of two can survive long enough to raise their own children. Men will be valued for the heavy manual labor that they can perform. Today’s view of the equality of the sexes is likely to disappear because sex differences will become much more important in a low-energy world.

Needless to say, other aspects of a low-energy economy might be very different as well. For example, one very low-energy type of economic system is a “gift economy.” In such an economy, the status of each individual is determined by the amount that that person can give away. Anything a person obtains must automatically be shared with the local group or the individual will be expelled from the group. In an economy with very low complexity, this kind of economy seems to work. A gift economy doesn’t require money or debt!

[6] Most people assume that moving away from fossil fuels is something we can choose to do with whatever timing we would like. I would argue that we are not in charge of the process. Instead, fossil fuels will leave us when we lose the ability to reduce interest rates sufficiently to keep oil and other fossil fuel prices high enough for energy producers.

Something that may seem strange to those who do not follow the issue is the fact that oil (and other energy prices) seem to be very much influenced by interest rates and the level of debt. In general, the lower the interest rate, the more affordable high-priced goods such as factories, homes, and automobiles
The cost of extracting oil is less important in determining oil prices than a person might expect. Instead, prices seem to be determined by what end products consumers (in the aggregate) can afford. In general, the more debt that individual citizens, businesses and governments can obtain, the higher that oil and other energy prices can rise. Of course, if interest rates start rising (instead of falling), there is a significant chance of a debt bubble popping, as defaults rise and asset prices decline.

Interest rates have been generally falling since 1981 (Figure 7). This is the direction needed to support ever-higher energy prices.
energy prices with falling interest rates practically the whole time since oil prices rose above the inflation adjusted level of $20 per barrel!

In the 1970s, oil became unaffordable. Its use couldn’t grow without lower interest rates and growing debt.

Once the Federal Reserve and other central banks lose their ability to cut interest rates further to support the need for ever-rising oil prices, the danger is that oil and other commodity prices will fall too low for producers. The situation is likely to look like the second half of 2008 in Figure 6. The difference, as we reach limits on how low interest rates can fall, is that it will no longer be possible to stimulate the economy to get energy and other commodity prices back up to an acceptable level for producers.

[7] Once we hit the “no more stimulus impasse,” fossil fuels will begin leaving us because prices will fall too low for companies extracting these fuels. They will be forced to leave because they cannot make an adequate profit.

One example of an oil producer whose production was affected by an extended period of low prices is the Soviet Union (or USSR).
The US substantially raised interest rates in 1980-1981 (Figure 7). This led to a sharp reduction in oil prices, as the higher interest rates cut back investment of many kinds, around the world. Given the low price of oil, the Soviet Union reduced new investment in new fields. This slowdown in investment first reduced the rate of growth in oil production, and eventually led to a decline in production in 1988 (Figure 9). When oil prices rose again, production did also.

The Soviet Union’s energy consumption per capita reached its highest level in 1988 and began declining in 1989. The central government of the Soviet Union did not collapse until late 1991, as the economy was increasingly affected by falling oil export revenue.
Some of the changes that occurred as the economy simplified itself were the loss of the central government, the loss of a large share of industry, and a great deal of job loss. Energy consumption per capita dropped by 36% between 1988 and 1998. It has never regained its former level.

Venezuela is another example of an oil exporter that, in theory, could export more oil, if oil prices were higher. It is interesting to note that Venezuela’s highest energy consumption per capita occurred in 2008, when oil prices were high.

We are now getting a chance to observe what the collapse in Venezuela looks like on a day-by-day basis. Figure 5, above, shows Venezuela’s energy consumption per capita pattern through 2017. Low oil prices since 2014 have particularly adversely affected the country.

[8] Conclusion: We can’t know exactly what is ahead, but it is clear that moving away from fossil fuels will be far more destructive of our current economy than nearly everyone expects.

It is very easy to make optimistic forecasts about the future if a person doesn’t carefully examine what the data and the science seem to be telling us. Most researchers come from narrow academic backgrounds that do not seek out insights from other fields, so they tend not to understand the background story.

A second issue is the desire for a “happy ever after” ending to our current energy predicament. If a researcher is creating an economic model without understanding the underlying principles, why not offer an outcome that citizens will like? Such a solution can help politicians get re-elected and can help researchers get grants for more research.

We should be examining the situation more closely than most people have considered. The fact that interest rates cannot drop much further is particularly concerning.