Our Finite World
Exploring how oil limits affect the economy

What Greece, Cyprus, and Puerto Rico Have in Common

Posted on July 8, 2015 by Gail Tverberg

We all know one thing that Greece, Cyprus, and Puerto Rico have in common–severe financial problems. There is something else that they have in common–a high proportion of their energy use is from oil. Figure 1 shows the ratio of oil use to energy use for selected European countries in 2006.

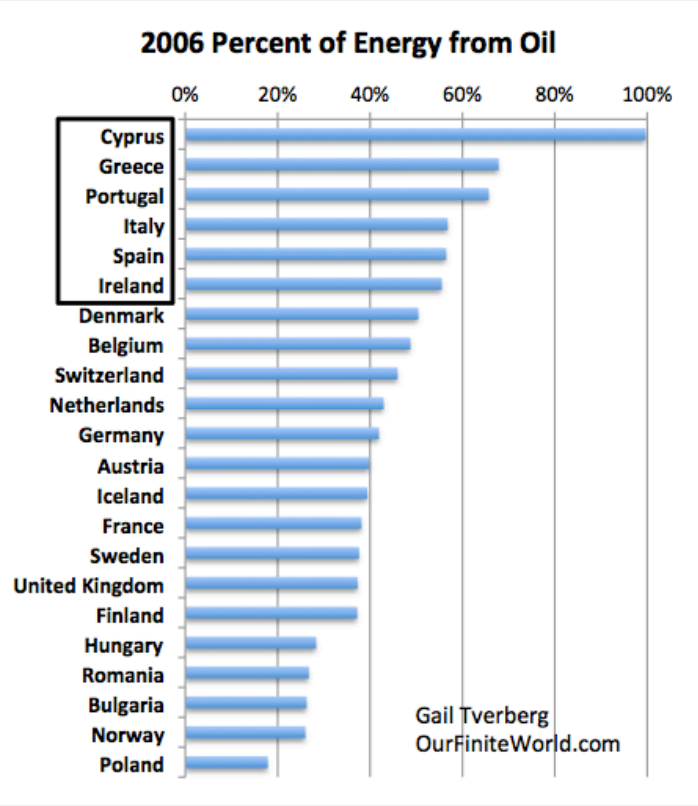

Figure 1. Oil as a percentage of total energy consumption in 2006, based on June 2015 Energy Information data. (Inverted order from chart originally shown.)

Greece and Cyprus are at the top of this chart. The other "PIIGS" countries (Ireland, Spain, Italy, and Portugal) are immediately below Greece. Puerto Rico is not European so is not on Figure 1, but it if were shown on this chart, it would appear between Cyprus and Greece–its oil as a percentage of its energy consumption was 98.4% in 2006. The year 2006 was chosen because it was before the big crash of 2008. The percentages are bit lower now, but the relationship is very similar now.

Why would high oil consumption as a percentage of total energy be a problem for countries? The issue, as I see

it, is competitiveness (or lack thereof) in the world marketplace. Years ago, say back in the early 1900s, when countries built up their infrastructure, oil price was much lower than today–less than $20 a barrel (even in inflation-adjusted dollars). Between 1985 and 2000 there was another period when prices were below $40 barrel. Back then, the price of oil was not too different from the price of other types of energy, so an energy mix slanted toward oil was not a problem.

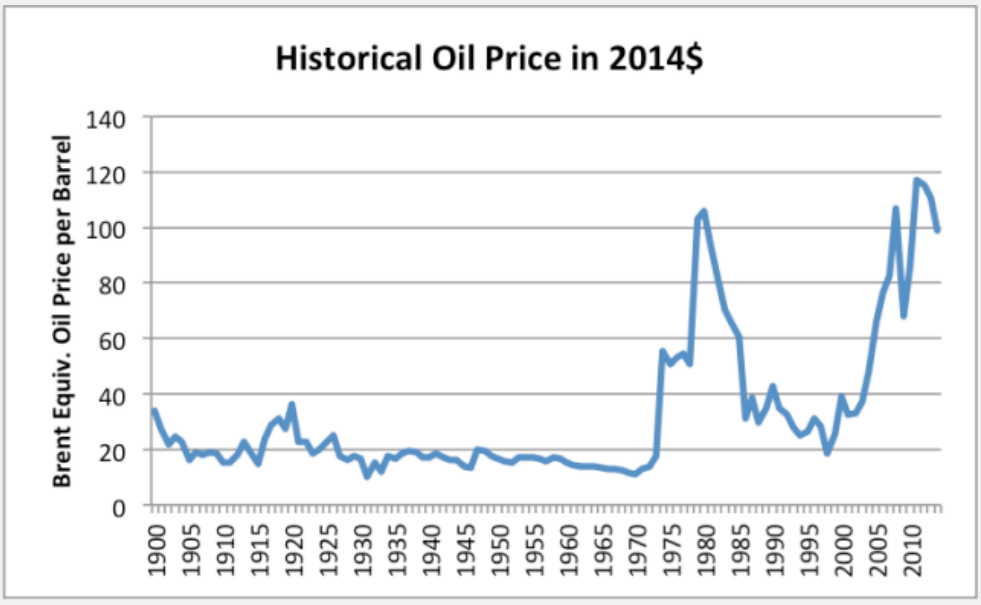

Figure 2. Historical World Energy Price in 2014$, from BP Statistical Review of World History 2015.

Oil prices are now in the $60 barrel range. This is still high by historical standards. Furthermore, much of the financial difficulty countries have gotten into has occurred in the recent past, when oil prices were in the $100 per barrel range.

While countries with a large share of oil in their energy mix tend to fare poorly, at least some countries with a preponderance of cheap energy fuels in their energy mix have tended to do very well. For example, China's economy has grown rapidly in recent years. In 2006, its share of oil in its energy mix was only 23.0%, putting it below Norway but above Poland, if it were included in Figure 1.

Let's look a little at what it takes for an economy to produce economic growth, and what goes wrong in countries with high energy costs. I should mention that high energy costs can occur for any number of reasons, not just because a country's energy mix includes a large proportion of oil. Other causes might include a high percentage of high-priced renewables or high-priced liquefied natural gas (LNG) in a country's energy mix. The reason doesn't really matter–high price is a problem, whatever its cause.

What Is Needed for an Economy to Grow

The following reflects my view regarding what is needed for an economy to grow:

1. A *growing supply* of energy products, either internally produced or purchased on the world market, is needed for an economy to grow.

The reason why a growing supply of these energy products is needed is because it takes energy (human energy plus supplemental energy) to make goods and services.

The availability of today's jobs is also tied to the use of supplemental energy. High-paying jobs such as operating a bull-dozer, producing large quantities of food on a farm using modern equipment, or operating a computer, require supplemental energy in addition to human energy. While jobs can be created that use little supplemental energy to leverage human energy (for example, manual accounting without electricity or computers, growing food without modern equipment, or digging ditches with shovels), these jobs tend to pay very poorly because output per hour worked tends to be low.

To obtain growth in the number of jobs available to workers, a growing supply of energy products to leverage human energy is needed. Looking at the world economy, we can see that historically, growth in energy consumption is highly correlated with economic growth.

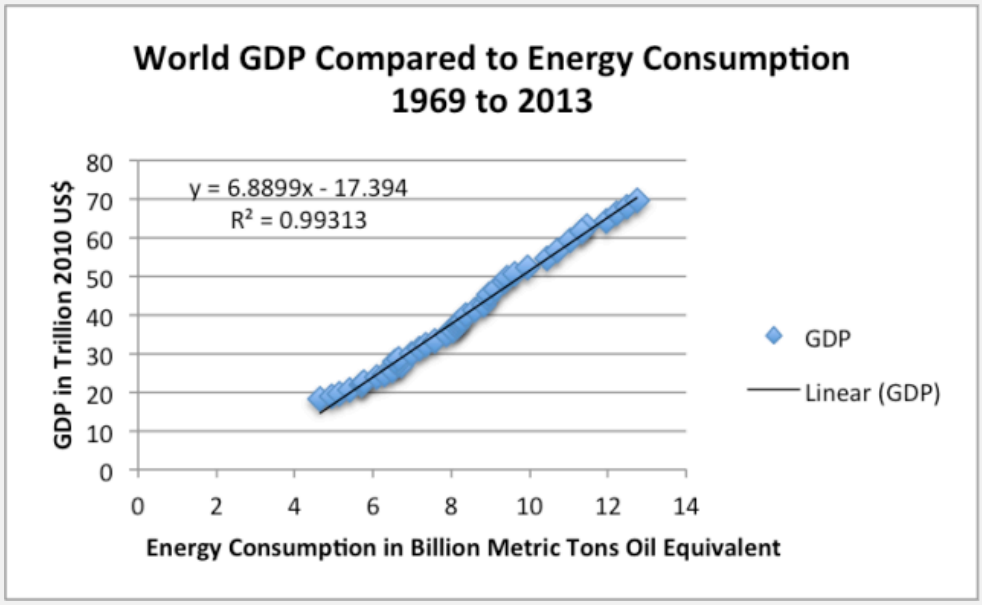

Figure 3. World GDP in 2010$ compared (from USDA) compared to World Consumption of Energy (from BP Statistical Review of World Energy 2014).

In fact, we tend to need an increasing percentage growth in energy supply to produce a given percentage growth of GDP because the y intercept of the fitted line is -17.394, rather than 0.000. Back in 1969, 1.0% growth in the consumption of energy products produced 2.2% GDP growth. The fitted line implies that recently, the amount of GDP growth associated with one percentage growth in energy consumption is only 1.2% of GDP. This poor result is taking place, despite all of our efforts toward increased efficiency. Thus, as time goes on, we need more and more energy growth to produce the same level of GDP growth. This is a rather unfortunate situation that world leaders don't mention. They tend to focus instead on the fact that the growth in GDP tends to be at least a

little higher than the growth in energy use.

2. This growing energy supply must be inexpensive, in order to be able to create goods that are competitive in the world market.

Human energy is by its nature expensive energy. Humans require food, water, clothing, and housing to support their biological needs–we are not adapted to eating entirely uncooked food, or to living in climates that get very cold in winter, unless we have protection from the elements. Thus, wages must be high enough to cover these costs.

Cheap supplemental energy provides a great deal more leveraging power than expensive supplemental energy. If we can leverage human energy with cheap energy such as wood or fossil fuels, it is easy to bring down the average cost of energy. (This calculation is made on a Calorie or Btu basis, for the sum of the energy provided by human labor plus that provided by supplemental energy.) If we are dealing with supplemental energy that is by itself high-cost, it is very difficult to bring down this weighted average cost. This is why high-cost oil, or for that matter high-cost supplemental energy of any kind, is a problem.

If human energy can be leveraged with increasing amounts of cheap energy, it can produce an increasing amount of goods and services, ever more cheaply. In fact, *this seems to be where economic growth comes from*. These goods and services can be shared with many parts of the economy, including government funding, wages for elite workers, wages for non-elite workers, payback of loans with interest, and dividends to stockholders. If there are enough goods and services produced thanks to this increased leverage, all of the various parts of the economy can get a reasonable share, and all can adequately prosper.

If there is not enough to go around, then there are likely be shortfalls in many parts of the economy at once. It is likely to be hard to find good paying jobs, for ordinary "non-elite" workers. Governments are likely to find it difficult to collect enough taxes. Governments may lower interest rates, or may take other steps to make it easier for businesses to continue their operations. Even with lower interest rates, debt defaults may become a problem. See my post, Why We Have an Oversupply of Almost Everything. The entire economy tends to do poorly.

Ayres and Warr provide an illustration of how an increasingly inexpensive supply of energy can lead to greater consumption of that energy–in this case electricity–in their paper Accounting for Growth: The Role of Physical Role of Physical Work.

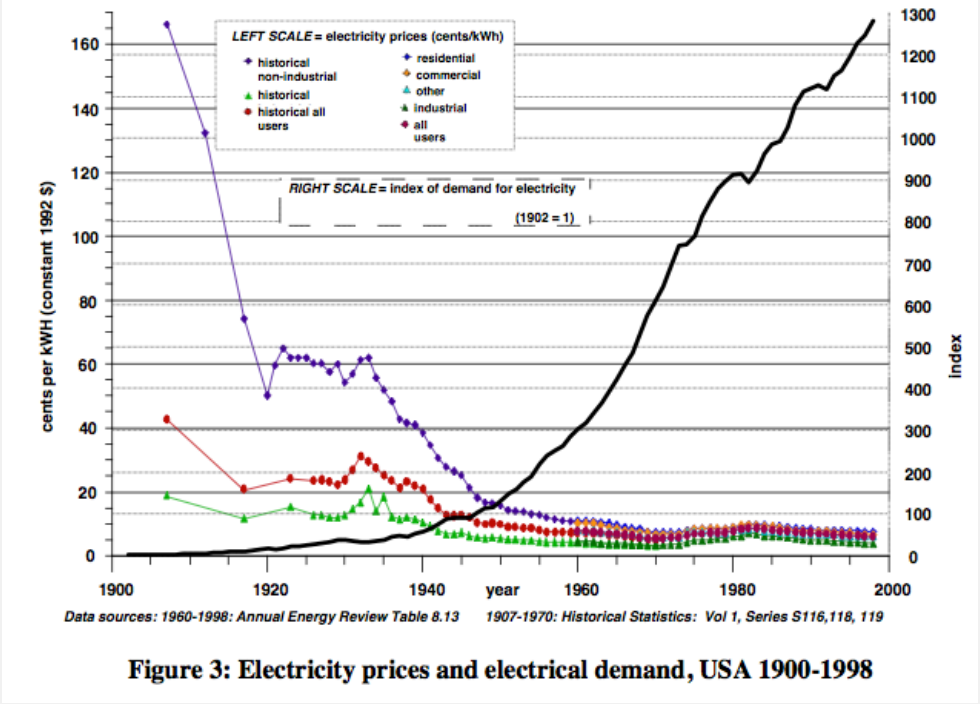

Figure 4. Ayres and Warr Electricity Prices and Electricity Demand, from "Accounting for growth: the role of physical work."

There is a logical reason why falling energy prices would lead to rising use of an energy product. If a person can afford to buy, say, $100 worth of energy and the cost is $1 per unit, the person can afford to buy 100 units. If the cost is $5 per unit, the person can afford to buy 20 units of energy. If it is the energy itself that aids growth in economic output (by moving a truck farther, or operating a machine longer), then lower energy prices lead to more energy consumed. This higher amount of energy consumed in turn leads to more economic output. This greater economic output is frequently shared with workers in the form of higher wages because of the workers' "higher productivity" (thanks to the leveraging of cheap supplemental energy).

When it comes to *the cost* of energy production, there are "tugs" in two different directions. In one direction, there is *the savings in costs that technology can provide*. In the other, there is the trend toward higher extraction costs because companies tend to extract the cheapest resource of a given type first. As the inexpensive-to-extract resources are exhausted, the cost of resource extraction tends to rise. We can see from Figure 2 that oil prices first began to spike in the 1970s. After some temporary "fixes" (shifting much electrical production away from oil to cheaper fuels, shifting home heating from oil to other fuels, and starting new extraction in Alaska, Mexico, and the North Sea), the problem was more or less solved for a while. The problem came back in the early 2000s, and hasn't really been solved. Thus, most of the tug now is in the direction of higher costs of production.[1]

Once oil prices rose, Greece and other countries that continued to use a high percentage of oil in their energy mix were handicapped because their products tended to become too high-priced for customers. Wages of customers did not rise correspondingly. Potential tourists could not afford the high cost of airline tickets and

cruise ship tickets, because these prices depended on the price of oil. Even when oil prices dropped recently, airline companies have not reduced airline ticket prices to reflect their savings.

Because of the high-cost energy structure, manufacturing costs have tended to be high as well. With fewer tourism jobs and few possibilities for making goods for exports, the number of good-paying jobs has tended to shrink. Without enough good-paying jobs, Greek **demand** for fuel products of all kinds dropped rapidly. (Demand reflects the amount of goods a person wants and *can afford*. Young people without jobs live with their parents, and thus do not buy new homes or cars, lowering consumption.)

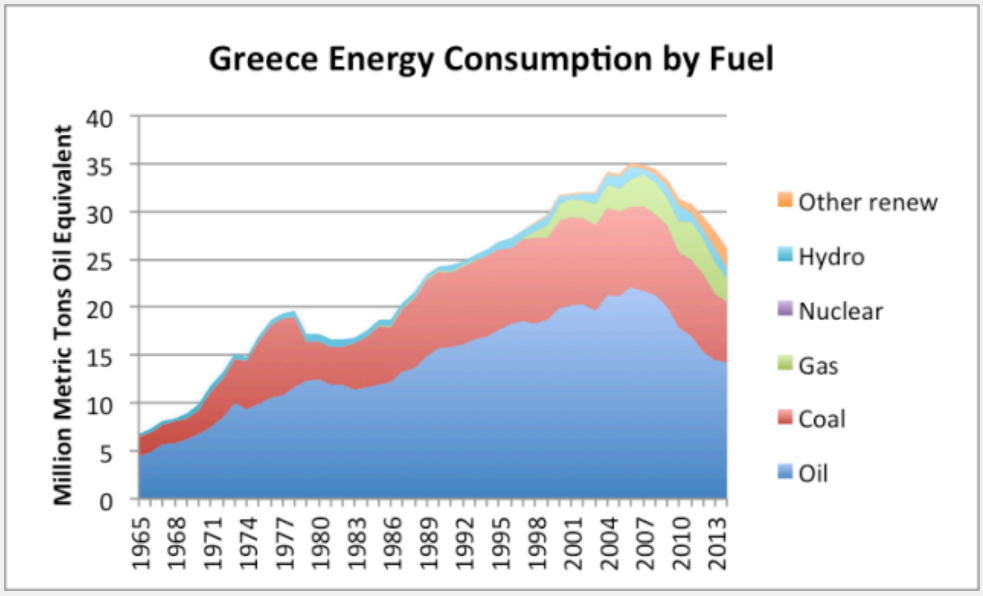

Figure 5. Greece's energy consumption by fuel, based on BP Statistical Review of World Energy, 2015 data.

Other countries that were positioned to add huge amounts of inexpensive energy were able to continue to grow. The country that did this best was China. It was able to cheaply and rapidly ramp up its coal supply, once it entered the World Trade Organization in 2001. If Greece now adds production of goods, it needs to be able to compete in price with China and other goods-producers.

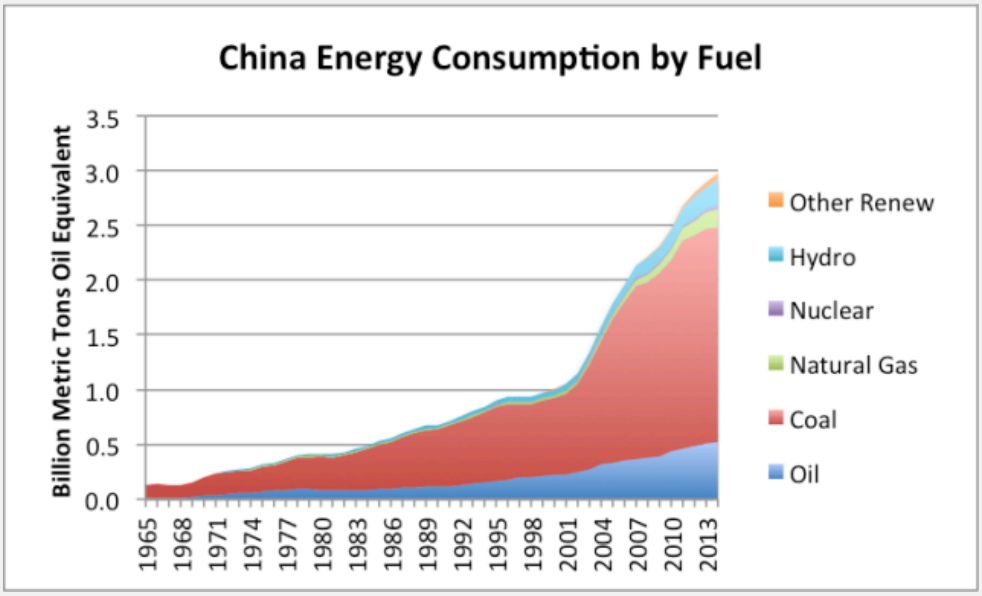

Figure 6. China's energy consumption by fuel, based on data of BP Statistical Review of World Energy 2015.

3. If the energy supply that a country plans to use is cheap, it doesn't matter whether the energy supply is locally produced or not.

If the energy supply that a country is locked into using is expensive, then using locally produced high-priced energy is "less bad" than using imported energy, but there is still a problem.

If a growing supply of cheap energy is available, this can be used to leverage local human labor to produce inexpensive goods. This works well, regardless of whether the fuel is imported or not. Because imported energy "works" in such a situation, many island nations (including Cyprus and Puerto Rico) were able to develop their economies using oil as the energy base. These island nations typically did not have natural gas available, unless they imported expensive LNG. Coal and nuclear were also difficult to use, because power plants of these types are built on too a large scale to be suitable for on an island. But oil generally worked well, even if imported.

Greece includes 227 inhabited islands, and thus is faced with many of the problems of an island nation. Back when oil was cheap, oil was an easy solution. It could be used for electricity and for many processes that require heat, such as baking bread, dying cloth, making bricks, and recycling metals.

If a county is using imported oil, once oil becomes high-priced, there is essentially nothing that can be done to fix the problem. *Devaluing the currency doesn't work*, because then oil becomes higher-priced in the new devalued currency. As a result, it still is prohibitively expensive to make goods, even after the devaluation. In fact, devaluing the currency also tends to make other imported energy products, such as LNG and solar PV panels, more expensive as well.

With respect to previously purchased renewables, the ongoing cost is typically the debt payments for the devices used to generate this energy. How devaluation will affect these payments depend on the currency the debt is in.

If these debt payments are in the country's own currency, then devaluing the currency will not affect the payments (so devaluation won't help reduce costs). If debt payments for renewables are in another currency (such as the dollar or Euros), then devaluing the currency will *increase the cost*, making the loans more difficult to repay.

Even for an oil exporter like Saudi Arabia, high-priced oil is a problem, for a number of reasons:

1. If the oil exporter uses some of its oil itself, the revenue that would have been gained by selling this oil abroad is lost. The government may be able to purchase the oil for essentially the cost of extraction, but it loses the extra revenue that it would gain by selling the oil abroad. This revenue could be used to fund government programs and new oil investment.
2. The countries that import this high-priced oil tend to find their economies depressed, leading to less use of the oil. Thus, oil exports tend to become depressed.
3. The price of oil may fall (and in fact has fallen, and may fall more), because of low demand. With low prices, it becomes difficult for exporters to collect enough revenue for government projects and investment in new supply.

The reason why locally produced high-priced oil is "less bad" than imported oil is because jobs related to producing the oil tend to stay in the country. This is a plus, in itself. If there is a currency devaluation, wage costs and other local costs will be lower, making the energy product less expensive to produce. Unfortunately, production costs (including taxes needed to support government services) may still be above the market price, because of depressed demand.

4. Debt helps increase demand for goods. But to make the debt repayable, these goods need to be made with *low-priced* energy products.

Ramping up debt for a country helps, but only if, with this debt, the country is able to profitably sell more goods and services in the world marketplace. Greece seems to have added debt, but wasn't able to use this debt to create goods and services that could be sold cheaply enough that their prices would be competitive in the world market.

China clearly has been willing to add huge amounts of debt to support all of its new industry and new homes it has built with the coal it has been extracting. There is no doubt that the growth in China's debt has played a major role in extracting growing quantities of coal. Now China's coal consumption is slowing for a number of reasons including overbuilding of factories, too much pollution, and higher cost of coal production. China's slowdown in energy consumption is leading to a slow-down in economic growth, and may even lead to a hard crash.

Greece has added a lot of debt in recent years, but it has not been used for ramping up the use of a new cheap supply of energy. Instead, much of Greece's debt seems to be for purposes such as bailing out banks. This doesn't really tell us what is/was wrong with the economy to begin with. I would argue that high-priced fuel

tends to make it difficult to make any kind of goods or services inexpensively enough to compete in the world market, and this is at least part of the problem. The result of this is that companies, no matter what they invest debt in, have a difficult time being profitable.

The Greek government tries to cover up the country's problems with programs that are funded by debt. Hidden subsidies may be occurring in several government-owned energy-related firms: Public Power Corporation of Greece (Greece's largest electric utility), Hellenic Petroleum, DEPA Natural Gas, and ADMIE Grid Operating Company. There have been proposals to privatize these companies because they are poorly run. Whether or not they are poorly run, I expect that it will be very difficult to run them profitably, simply because of the inherent high-cost nature of the products they produce and workers' lack of disposable income. This problem reflects the high cost of the underlying products they are producing.

There have been some proposals to try to get energy costs down, including a proposal to install a new lignite coal-fired electric power plant. There is also a plan to connect four of the islands to the electric grid, so that the islands won't have to depend on oil-fired electricity. Even if these changes are made, it is not clear that Greece's energy costs will be low enough to produce goods that are competitive in the world market. For one thing, airplanes and cruise ships operate using oil, not electricity produced by lignite, so will not be affected by additional inexpensive lignite electricity production.

From everything I can see, Greece's debt needs to be written off. There is no way that the country can change its system to repay it. Greece can perhaps repay a little new debt, if it is channeled to support low-cost energy production to substitute for current high-cost energy.

Conclusion

Most people don't understand that our world economy runs on ***cheap*** energy. High-priced energy is not an adequate substitute, even if the high-priced energy is "low carbon" or claims to have a reasonably high EROEI (Energy Return on Energy Invested) ratio. Our world economy is sensitive to prices and costs, even if the current "politically correct" discussion ignores these matters.

Economies that are part of our current system can't get along without energy supplies, either. Humans have used supplemental energy since our hunter-gatherer days, when we learned to control fire. In fact, the use of large amounts of supplemental energy seems to be the way we are now able to support a world population of 7+ billion people.

Given that the world economy runs on "cheap" energy, adding expensive energy production, no matter how "green" it may appear to be, does not solve a country's financial problems. In fact, it likely tends to make its financial problems worse. There is no way that high-priced energy will produce goods and services that are competitive in the world market. In fact, it is doubtful that high-priced energy will return a high enough "profit" to pay its own way, in terms of having the ability to pay suitable taxes to support required government services, such as schools and roads. High-priced energy is instead likely to need government subsidies, both for initially

building the devices and for helping citizens pay the ongoing cost of electricity.

Greece clearly has a lot of problems besides its high-energy cost, including excessive pensions and inefficiently operated state-owned companies. To some extent, I expect that these other problems reflect the difficulty of creating goods that can compete profitably in the world economy. If there is no way businesses can successfully compete in the world economy, I can see why leaders would do whatever they could to keep the system operating. This might mean adding more debt, keeping staffing at government-operated companies at higher levels than needed, and providing overly generous pension programs.

The thing that Greece has going for it is a relatively warm climate and a history of doing well with relatively little supplemental energy. Ancient Greece was known for its philosophy, literature and theatre, music and dance, science and technology, and art and architecture. Northern Europe, because of its cold climate, was not able to do very much until it added peat moss and coal as supplemental energy. Once these cheap supplemental energies were added, Northern Europe was able to industrialize, while Southern Europe lagged behind. If we are running into obstacles now with respect to fossil fuels, perhaps the advantage will again go back to people who live in warm enough climates that they can mostly live without supplemental energy.

Note:

[1] While cost of oil production is rising, oil prices are not necessarily rising to match the cost of production, and in fact, have fallen below the cost of production. This occurs because costs are now too high relative to wages, so oil isn't affordable. This is an important story in its own right, and is likely to eventually bring down the whole system. See for example my post, Ten Reasons Why a Severe Drop in Oil Prices is a Problem.

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About Gail Tverberg

My name is Gail Tverberg. I am an actuary interested in finite world issues - oil depletion, natural gas depletion, water shortages, and climate change. Oil limits look very different from what most expect, with high prices leading to recession, and low prices leading to inadequate supply.

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