



## Our World Is Finite: The Implications of Resource Limitations

Posted by [Gail the Actuary](#) on October 24, 2007 - 10:00am

Topic: [Environment/Sustainability](#)

Tags: [ethanol](#), [fresh water](#), [global warming](#), [money supply](#), [natural gas](#), [oil](#), [original](#), [pollution](#) [[list all tags](#)]

We all know the world is **finite**. The number of atoms is finite, and these atoms combine to form a finite number of molecules. The mix of molecules may change over time, but in total, the number of molecules is also finite.

We also know that **growth** is central to our way of life. Businesses are expected to grow. Every day new businesses are formed and new products are developed. The world population is also growing, so all this adds up to a huge utilization of resources.

At some point, growth in resource utilization must collide with the fact that the world is finite. We have grown up thinking that the world is so large that limits will never be an issue. But now, we are starting to bump up against limits.

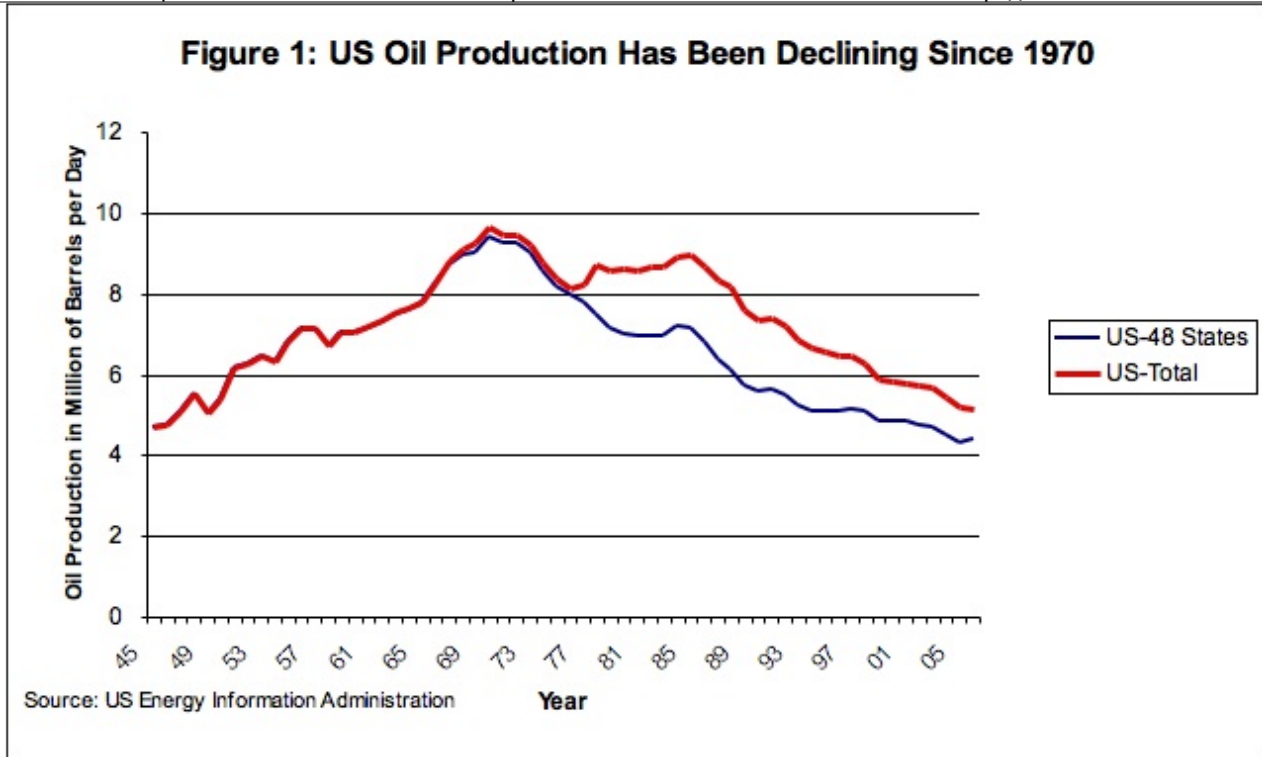
What are earth's limits? Are we reaching them?

*ED Note by PG: Note that this is an updated version of an [article](#) that was run about six months ago. With all of the new folks (Welcome!) around, it seemed like a good time for an article like this. We appreciate your sharing this and all the work here at The Oil Drum with the people you care about.*

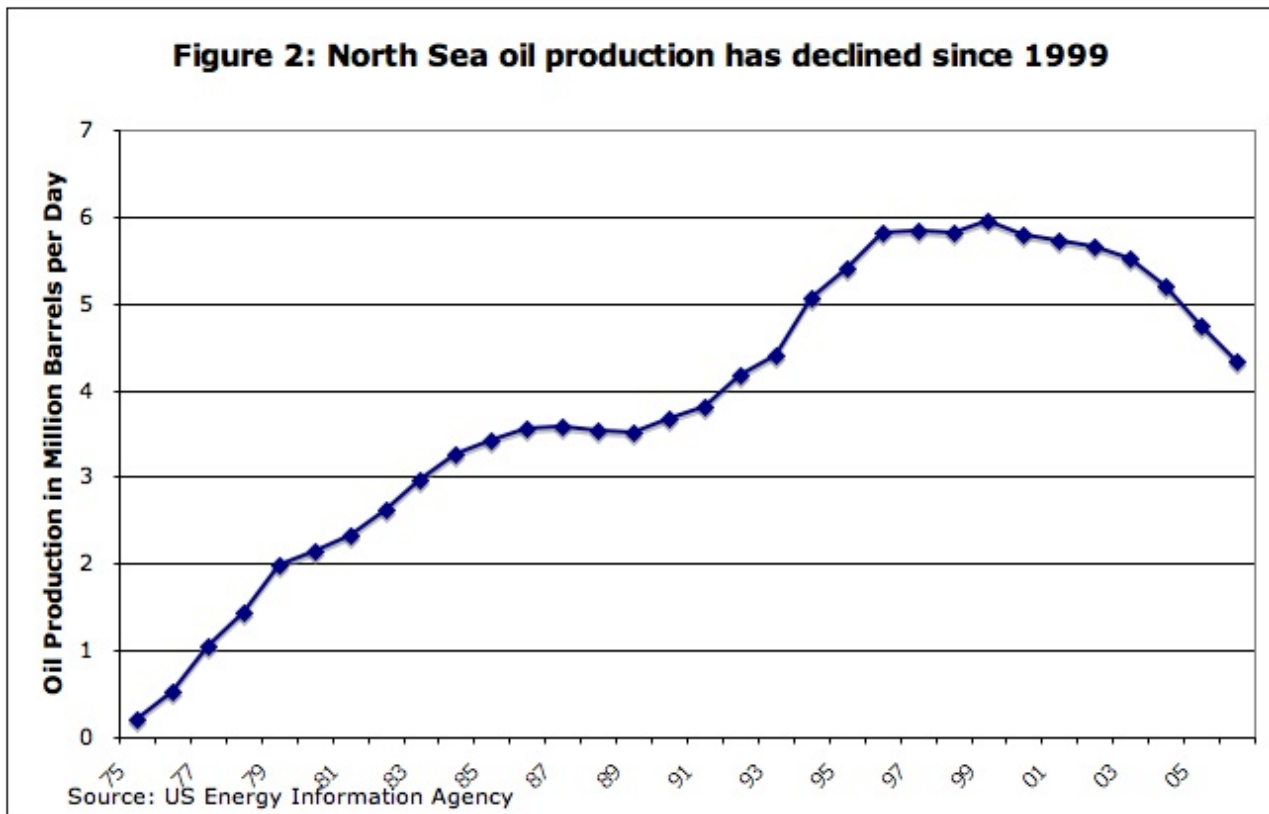
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### 1. Oil

Oil is a finite resource, since it is no longer being formed (at least in any meaningful quantity). Oil production in a given area tends to increase for a time, then begins to decline, as geological limits are reached. Oil production in the United States has followed this pattern (Figure 1).



Oil production in the North Sea (Figure 2) has also followed this pattern.



The declines in both the United States and the North Sea took place in spite of technology improvements. There is now serious concern that world oil production will begin to decline ("peak"), just as it has in the United States and the North Sea.

The US Government Accountability Office studied this issue, and issued a report in the spring

The Oil Drum | Our World Is Finite: The Implications of Resource Limitations <http://www.theoil drum.com/node/3129> of 2007 titled [CRUDE OIL: Uncertainty about Future Supply Makes It Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production](#). The US Department of Energy also asked the National Petroleum Council to look into this issue. Its report, [Facing Hard Truths about Energy](#), further confirms the importance of this issue.

Exactly how soon the decline in oil production will begin is not certain, but [many predict](#) that the decline may begin within the next few years. There is even [some evidence](#) that the decline may have begun in 2005.

Even if oil production were not to decline, but simply remain level, there is sufficiently strong growth in demand that the shortfall would be a serious issue. Matt Simmons [talks about](#) this issue in his talk at the Houston meeting of the Association for the Study of Peak Oil. Also, a recent report called [Lighting the Way: Toward a Sustainable Energy Future](#) by the Interacademy Council [states](#):

Overwhelming scientific evidence shows that current energy trends are unsustainable.

## 2. [Natural Gas](#)

[Natural gas](#) in North America is also reaching its limits. United States natural gas production reached its peak in 1973. Each year, more and more wells are drilled, but the average amount of gas produced per well declines. This occurs because the best sites were developed first, and the later sites are more marginal. The United States has been importing more and more natural gas from Canada, but Canadian production is [beginning to decline](#) as well. Because of these issues, the total amount of natural gas available to the United States is likely to decline in the next few years - quite possibly leading to shortages.

## 3. [Fresh Water](#)

Fresh water is needed for drinking and irrigation, but here too we are [reaching limits](#). Water from melting ice caps is declining in quantity because of global warming. Water is being pumped from aquifers much faster than it is being replaced, and water tables are dropping by one to three meters a year in many areas. Some rivers, especially in China and Australia, are close to dry because of diversion for agriculture and a warming climate. In the United States, water limitations are especially important in the Southwest and in the more arid part of the Plains States.

## 4. [Top soil](#)

The topsoil we depend on for agriculture is created very slowly - about one inch in 300 to 500 years, depending on the location. The extensive tilling of the earth's soil that is now being done results in many stresses on this topsoil, including erosion, loss of organic matter, and chemical degradation. Frequent irrigation often results in salination, as well. As society tries to feed more and more people, and produce biofuel as well, there is pressure to push soil to its limits--use land in areas subject to erosion; use more and more fertilizer, herbicides, and pesticides; and remove the organic material needed to build up the soil.

### **Are there indirect impacts as well?**

Besides depleting oil, natural gas, fresh water, and top soil, the intensive use of the earth's

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resources is resulting in [pollution](#) of air and water, and appears to be contributing to [global warming](#) as well.

## **Can technology overcome these finite world issues?**

While we have been trying to develop solutions, success has been limited to date. When we have tried to find substitutes, we have mostly managed to trade one problem for another:

### Ethanol from corn

Current production methods usually require large amounts of natural gas and fresh water, both of which are in short supply. Increasing production may require the use of land which has been set aside in the Conservation Reserve Program because of its tendency to erode. The amount of ethanol produced is [tiny](#) compared to our fuel need, but still drives up the cost of all types of food.

### Oil from oil sands and oil shale

Oil from [oil sands](#) requires large energy inputs, currently from natural gas, as well as fresh water, and creates pollution issues. Oil from oil shale is expected to require even more energy and fresh water.

### Coal to liquid and coal substitution for natural gas

"Clean coal" and sequestration of carbon dioxide from coal are not yet commercially available, and are expected to be very expensive if they become available. Thus, coal production is likely to exacerbate global warming and raise pollution levels. If coal is used to replace both oil and natural gas, it is likely to [deplete](#) within a few decades, like the natural gas and oil it replaces.

### Deeper wells for fresh water

If deeper wells are used, they will require more energy to pump the water farther. In locations that use aquifers that replenish over thousands of years, the available water will eventually be depleted.

There are a number of promising technologies — including solar, wind, wave power, and geothermal — but the amount of energy from these sources is tiny at this time. Nuclear power also seems to have promise, but has toxic waste issues and is difficult to scale up quickly. A general introduction to alternative technologies is provided in [What Are Our Alternatives If Fossil Fuels Are a Problem?](#)

## **What if we don't find technological solutions?**

We can't know for sure what will happen, but these are some hypotheses:

1. Initially, higher prices for energy and food items and a major recession.

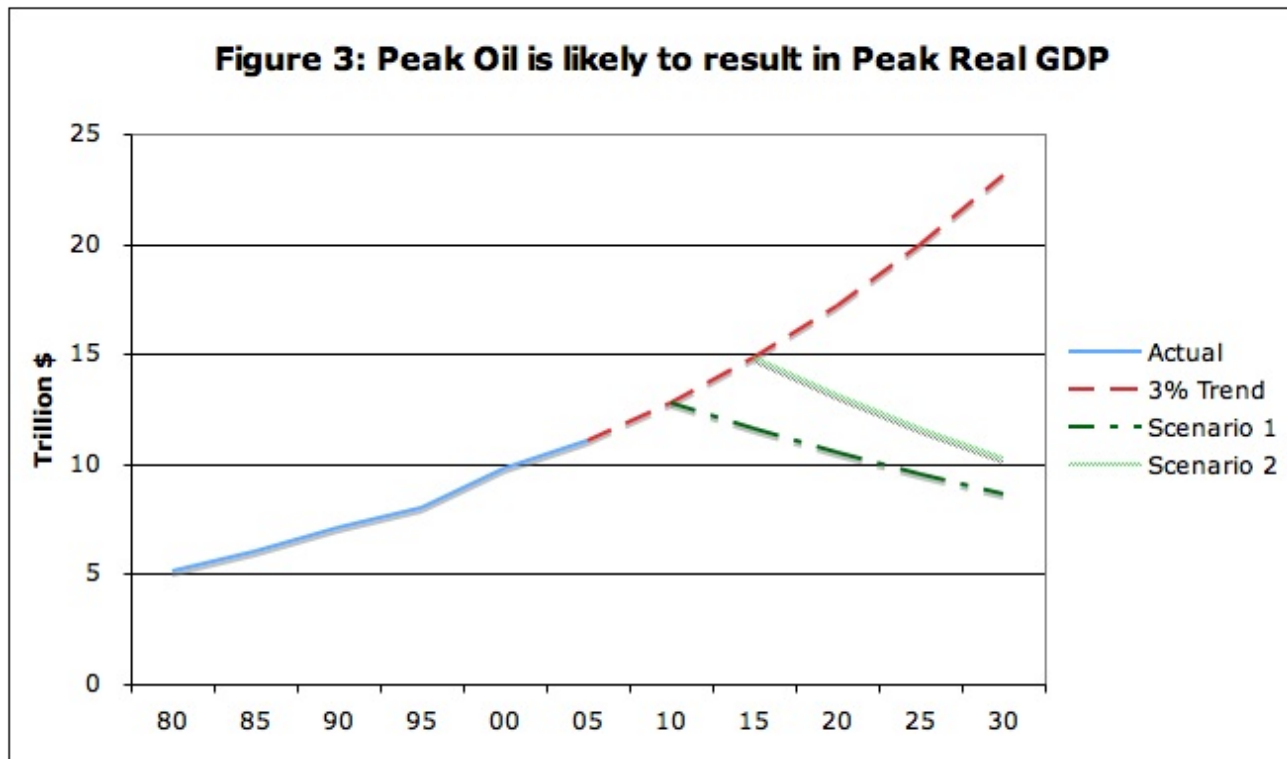
If the supply of oil lags behind demand, we can expect rising prices for oil and gasoline and possibly other types of energy. Prices for food may also rise, because oil is used in the production and transportation of food. Recession is likely to follow, because people will cut down on their purchases of discretionary items, so as to be able to afford the necessities. Layoffs will follow. People laid off will find it difficult to pay mortgages and other debt, so banks and other creditors will find themselves in increasing financial difficulty.

2. Longer term, a decline in economic activity.

With fewer resources, economic activity is likely to decline. We will need to find replacements for many products in a relatively short time frame — heating fuel, transportation fuel, plastics,

synthetic fabrics, fertilizer (currently made from natural gas), and asphalt, among other things. Living standards are likely to drop, because we don't have infinite resources for replacing all the things that are declining in availability.

A graphic representation of how this might happen is shown in Figure 3. Real gross domestic product (GDP) gives a measure of how much goods and services the United States is producing in a year, in constant (year 2000) dollars. The 3 per cent trend line in Figure 3 shows the expected growth in real GDP, if growth continues as in the past. Scenarios 1 and 2 show two examples of how limitations on oil and natural gas might impact future real GDP. Scenario 1 shows a fairly rapid decline, starting very soon. Scenario 2 shows a slower decline, starting in 2020. If the downturn is still several years away, we have longer to plan, and a better chance that the decline will be more gradual.



### 3. Transportation difficulties and electrical outages.

Since transportation generally uses petroleum products for fuel, a reduction in the amount of oil available is likely to cause transportation difficulties. These difficulties may extend to all forms of transportation--automobile, trucks, airplanes, boats, and railroads, to the extent that fuel is unavailable due to shortages, cost, or rationing.

If natural gas supplies decline, electrical outages are likely, especially during high-use times of the year. Electrical outages may also result from interruption of transportation of other fuel, such as coal, to power plants, because of petroleum shortages. Outages may be one time events, or may be planned outages at certain times of the day, to compensate for an inadequacy in the fuel supply.

### 4. Possible collapse of the monetary system.

This is perhaps the biggest single issue, and the most difficult to understand.

There is a huge amount of debt in the world today. When loans were made, the expectation of the

lenders was that the economy would continue to grow as in the past--that is like the 3 percent trend line in Figure 3 above. If this continued growth occurred, people, on average, would be a little better off financially when the time came to pay off their loans than they were when the loans were taken out, so they would have a reasonable chance of paying off the loans with interest. Corporations would continue to grow, and because of this continued growth, most would be able to pay off their debt with interest.

What happens if a scenario like that shown as Scenario 1 or Scenario 2 on Figure 3 occurs? When it comes time to repay the loans, people and corporations will be on average, worse off, rather than better off, than when they took them out. It is likely that many people will be unemployed, and cannot pay back their debt. Companies manufacturing goods that are no longer in demand are likely to be bankrupt, and thus will be unable to repay their debt. Organizations holding this debt, such as banks, insurance companies, and pension funds will find themselves in financial difficulty, because of the many defaults on the loans that are the assets of these organizations.

Two possible outcomes of widespread defaults come to mind. One is that there is so much debt that cannot be repaid that banks, insurance companies, and in fact the whole monetary system fails. The other alternative is that the government guarantees all the debt, so that the institutions do not fail. The latter approach would likely lead to hyper-inflation.

In either event, people and businesses would lose their savings, because money either would either be no longer available (first approach), or would be worth very little due to inflation (second approach). In either event, foreign countries would be unlikely to accept our currency in trade. Simple transactions, such as purchasing food or paying an employee, would become very difficult. Eventually, some approach would likely be found to circumvent these difficulties--perhaps a more barter-based approach--but this would be a huge change from our current system.

#### 5. Failure of economic assumptions to hold.

We have been raised in a world where supply and demand are generally in balance. An increase in demand results in a greater price, which in turn leads to a greater supply. If the particular item isn't available, substitution is generally available.

Once we reach geological limits, these basic principles seem much less likely to hold. An increase in energy demand isn't likely to translate into greater supply. Distribution of the limited available supply seems likely to reflect considerations other than price, such as rationing and long-term alliances. There may also be military conflict over available supplies.

I talk more about the economic implications of peak oil in a three part series: [Part 1](#), [Part 2](#), and [Part 3](#).

#### 6. Changed emphasis to more local production.

Two factors are likely to encourage local production and discourage international trade. One is the higher cost and/or unavailability of fuels used for transportation. The other is difficulty with the monetary system--either hyper-inflation or complete failure of the system. If there are monetary system problems, other countries are likely to want actual goods in trade, rather than IOUs or money. This requirement is likely to greatly reduce the amount of trade with foreign countries.

Food production is likely to be more localized, since this insures a continuous supply, and reduces the amount of fuel needed for transportation. If there are problems with shortages, people may

#### 7. Reduced emphasis on debt.

Once it is clear that future production is likely to be less than current production, as in either Scenario 1 or Scenario 2 of Figure 3, it will be very difficult to find any lender willing to provide long term loans, since if the loan is paid back at all, it is likely to be paid back in money that is worth very much less than it was at the time the loan was taken out.

If governments still have debt at this point, they will find it difficult to sell new bonds to replace the ones that mature. Businesses desiring to build new plants may find it necessary to accumulate resources for new plants in advance of their construction. Mortgages may not be available for prospective home owners, either.

#### 8. Reduced emphasis on insurance and pensions.

If there are difficulties with the monetary system, insurance companies and pension plans will be among the hardest hit, since they take in funds and invest them, and pay benefits later.

It is possible that a limited form of Social Security coverage may continue, but this is by no means certain. If a high level of inflation occurs (see point 4 above), benefits that have been promised to date will be worth very little. If a new monetary system is in place, it will be up to the government at that time to determine the level of benefits. Because total goods and services will be lower in the future (Figure 3 above), benefits to retirees will almost certainly be lower as well.

#### 9. More people will perform manual labor.

As the amount of oil and natural gas becomes less available, more work will need to be done by hand, since the fuels to run machines will be less available. In order to encourage people to take jobs involving manual labor, manual labor will pay better in relationship to desk jobs. Because food is such an important commodity, farming may be particularly highly valued, and may pay especially well.

#### 10. Resource wars and migration conflicts.

If there is an inadequate amount of a resource (water, oil, natural gas, or food), countries may fight over the limited supplies that are available. Conflicts are likely to spring up regarding areas where resources are plentiful.

Alternatively, people may choose to migrate from an area if resources become less abundant--for example, migration may occur if water supplies dry up, or if land is flooded due to global warming, or if declining oil supplies limit transportation. Receiving areas may not welcome the newcomers, leading to more conflict.

#### 11. Changes in family relationships.

Families are likely to see more of each other, because of reduced transportation availability. Families may work more closely together, tending gardens and running small family businesses. Co-operation may be more highly valued by society. Divorce rates may decline.

#### 12. Eventual population decline.

The food supply produced in the world today is many times greater than the food supply 100

years ago, before oil and natural gas were used in tilling crops, pumping water for irrigation, making fertilizer and pesticides, and transporting food to market. As oil and natural gas become less available, the food supply is likely to decline. Eventually, world population is also likely to decline, reflecting the lower food supply.

## Conclusion

We cannot know exactly what the future will hold, if technology is not able to overcome the many issues associated with a finite world, including declining oil and natural gas supply, decreasing fresh water supply, and climate change. Whatever changes occur are likely to differ from location to location, as the world activity becomes more localized.

We tend to think of governments as fairly stable, but these too may change. Countries may subdivide into smaller units. Some have even suggested that groups of states may break away from the United States.

Educational institutions will most likely change. Fewer students will probably attend colleges and universities, and the subjects of interest will likely change. The sciences and agriculture or permaculture are likely to be topics of interest. More students may want to live on campus, if transportation is a problem. Adult education may become more important, as people seek to develop skills for a changing world.

Businesses will also change. Local businesses will become more important, while multinational companies recede in importance. Manufacturing will become less important, and recycling will become more important. Providing necessities will get top priority, while nice-to-have items will not sell well. Barter, or a new monetary system that substitutes for barter, may be the way business is done.

People may choose to live closer to work, or may work at home, so as to minimize costs associated with commuting. Some people may choose to live with relatives or friends, so as to save on utility costs. Eventually, many homes in undesirable locations may be left empty, and the parts of these unoccupied homes that can be used elsewhere will be recycled.

The next 50 years will certainly be interesting ones. Perhaps, with technological advances, some of the potential problems can be avoided. But we will need to work hard, starting now, to develop ways to work around the problems which seem to be ahead.

### To Learn More

[The Power of Community: How Cuba Survived Peak Oil](#) 53 minute film, available for \$20, tells the story of how Cuba adapted to losing over half of its petroleum imports after the collapse of the Soviet Union.

[Closing the Collapse Gap: The USSR Was Better Prepared for Peak Oil than the United States](#) Humorous talk by Dmitry Orlov

[The Long Emergency: Surviving the End of Oil, Climate Change, and Other Converging Catastrophes of the Twenty-First Century](#) Book by James Howard Kunstler

## Discussion Questions

1. What are five things that might **improve** after world oil production begins to decline? (Hint: Consider exercise, weight problems, family situations, etc.)
2. If there is a decline in oil and gas production, how do you expect the large amount of debt outstanding to resolve itself? Do you think there will be monetary collapse, hyperinflation, or some other solution?
3. Do you expect that families will have more or fewer children after oil and natural gas production begin to decline? Why?
4. How can businesses prepare for interruptions in electrical service?
5. What types of buildings are best adapted to frequent outages of electrical service? Which buildings are likely to have the most problems?
6. What vocations appear to be most likely to be useful for supporting a family, after oil and gas production begin to decline?
7. What changes might a college make to its curriculum, to better prepare students for the changing world situation expected after production of oil and natural gas begin to decline?
8. In Figure 3, real GDP in Scenarios 1 and 2 are shown as changing in relatively straight lines. Could alternative scenarios have the lines zig-zag or drop suddenly? What real world situations might cause different patterns?



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