Energy Resource Degradation and Implications

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Background

Local Energy began studying the energy-resource degradation problem in 2001, and over time we have begun to develop a deep appreciation of the depth and gravity of the problem. We believe that the degradation of fossil-energy resources is a major factor driving the worldwide destabilization of economies, ecosystems, and geopolitical relationships.

We furthermore recognize that the problem of energy-resource degradation is complex, involving geological, thermodynamic, economic, ecological, and social factors. Perhaps its complex nature is the reason it is not widely understood. A thorough characterization of the problem is nonetheless needed before viable solutions can be crafted and implemented.

Our current research focus at Local Energy is aimed at improving our understanding of fossil energy resource degradation and the hardships it creates in order to develop and implement viable, community-based means to reverse the trend locally.

The Problem

The following premises characterize the problem:

1. As finite energy resources are consumed, particularly oil and natural gas, the quality of the remaining resource base steadily degrades. This is because competitive markets tend to develop the highest available quality reserves first, leaving lower quality reserves for later.
2. The steady reduction in resource quality means that it becomes progressively more challenging to maintain production rates, requiring greater investments of both energy and money to produce the same amount of net energy. Continually investing more and getting less eventually results in a supply peak, regardless of increased efforts.
3. Economic growth has been dependent upon two things: a steadily growing supply of energy resources with very high energy profit ratios (EPR’s), and a steady transition to energy resources of greater economic usefulness. Oil and natural gas were capable of fueling rapid economic growth because of their combined very high EPR and remarkable economic usefulness.
4. There are no known resources having both a higher EPR and greater economic usefulness than oil and natural gas. This suggests that as these resources degrade and begin to decline we will have an energy-limited economy.
5. Spare capacity margins for oil and gas have already shrunk to levels insufficient for maintaining price stability. The destabilized markets appear to have an exponentially increasing price trend.
6. Rising energy prices coupled with the non-discretionary nature of energy purchases and the lack of available substitutes are creating hardships for consumers. The impact of these hardships is highly regressive, and are already severe in areas such as New Mexico that have high energy costs and low incomes.
7. The inexorable and growing economic pressure is driving the loosening of environmental regulations and an increased willingness to engage in ecologically risky and destructive practices.
8. The rising economic pressure is leading to a high-stakes global competition for the remaining available high-quality energy resources.

Supporting Information

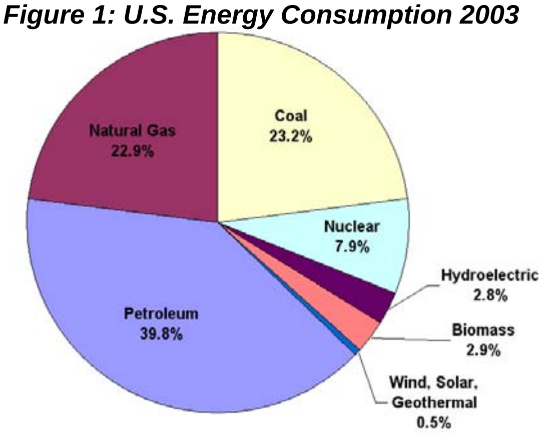
Petroleum accounts for nearly 40 percent of total energy consumption and 96 percent of transportation energy, and natural gas provides for 23 percent of all energy consumed in the U.S. [1,6]. See Table 1 and Figure 1.

Table 1: U.S. Energy Consumption 2003

Source	Million MWH
Petroleum	11,449
Natural Gas	6,590
Coal	6,672
Nuclear	2,284
Hydroelectric	814
Biomass	839
Wind, Solar, Geothermal	142
Total Consumption:	**28,790**

Source: U.S. Energy Information Administration

Figure 1: U.S. Energy Consumption 2003



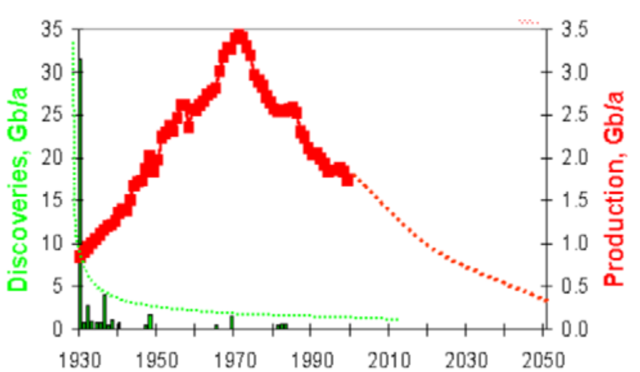
Petroleum Decline

U.S. oil production peaked at about 11.6 million barrels per day (million bbl/d) in 1970 and has since declined to its present level of 7.5 million bbl/d. [1]. The steady decline is not for lack of trying: the 165 active oil-drilling rigs in the U.S. brought 5,694 new wells on line in 2003, adding to the more than 500,000 wells already producing [2]. In comparison, Saudi Arabia produces 9.8 million bbl/d from 1,560 active wells [1,3]. Oil consumption in the U.S. has meanwhile increased from 14.7 million bbl/d in 1970 to the current level of 20.0 million bbl/d [1]. The net result is that 62 percent of all oil demand is now met with imports. Petroleum decline for the continental U.S. is shown in Figure 2.

Natural Gas Decline

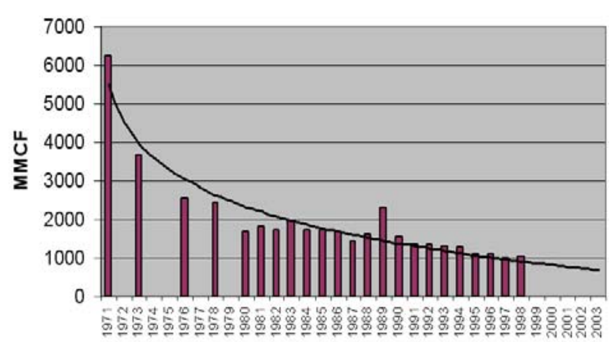
Annual natural gas production in the U.S. peaked at 21.6 trillion cubic feet (tcf, 624 Billion cubic meters) in 1971, and has since declined to its current level of 19.1 tcf (550 billion cubic meters, bcm) in 2003. Consumption stands at 22.2 tcf (629.8 bcm). Imports, mainly from Canada, comprise about 17% of consumption [1]. The steady decline once again is not for lack of effort: The natural gas industry drilled an estimated 20,011 wells in 2003, but no increase in production resulted [2]. The drilling required deployment of more than 1000 drilling rigs, whereas in 1995 only about 400 rigs were needed to maintain the same production level [4]. Declining productivity in Texas gas wells, dominated by the decline of the important Texas Gulf region, is shown in Figure 3.

Figure 2. Oil Discovery and Production in the Continental (lower-48) United States



Source: Colin Campbell, Association for the Study of Peak Oil
Note: Excludes heavy, deepwater, polar, and natural gas liquids.

Figure 3: Average Projected Ultimate Recovery from a Texas Gas Well, by Year Drilled



Source: Gary S. Swindell and Associates

Understanding the Implications of Oil and Gas Decline

The problem that results from the decline of fossil-energy resources is discussed on three levels below. Each higher-order discussion eliminates more misconceptions about the problem, especially regarding the substitutability of energy resources and overestimation of the potential of new technologies.

First-Order Discussion: The quantity of the resources is finite. This premise – that the fossil-energy endowment is limited – is widely accepted based on the nearly uniform concurrence that the earth's fossil-energy resources were formed in the geologic past and are not being renewed, at least not within a timeframe that is useful to us. One contrasting theory suggests that petroleum is still being produced in large quantities by chemical reactions within the earth's mantle, but overall the premise that the geology is well understood and that fossil-energy resources are finite is widely accepted. This discussion unfortunately can lead to incorrect conclusions regarding the energy problem, most notably the belief that the problem manifests only after all of the oil has been consumed.

Second-Order Discussion: The production rate of the resources has a maximum. This premise is actually nothing more than a logical extension of the first, but its acceptance is nonetheless limited, and its consequences are not widely understood. Further, calculating where we are relative to this maximum requires an understanding of energy resource *quality*, which shows that the amount of effort required to extract and process a resource increases over time as the easier-to-extract (higher quality) resources, such as onshore gusher wells, become depleted and we turn to harder-to-get (lower quality) resources (i.e. ones that are distant, in deep water, or not as "sweet"). Organizations studying energy from both a quantity and quality perspective, including the Association for the Study of Peak Oil and Gas (ASPO), have done a lot to promote discussions of the second-order effects.

Third-Order Discussion: Declining energy-resource quality leads to destabilization. This is the least discussed level of the energy problem because, beyond the second-order discussion, it requires an understanding of thermodynamics, economics, and the relationship between the two. The comprehension of thermodynamics is needed primarily to appreciate the importance of life-cycle analyses of energy processes, which characterize the degree to which energy extraction and production methods yield net-excess energy. Economics tells us that healthy economies are fundamental prerequisites for maintaining social and geopolitical stability. The interrelationship of thermodynamics and economics is, first and foremost, that energy is the fundamental building block of the economy, without which there can be no goods or services; second, that the energy that runs the economy is the net-excess energy produced by a supply technology; and third, that chemical and physical differences in energy resources and the fuels produced from them dictate that not every unit of energy is capable of producing the same amount of economic activity.

An important component of the third-order discussion is the recognition that energy resources and technologies are not economically interchangeable. The amount of economic activity that can be produced depends on both the amount and the type of excess energy produced. The misguided faith in substitutability is likely the result of undergoing so many past substitutions, each one bringing new energy resources and technologies into use. But the substitutions of the past – from solid fuels such as biomass and coal to liquid and gaseous petroleum and natural gas – have always been from lower-quality resources and source technologies to higher-quality ones. Each change brought economic advantages that enabled growth.

Petroleum spawned unprecedented world-economic growth because the net excess energy (also called the energy profit ratio or energy return-on-investment) of the exploration, extraction, refining, and transport process was enormous, and because the energy could be delivered in a highly useful form – an energy-dense liquid. The hypothesis that our current economic level, built and powered by the highest quality fuels known, can be maintained as these resources decline, may not be grounded in sound scientific and economic principles.

The Onset of Destabilization

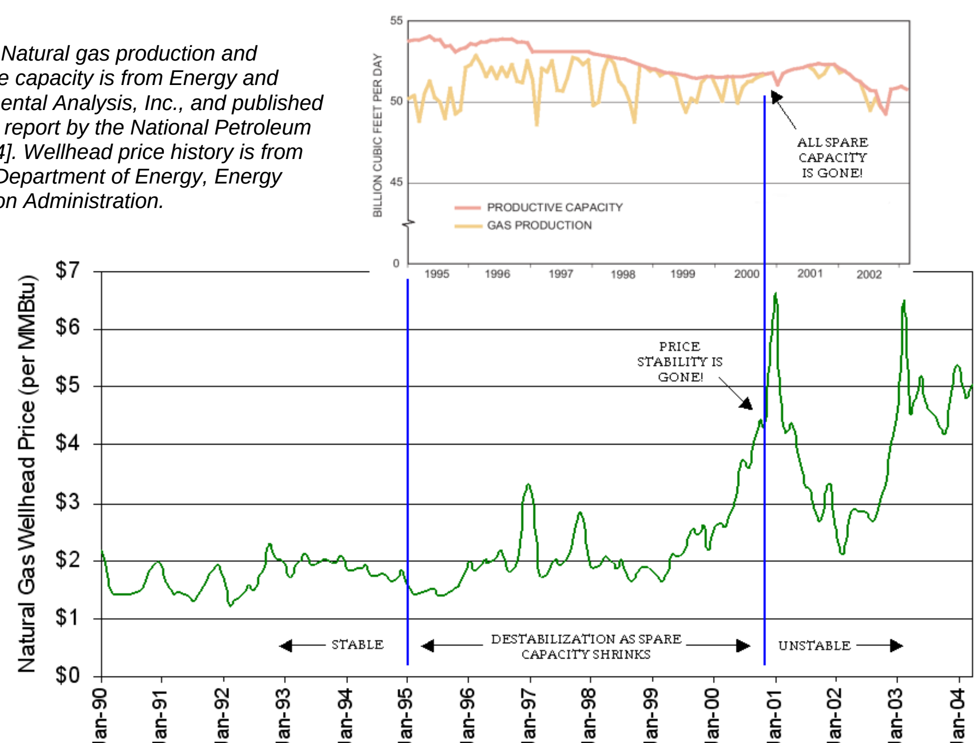
The instability precipitated by the decline of oil and gas has already begun in the form of price destabilization. Maintaining a stable energy price requires the existence of excess production capacity. Excess production capacity for world petroleum is not known exactly, but is believed to be less than 2 percent of market volume – far less than needed for price stability. Crude oil prices now sometimes fluctuate by 5 percent per day on speculation of changing political or climatic conditions. The inability to increase production elsewhere when political or weather events threaten a particular energy supplier makes each event significant from a market perspective.

Spare productive capacity for continental U.S. natural gas had been shrinking for many years before it finally vanished in the fall of 2000 [4]. This phenomenon, and its effect on prices, are shown in Figure 4.

The destabilization of energy prices, particularly for oil and gas, has immediate economic consequences. Higher energy prices reduce the amount of money consumers have to spend while simultaneously raising the cost of consumer goods (which are made and transported with energy). The effect is highly regressive because low-income households spend a disproportionate share of their income on energy. Energy purchases for home-heating, cooking, and transportation are furthermore basically non-discretionary.

Research of the process by which energy price instability develops into economic instability, and how this in turn leads to social and geopolitical instability, is ongoing. The growing body of empirical evidence correlating the worsening fossil-energy supply problem with economic and geopolitical events suggests that the process may already be well underway.

Figure 4: Loss of Spare Productive Capacity and its Relation to Price, Continental U.S. Natural Gas



Sources: Natural gas production and productive capacity is from Energy and Environmental Analysis, Inc., and published in a 2003 report by the National Petroleum Council [4]. Wellhead price history is from the U.S. Department of Energy, Energy Information Administration.

References

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