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The Goldilocks Policy in Turbulent Times

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A B S T R A C T

The shift from a reliance on fossil fuels to a sustainable energy mix is now taking place in society. This article demonstrates how past energy transitions can be used to estimate a suitable time frame for an orderly transition to a sustainable energy portfolio. The resulting Goldilocks Policy for energy transition is proposed as the corner-stone of a comprehensive grand energy bargain. An updated forecast of global energy consumption that includes the Covid pandemic period and global energy consumption data through 2022 is presented here. Recent events that serve as obstacles to implementing the Goldilocks Policy are discussed.

1. Introduction

A new energy mix is being developed to provide sustainable energy in the 21st century[1]. There are several causes driving changes in the energy mix. They include a finite supply of fossil fuels, climate change resulting from the combustion of carbon-based fuels, the growth in energy demand associated with an increasing global population, and national security.

In the second part of the 20th century, wood, coal, oil, natural gas, water, and nuclear fission were the primary energy sources in the energy mix. Renewable and nonrenewable energy sources are expected to contribute to the evolving energy mix. The energy mix is shifting toward renewable energy systems as a result of increasing political pressure from people concerned about anthropogenic climate change. Technological, commercial, and geopolitical factors such as the Russian invasion of Ukraine are requiring retention of nonrenewable energy sources in a declining and complementary role.

Energy demand is expected to increase as global population increases and developing nations seek a higher quality of life. The ability of energy producers to access natural resources affects energy production forecasts. Access to natural resources depends on relationships between societies with the technology to produce natural resources and societies with territorial jurisdiction over natural resources. Energy-related issues are forcing countries to make crucial policy decisions, such as whether to pursue energy independence or interdependence. Should they worry about sustaining the environment?

In this article, we consider the length of time that has been needed historically to achieve a transition from one primary energy source to another. We then provide an update of the Goldilocks Policy for energy transition.

2. How Much Time Do We Have?

An examination of energy consumption as a function of time and the duration of energy transition periods in the United States provides an estimate of the time needed to achieve an energy transition.

Figure 1 shows the contribution of different energy sources to the United States energy mix during the period from 1775 to 2022. The energy category labeled "Nuclear Electric" refers to electricity generation by nuclear fission reactors. The energy category labeled "Other Renewable" includes wood, geothermal, solar thermal, photovoltaic, and wind.

The data in Figure 1 can be rearranged to approximate the length of time it has taken historically for a developed nation to transition from one energy source to another. Figure 2 displays the percent contribution of different energy sources to the United States energy mix during the period from 1775 to 2022.

Estimates of coal and oil transition periods in the United States are shown in Figure 2. The transition period begins when the leading energy source begins to decline. In Figure 2, wood is the first leading energy source. The consumption of wood begins to decline when another energy source, coal, is available and adopted for use in the mid-1800s. Petroleum began to replace

coal in the early 1900s and peaked in the latter half of the 20th century. It took approximately 60–70 years to transition from wood to coal and then from coal to oil.

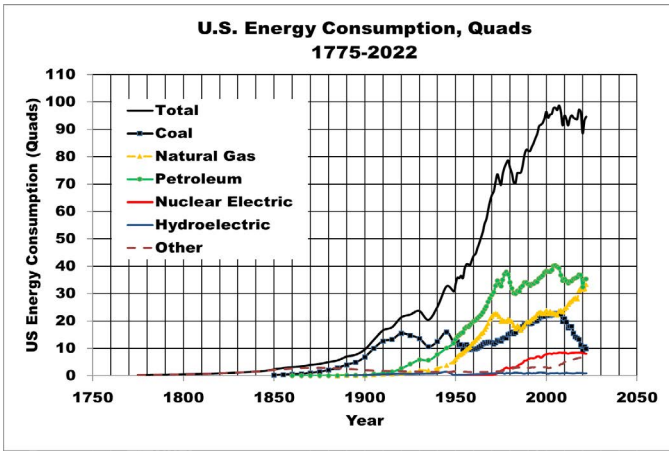

Figure 1: U.S. Energy Consumption by Source, 1775 – 2022 [1650 to 1945 data from US EIA AER, 2011; remaining data from US EIA MER Table 1.3, September 2023]

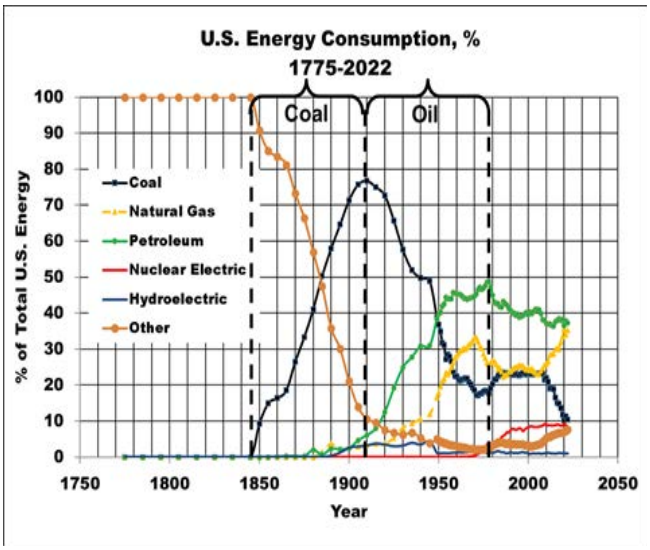

Figure 2: Coal and Oil Transition Periods based on U.S. Energy Consumption by Source, 1775 – 2022 (%)

Energy expert Vaclav Smil expressed his belief that we should rely less on fossil fuels to help combat climate change in an interview with Paul Voosen in 2018[2].

Smil wrote in his 2003 book **Energy at the Crossroads** that the "transition from societies energized overwhelmingly by fossil fuels to a global system based predominantly on conversions of renewable energies will take most of the twenty-first century[3]. Technological advances like the development of nuclear fusion energy or low-cost energy storage might shorten the transition period.

Energy transitions can take decades, according to energy expert and economic historian Daniel Yergin. It is possible to shorten the transition period by enacting a government law or regulation that requires utilities to generate electricity from renewable energy sources by a specified date[4,5,6]. Yergin added that older energy sources can coexist with newer ones after the transition.

3. Goldilocks Policy for Energy Transition

The ability to sustain economic growth, provide a secure energy supply, and create a clean and safe environment are three key objectives of an energy policy. The following three factors can help achieve these objectives: technical feasibility, economic viability, and government policy.

Technical feasibility refers to the use of contemporary technology that minimizes safety risks to people or the environment.

Economic viability recognizes that most of the world's energy infrastructure depends on fossil fuels. The rate of transition to a sustainable energy mix will be influenced by the cost of transforming the energy infrastructure.

The goal of government policy should be to optimize the rate of transition to sustainable energy sources. The discussion above covered the historical basis for establishing a reasonable period for transitioning from one energy source to another. Energy transition periods in the United States have lasted approximately 60 to 70 years[7].

Fanchi and Fanchi introduced the Goldilocks Policy for Energy Transition as a policy that would implement a transition to a sustainable energy mix based on historical energy transition periods. It is called the Goldilocks Policy because it relies on an energy transition period that is neither too fast nor too slow, but just right; that is, the Goldilocks Policy should be based on an implementation plan that minimizes environmental impact and reduces uncertainty in business planning with predictable public policy. If the Goldilocks Policy is not applied, government policy may vacillate between an energy transition that is so fast that it could significantly damage the global economy, or an energy transition that is so slow that it could permanently damage the environment. One way to implement the Goldilocks Policy is to adopt the two percent solution.

3.1 The Grand Energy Bargain

New York Times columnist Thomas L. Friedman suggested the adoption of a Grand Energy Bargain advocated by Hal Harvey of Energy Innovation because he was concerned that the 2014 Russian annexation of Crimea from Ukraine would have an adverse effect on European economies that depended on Russian fossil fuels[8]. The Harvey-Friedman Grand Energy Bargain had the following major elements of an energy strategy:

- Simultaneously optimize energy affordability, reliability, and environmental compatibility;
- Use modern technology to provide affordable, reliable, and clean energy; and
- Rely on the government to ensure that natural gas resources are used to usher in a secure, clean-energy future

The four objectives of the Harvey-Friedman Grand Energy Bargain are shown in Table 1.

Table 1: Harvey-Friedman Grand Energy Bargain.

Step	**Objective (see [Friedman, 2014] for quotes)**
1	Adopt "national rules for extracting natural gas based on known best practices, including strategies that eliminate the leakage of methane, which is so much more potent a greenhouse gas than carbon dioxide"
2	Set "a national clean energy standard for electricity. One popular approach is to require utilities to raise the fraction of their electricity from zero-carbon sources — such as wind, solar or nuclear — by, say, 2 percent per year"
3	Accelerate "energy efficiency and clean power technologies by building up our research and development programs"
4	Impose "a revenue-neutral carbon tax … that would replace payroll and corporate taxes"

Advocates of the Harvey-Friedman Grand Energy Bargain would have to negotiate details with proponents of other strategies. For example, the Harvey-Friedman Grand Energy Bargain called for a carbon tax. Hofmeister preferred a cap-and-trade system to a carbon tax[9]. Limited government proponents might object to imposing a carbon tax, a cap-and-trade system, or a Federal Energy Regulatory Board proposed by Hofmeister with extensive regulatory power.

3.2 The 2% Solution

The Two Percent Solution is an energy transition rate of 2% per year. It was described in step 2 of Table 1 and fits within the historically observed energy transition rate discussed previously. According to[10], the average global temperature is predicted to rise by 0.36°F (0.22°C) per decade. The average global temperature would rise about 2.16°F (1.32°C) if the temperature increases at an average rate of approximately 0.36°F (0.22°C) per decade during an energy transition period of 60 years.

We can use the Goldilocks Policy to forecast energy consumption given a few assumptions. In this calculation, we assume that energy consumption will continue the linear growth it has shown in this century, and that the consumption of nuclear fission energy will not change. The Goldilocks Policy calls for increasing the consumption of alternative energy by 2% per year to match the decline in fossil fuel consumption. The energy consumption forecast shown in Figure 3 includes the Covid pandemic period[11]. The forecast in Figure 3 shows that fossil fuel consumption will end by 2080 unless society decides to continue some reliance on fossil fuels.

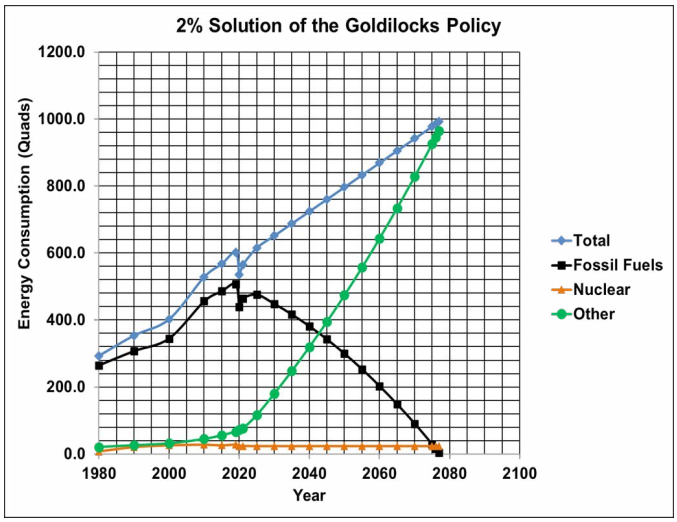

Figure 3: Forecast of Energy Consumption Based on the 2% Solution of the Goldilocks Policy[1].

4. The Future

A road map to a sustainable energy future is provided by the Goldilocks Policy, the Two Percent Solution, and the Grand Energy Bargain. The road map would let society proceed from a carbon-based economy to a sustainable economy in a predictable framework, but the transition would require discipline and patience.

The Goldilocks Policy is based on a vision that acknowledges the need to safeguard the environment from fossil fuel combustion while preserving regional, national, and international economies. Implementation of the Goldilocks Policy faces several challenges. Many of the challenges are discussed in more detail elsewhere[12]. Additional challenges have appeared in the 2020s, including the Russian invasion of Ukraine in 2022, the Hamas attack on Israel in 2023, and the difficulty of converting from vehicles with internal combustion engines to electric vehicles[1].

The development of nuclear fusion energy is a wild card in this discussion. The harnessing of nuclear fusion would provide a nearly limitless and sustainable source of energy. The commercialization of nuclear fusion could be achieved by the middle of the 21st century, but Charles Seife has discussed ongoing issues such as cost overruns and a timeline that keeps changing in the development of commercial nuclear fusion prototype ITER [13].

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