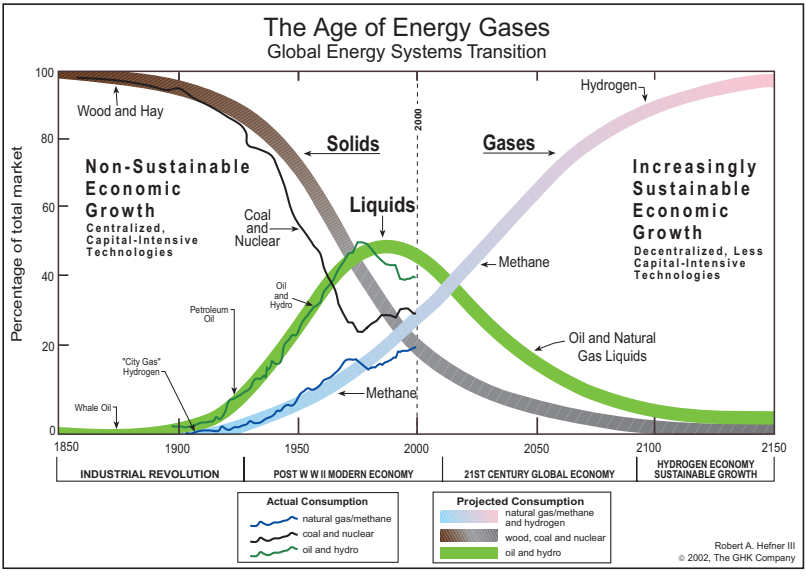
THE AGE OF ENERGY GASES

In the New Millennium

By Robert A. Hefner III
The GHK Company, 2002



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By Robert A. Hefner III, 2002
E-Mail: ghk@ghkco.com

The GHK Company
Oklahoma City, Oklahoma
USA

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Introduction

It is likely that natural gas is by far Earth's most abundant hydrocarbon, exceeding in quantity both coal and oil. Though conventional wisdom holds that natural gas resources rank third behind coal and oil, studies of the origins of natural gas, the abundance of methane in the solar system, the pervasive nature of natural gas in the Earth's lithosphere[1], and the vast quantities of methane trapped in gas hydrates[2] requires that this old thinking be vigorously challenged, if not overturned. Yet, forecast after forecast of world energy production shows natural gas remaining below both coal and oil and, in the second half of the century, often even nuclear. This brief paper expresses a significantly different view of our energy future: That increasing consumption of energy gases (methane and eventually hydrogen) will displace oil, coal and nuclear as the world's principal source of energy. I believe we are entering the "Age of Energy Gases"[3] and that by about 2050 the consumption of energy gases will surpass both coal and oil and, by the end of the Century, the energy gases – methane and hydrogen – will have, like coal in its heyday, captured more than 75% of the global energy market[4].

Where We Have Been

For more than 100 years, free markets and the ingenuity of humankind worked efficiently to decarbonize our energy systems. This transition can be seen on Fig.1, "U.S. Primary Energy Substitution"[5], that shows the natural transition from wood to coal to oil and the beginning of natural gas. It was only starting in the 1950's, when governments began to tinker with price controls and later, reacting to the "sky is falling" cries of shortages by the energy industry, allocated fuels among sectors of consumers, that we once again began to recarbonize the energy system. This government intervention, most stringent in the U.S., is clearly shown by the significant distortion over the past three decades of the formerly natural sine curves of transition as seen on Fig. 1. Only now, after significant deregulation, is the natural course of energy transitions in the U.S. beginning to return to its natural order.

In the U.S., beginning in the 1950's, 20 years of stringent, politically motivated low price controls led to natural gas supply shortages, coupled with artificial increases in demand. While criticizing

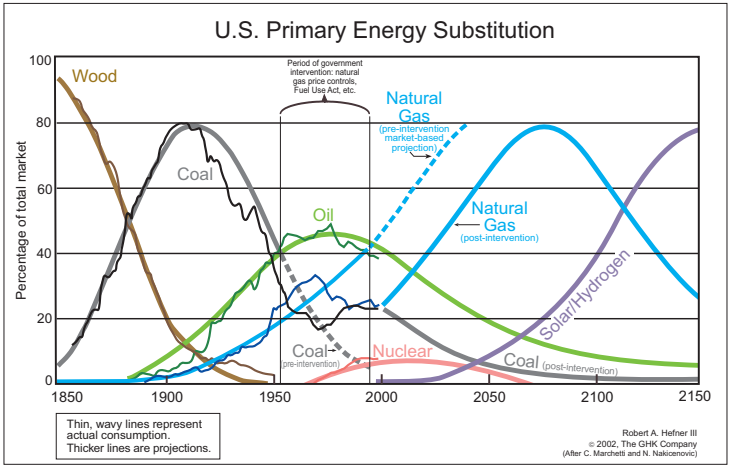

Fig. 1

the Soviet Union for its controlled economic system, the United States, with abundant affordable natural gas resources, nearly regulated its cleanest fuel out of existence, just as the Soviet Union did many of its agricultural products. During the days of price control, natural gas, as compared to oil on a Btu basis, sold for only 30% of the price of oil[6]. Yet natural gas in the free market would tend to bring a premium because it is a more efficient and cleaner fuel than coal or oil; thus, the upward distortion in natural gas consumption beginning in the 1950's.

Both the oil companies and the natural gas companies truly believed the United States was running out of natural gas and therefore would not be able to sustain its rapidly increasing use. This became the "herd mentality" of the times. Their largely misconceived views were held principally for three reasons: first, the oil companies historically considered regulated and uneconomic natural gas to be, at best, an unwanted by-product of oil production. Second, the natural gas companies were not natural gas producers because historically there had been plenty of natural gas produced (as a by-product of oil production) for the natural gas companies to transport and distribute and therefore there was no need for the stringently regulated natural gas transportation companies to take the risk required by oil and gas explorers and producers. And third, the politically motivated, low price regulations sapped the entrepreneurial spirit to develop ways to find natural gas when it was not associated with oil. Yes, the United States was running out of natural gas in the midst of natural gas resource abundance, but the natural gas the United States was running out of was either natural gas that was produced in association with the generally declining oil production of the times and found because of the non-regulated and profitable price of oil, or natural gas from very shallow fields that could be found and produced profitably at very low regulated prices.

At the Aspen Institute in 1978[7], prestigious members of the energy industry gathered and listened to the presentations of woe predicting the end of natural gas in the United States. They were led by Dr. Richard Gonzalez, a consulting economist for Exxon, who simply said, "We are running out, and it will be soon." Two years earlier, Exxon had estimated a rather pathetic 287 trillion cubic feet (Tcf) of remaining

natural gas resources, and considered about 650 Tcf to be "wildly optimistic"[8]. And, in 1977, John D. Moody of Mobil Oil Corp. (and then President of the American Association of Petroleum Geologists) published in a congressional statement an equally woeful estimate of 443 Tcf of undiscovered potential natural gas in the United States and, in the same congressional statement, said: "We have arrived pretty much at a consensus among responsible estimators of some 400 to 600 Trillion cubic feet as the undiscovered potential for gas in the United States"[9]. As a small independent, not considered to be among John Moody's "responsible estimators", who was I to try to counter this tidal wave? But my 1978 Aspen Institute presentation estimated that about 1,500 Tcf of natural gas was yet to be found in the U.S., most of it not associated with oil, and at reasonable and competitive prices[10].

Over many years, I attempted to counter these pervasive arguments of scarcity in Congress eighteen times[11] by presenting my case of natural gas resource abundance. On April 26, 1984, before the Committee on Energy & Natural Resources of the United States Senate, I said: "I predict the remaining U.S. natural gas resource base to be between 1,000 and 1,500 Tcf and that of North America to be at least double that, >2,000-3,000 Tcf"[12]. My efforts were to no avail. Before the same Senate Committee in 1984, Charles B. Wheeler, Senior Vice President of Exxon, said: "We estimate the volume of as-yet-undiscovered gas from conventional sources in the United States to be about 300 Tcf"[13].

Of course, a major part of the problem was that until the early 1970's natural gas was considered at best a marginally economic by-product of the oil industry. The large-scale natural gas transmission system in the United States was built in the decades following World War II. Only during the past 20 years has natural gas begun to achieve independent economic value, whereas oil has been largely non-regulated and has maintained significant intrinsic value as an important, easily traded and readily transported energy commodity since the turn of the last century. More recently natural gas exploration and production has responded to the market, and estimations of U.S. natural gas resources have grown radically. The USGS's 1975 estimate of mean undiscovered recoverable natural gas resources was 484

Tcf[14], their 1981 estimate was 594 Tcf[15], their 1989 estimate was only 399 Tcf[16], but by 1995 their estimate was 1,074 Tcf[17] and in 2000 it was 1,054 Tcf[18]. The abundance of the natural gas resource base was affirmed in the last decade by a number of other governmental and institutional entities as well. In 1992 the National Petroleum Council estimated natural gas resources at 1,295 Tcf[19] and in a summary report approved December 1999, their estimate had risen to 1,466 Tcf[20]. In a 2001 publication the U.S. Department of Energy's Energy Information Administration (EIA) estimated resources at 1,111 Tcf[21] and the Potential Gas Committee, also in a 2001 publication, estimated 1,258 Tcf[22]. The Gas Technology Institute's "current" resource estimate is 1,805 Tcf and their "advanced" estimate is 2,058 Tcf[23]. In 1993, in my article "New Thinking About Natural Gas", which appeared in the U.S. Geological Survey's Professional Paper 1570, I raised my estimate to the 3,000 to 4,000 Tcf range[24].

As we attempted to seek deregulation of natural gas prices in Congress in the 1970's, one of my principal adversaries was Mr. Zareski of the Federal Power Commission[25], who published the pitiful, but generally typical declining natural gas projections seen on page 13 in Fig. 2, "Weeping Willow" (Various U.S. Natural Gas Production Forecasts vs. Actual Production Capability). Even the American Gas Association (AGA) didn't realize that its mid-1970's "optimistic" natural gas projections were actually pessimistic. I wondered why, so I went to the AGA to find out how it had calculated its projections. Wishing to project the highest, reasonably possible quantities of natural gas that could be found and produced, the AGA economists had used the highest historical natural gas finding rates per well drilled. But they had failed to realize that the highest historical finding rates for natural gas were achieved during the 1950's when oil companies, solely on the basis of oil economics and with no thought of natural gas as a commodity with intrinsic value, were exploring and drilling the rather shallow geologic environments where their geologists expected to find oil, not natural gas. In those days, geologists avoided areas where natural gas was expected. So, although the AGA projection was indeed more optimistic than most other forecasts for natural gas, it had little relevance to future natural gas extraction. It included little consider-

ation of natural gas to be found not in association with oil or in domains in which natural gas is prolific and oil does not exist, such as much of the vast volume of rocks in overthrust belts and at depths below which oil is generally absent.

The general belief in the shortage of the natural gas supply caused an equal number of price forecasters, just as the forecasters of natural gas resource shortages, to suggest there would be significantly increasing price trends, as shown on page 14 in Fig. 3, "Price Explosion Vs. Actual Price" (Forecasts of Future U.S. Natural Gas Wellhead Prices Made from 1980 through 1993). The collective wisdom of the day was that even on the chance that there was enough natural gas to meet demand, it would be too expensive, so there was no alternative to coal or nuclear. Estimators had projections of U.S. natural gas prices curving up to the sky at approximately the same rate that supplies were curving down to the depths. None of this approached reality, of course, except for a brief anomalous price period in late 2000 and the first part of 2001. As early as 1983, I presented three testimonies to Congress that natural gas prices had already begun to decline and would continue to decline[26]. In 1993, GHK made an estimate that natural gas wellhead prices would average $2.39 in 1999 and another estimate that natural gas wellhead prices would average $3.10 in 2000[27] and, except for that anomalous period, our estimate was in the right direction.

The culmination of this collective wisdom of the 1970's of shortages and price escalation, that was caused as a result of decades of distortion of the marketplace through government intervention by price controls, led to the Fuel Use Act[28] that virtually prohibited the use of natural gas for base load power generation and industrial consumption. By way of this legislation the U.S. government forced the recarbonization of America's energy system. The best example of America's recarbonization is from my state of Oklahoma.

In 1976, before the Fuel Use Act, Oklahoma used its abundant domestic natural gas to generate 95% of its electricity[29]. Oklahoma was one of the nation's low cost, low emission generators of electricity. It was only after the Fuel Use Act, that prohibited the use of natural gas in new power facilities, that Oklahoma began to import coal from Wyoming to generate its electricity. Today, Oklahoma generates 64%

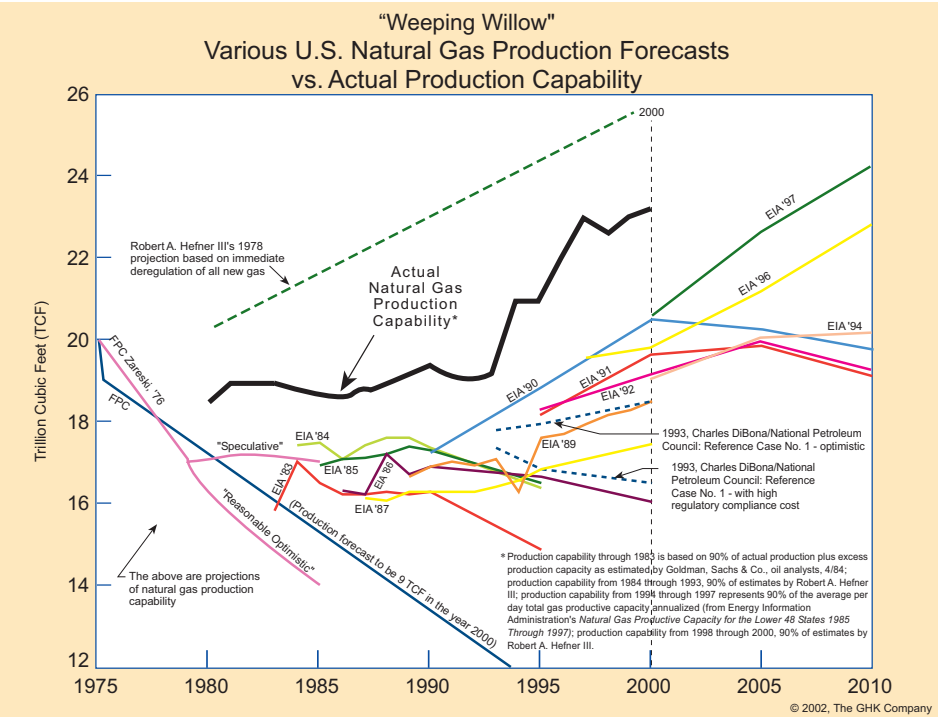
"Weeping Willow"
Various U.S. Natural Gas Production Forecasts
vs. Actual Production Capability
Trillion Cubic Feet (TCF)
26
24
22
20
18
16
14
12
1975
1980
1985
1990
1995
2000
2005
2010
2000
Robert A. Hefner III's 1978 projection based on immediate deregulation of all new gas
Actual Natural Gas Production Capability*
FPC 'Zarenski '76
FPC
"Speculative"
"Reasonable Optimistic"
(Production forecast to be 9 TCF in the year 2000)
EIA '84
EIA '85
EIA '86
EIA '87
EIA '88
EIA '89
EIA '90
EIA '91
EIA '92
EIA '94
EIA '96
EIA '97
1993, Charles DiBona/National Petroleum Council: Reference Case No. 1 - optimistic
1993, Charles DiBona/National Petroleum Council: Reference Case No. 1 - with high regulatory compliance cost
The above are projections of natural gas production capability
* Production capability through 1983 is based on 90% of actual production plus excess production capacity as estimated by Goldman, Sachs & Co., oil analysts, 4/84; production capability from 1984 through 1993, 90% of estimates by Robert A. Hefner III; production capability from 1994 through 1997 represents 90% of the average per day total gas productive capacity annualized (from Energy Information Administration's *Natural Gas Productive Capacity for the Lower 48 States 1985 Through 1997)*; production capability from 1998 through 2000, 90% of estimates by Robert A. Hefner III.
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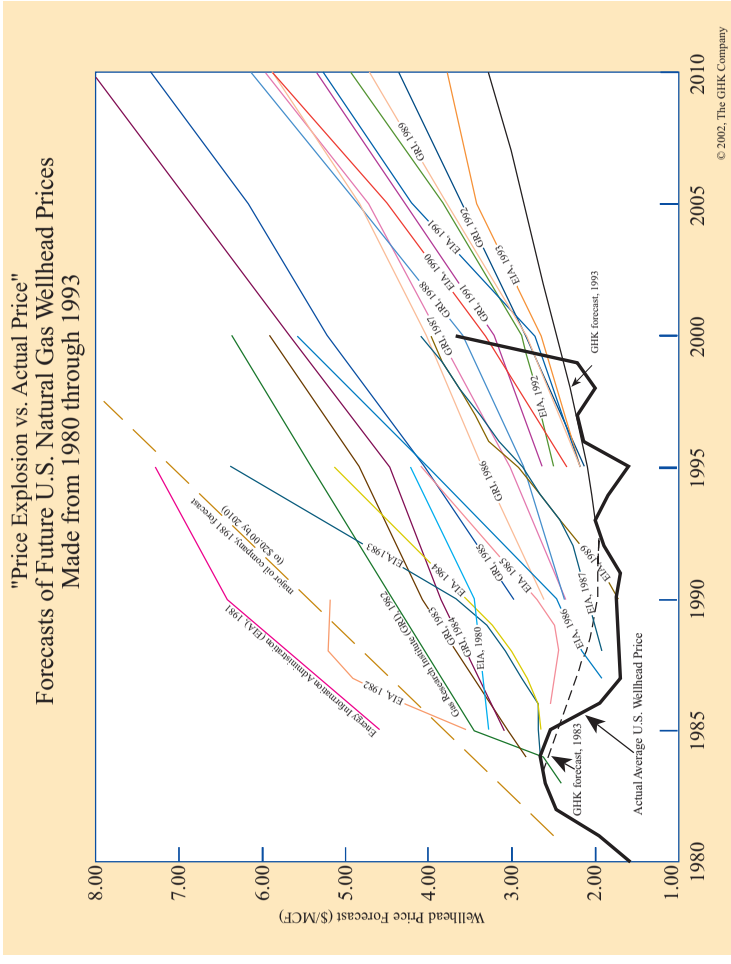
Fig. 2


"Price Explosion vs. Actual Price"
Forecasts of Future U.S. Natural Gas Wellhead Prices
Made from 1980 through 1993
Wellhead Price Forecast ($/MCF)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
1980
1985
1990
1995
2000
2005
2010
Actual Average U.S. Wellhead Price
GHK forecast, 1983
GHK forecast, 1993
Energy Information Administration (EIA), 1981
major oil companies, 1981 forecast
(to $30.00/bbl by 2010)
Data Resources Incorporated (DRI), 1982
EIA, 1982
EIA, 1983
EIA, 1984
DRI, 1985
DRI, 1986
EIA, 1985
EIA, 1986
EIA, 1987
EIA, 1988
DRI, 1987
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EIA, 1991
DRI, 1991
DRI, 1992
EIA, 1992
EIA, 1993
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Fig. 3

of its electricity by burning coal[30] and has lost its auspicious title of being one of the nation's lowest cost, cleanest and most efficient generators of electricity. Like the U.S. as a whole, the Fuel Use Act recarbonized Oklahoma (see Fig. 1).

In the U.S., coal fell to its lowest percentage of market share in the early 1970's when it had 16.9% of the total U.S. energy market, while natural gas's share of the total market was 32%. By 1986, coal's share had grown to 23.2% of the market and natural gas had declined to 22.5% of the market, and in 2000 coal had 22.7% and natural gas 23.7%[31].

Where We Are Going

The past is easy to summarize, but I believe to predict where we are going requires unbounded thinking and the courage of conviction to report where the real facts lead. In my opinion, many of the projections I see of the estimates of fuel consumption and the mixture of fuels to meet demand through this century are as much in error as they were in the 1970's. I say this for three fundamental reasons. First, like Herman Kahn in his 1976 book *The Next Two Hundred Years*[32], I do not believe in straight-line population growth. I, too, am of the opinion that rates of population growth are not likely to be sustained. I believe the Information Age will disseminate so much educational information to so many people around the world that birthrates will begin to fall during this century. Second, I believe that Amory Lovins[33] is on the right track and that we will find efficiencies in the energy system well beyond our imagination. Lovins' predictions of efficiency, coupled with population decreases possibly near the middle of the century, will mean that demand as a whole will not be as large as projected. Third, in my opinion, these projections are wrong because the fuel mix, based upon misconceptions of the quantity of the remaining fuels resource base, will not come close to what is typically often depicted in forecasts such as those shown on page 16 in Fig. 4, "Conventional Energy Production Forecast," taken from a chart published in 1999, by Dr. John Edwards[34] of the University of Colorado. I say this because unless governments once again step in to legislate

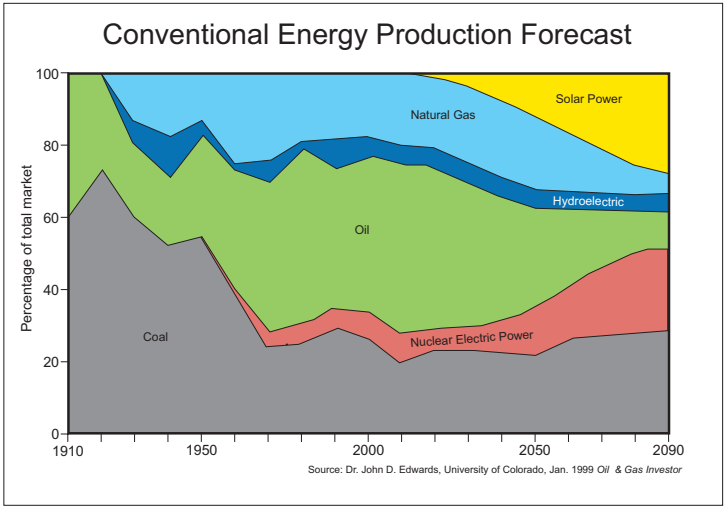

Fig. 4

energy markets, I believe free markets coming into existence around the world will once again work their magic to decarbonize the energy system over the next 150 years and usher in what I call the Age of Energy Gases. My opinion is that nuclear, unless fostered by government intervention, will go nowhere, as it's ultimately dirty and too capital intensive. A 1999 U.S. Gas Research Institute (now Gas Technology Institute) publication said: "Virtually all of the existing nuclear capacity in the U.S. is scheduled for retirement by 2030"[35]. And coal, unless also fostered by government intervention, will go back to its naturally declining percentage of the market. China is generally thought to be the major coal exception. But China has plenty of easily accessible coal, and where there is coal there is natural gas, so I believe China is heavily endowed with natural gas. I base this judgment not only upon China's enormous quantities of coal and the coal/gas relationship, but also upon research I conducted in the mid-1980's on China's natural gas resource base, which I found to be significantly abundant. However, in the 1980's, China's leaders did not believe my reports of abundant natural gas resources for their country[36] any more than U.S. leaders did

in the 1970's. I think China will indeed begin to explore, produce and consume its vast natural gas resources because I don't think the Chinese will continue to tolerate coal pollution; the Chinese want clean air and blue skies as much as we do. Within the next two decades or so, I forecast that China will begin its conversion from coal to natural gas. There is certainly one thing you can say about China's society – if the leaders want to go that way, that is indeed the path China will pursue and pursue with vigor.

The Age of Oil, as best described in Daniel Yergin's *The Prize*[37], is not our future, but our recent past. I believe oil has peaked in its percentage contribution to the global energy market. So today, the only abundant, clean fuel that is continuing to set new consumption records[38] around the world is natural gas. Several years ago I worked closely with Cesare Marchetti and Nebojsa Nakicenovic, at the International Institute for Applied Systems Analysis (IIASA)[39], who have done wonderful work on energy forecasting outside of the momentum of herd mentality[40]. Since 1979 they have forecast, by using their "market penetration" models, that the natural gas share of the market will move toward 80% in this century (as seen on Fig. 5, "World Primary Energy Substitution"). If the Marchetti, et al, forecasts are even close

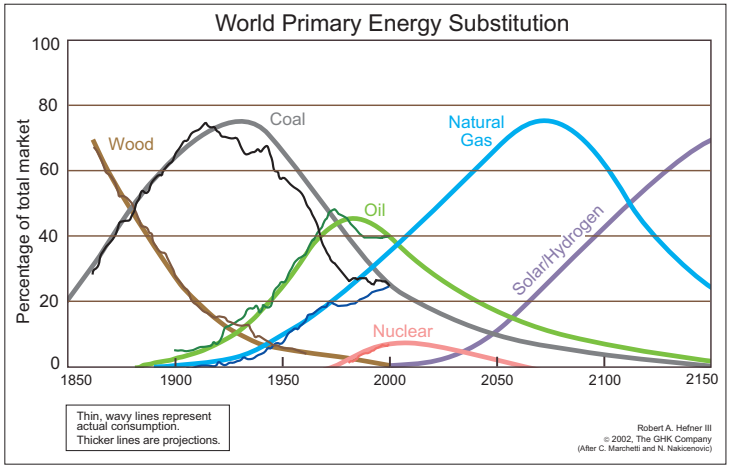

Fig. 5

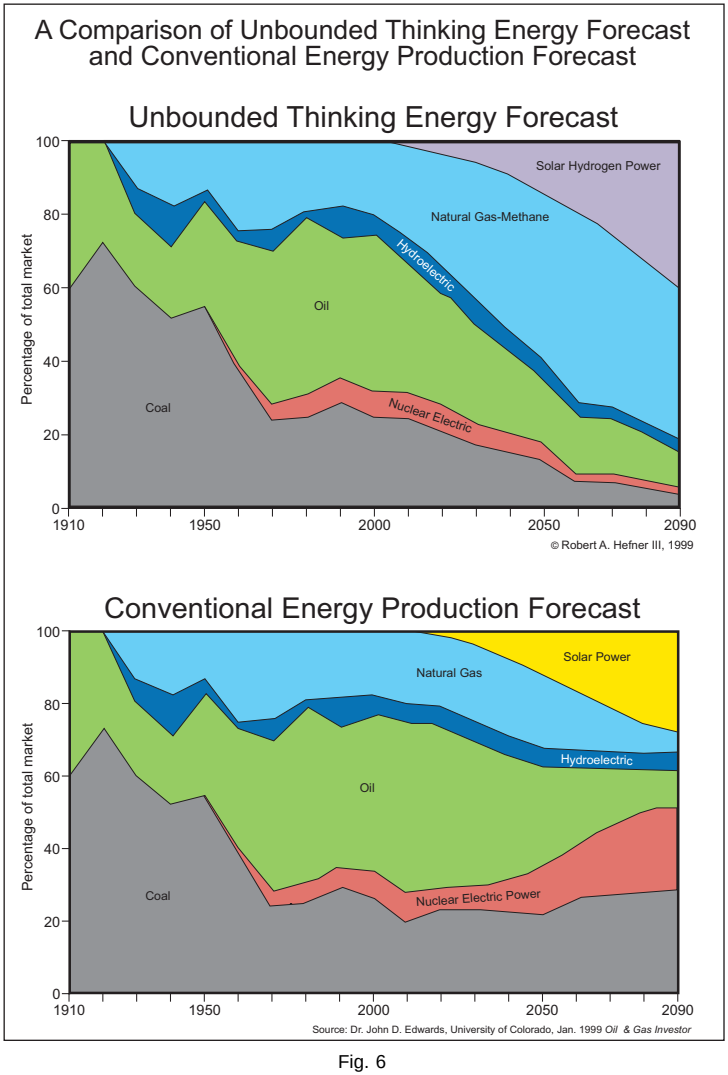
A Comparison of Unbounded Thinking Energy Forecast and Conventional Energy Production Forecast
Unbounded Thinking Energy Forecast
Percentage of total market
100
80
60
40
20
0
1910
1950
2000
2050
2090
Solar Hydrogen Power
Natural Gas-Methane
Hydroelectric
Oil
Coal
Nuclear Electric
© Robert A. Hefner III, 1999
Conventional Energy Production Forecast
Percentage of total market
Solar Power
Natural Gas
Hydroelectric
Oil
Coal
Nuclear Electric Power
Source: Dr. John D. Edwards, University of Colorado, Jan. 1999 Oil & Gas Investor

Fig. 6

to what our future holds, and I believe their market penetration models are on the right course, other fuels will be significantly displaced from the global energy system. So when we combine lower population growth, more efficiency in the energy production-consumption system and natural gas taking the lion's share of the market, we see curves that should look dramatically different and more like our modification of conventional forecasts, as seen on Fig. 6, "A Comparison of Unbounded Thinking Energy Forecast and Conventional Energy Production Forecast." In the EIA's *International Energy Outlook 2000* they project natural gas to be the fastest growing primary energy source worldwide and predict consumption to more than double between 1997 and 2020.[41]

My own personal philosophy of our energy future emerges from a lifetime of energy studies and differs at the bottom line from any I have seen. Fig. 7, "The Age of Energy Gases", takes the IIASA forecasts a step further; it shows what I believe to be the elegant simplicity of energy supply transitions. My thinking emerged from years of ques-

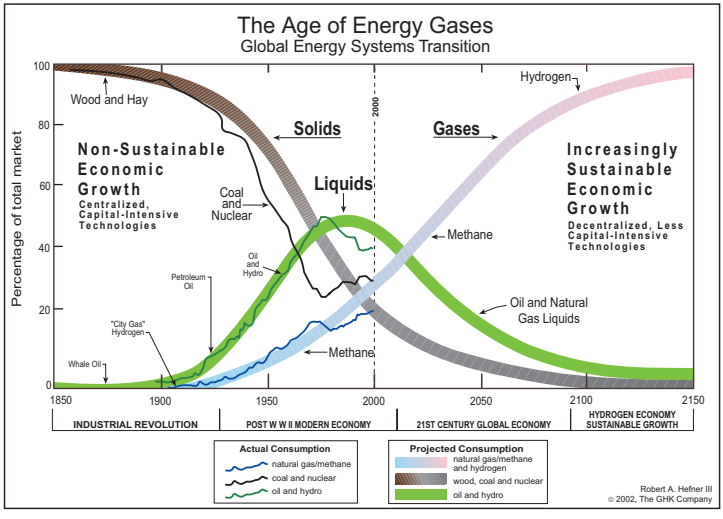

Fig. 7

tioning why oil, a more efficient, cleaner and more mobile fuel than coal, had, at its maximum, only met about 50% of global market demand and how that fact related to IIASA's forecasts of natural gas growth toward 80%. What never made sense to me was that oil, a better fuel than coal and one that had suffered little government control and regulation over its history of use, should capture only slightly more than one-half the percentage of the market coal had achieved, which, in its heyday, was about 95%. Early in the 1990's, it occurred to me why that may possibly be. Our Solar System and Earth, and for that matter the Universe, are basically composed of two forms of matter: solids and gases. Liquids are simply a transitional and relatively small state of matter. Therefore, in the big picture, I believe the Age of Oil to be only a liquid transition between the Age of Solids – animal dung, wood, coal and I include nuclear – and the Age of Energy Gases. So once we combine all the solids and look at the resulting curve, we have a rather smooth, natural progression from solids through a liquid transition to energy gases. We have an energy system that, with the exception of a short period of U.S. government intervention, has been clearly decarbonizing for over 150 years and will continue to decarbonize, leading our global civilization for the first time to sustainable economic growth. Over the last one and one-half centuries, we have moved from capital intensive, centralized, macro and immobile largely unsophisticated and inefficient energy technologies supplied by dirty and highly chemically complex fuels toward decentralized, distributed, micro, more mobile, sophisticated and highly efficient energy technologies fueled by more and more clean, chemically simple fuels (CH_4 to H_2). The trend is already here for us to observe and will continue throughout the next century.

Conclusion

The way forward toward sustainable economic growth lies with the Age of Energy Gases and calls for continuing the increasing consumption of our Earth's most plentiful and cleanest hydrocarbon, natural gas (CH_4, only one carbon atom and four hydrogen atoms). As natural gas displaces the old dirty solid coal and later liquid oil, the

global economy will become significantly more sustainable and efficient. Natural gas and its transportation and consumption systems are the pathfinders that will lead our global economy to the ultimate renewable and chemically simplest energy source, hydrogen. Once again, I believe Amory Lovins' "A Strategy for the Hydrogen Transition" is on the right course[42]. Hydrogen is the ultimate renewable primary energy source because its combustion produces simply water and oxygen. I forecast hydrogen will be produced from seawater by advanced, efficient, low cost solar technology and will be used directly as a primary fuel, as well as for the generation of electricity. As the Age of Energy Gases advances, together with the continuing revolutionary changes in communications, information transfer and education, the world economies will become increasingly globalized and capable of sustaining economic growth while enhancing the global environment. Our future is bright!

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[23] Potential Gas Committee, Potential Gas Agency, Colorado School of Mines, 2001, *Potential Supply of Natural Gas in the United States*, a report of the Potential Gas Committee, December 31, 2000 (published March 2001), Chapter: "Comparison of Resource Estimates," p. 4.

[24] Robert A. Hefner III, 1993, U.S. Geological Survey Professional Paper 1570 *The Future of Energy Gases*, "New thinking about natural gas," p. 825.

[25] Gordon K. Zareski, Chief, Resource Evaluation and Analysis Division, Bureau of Natural Gas, Federal Power Commission.

[26] Robert A. Hefner III testimonies before: U.S. Senate Subcommittee on Energy Regulation, Committee on Energy and Natural Resources, March 11, 1983; U.S. House of Representatives Subcommittee on Fossil and Synthetic Fuels, Committee on Energy and Commerce, March 24, 1983; and U.S. House of Representatives Subcommittee on Fossil and Synthetic Fuels, Committee on Energy and Commerce, April 14, 1983.

[27] The GHK Company internal memo, July 28, 1993, Re: "GHK's forecasts for wellhead prices."

[28] In 1978, President Jimmy Carter signed into law the Power Plant and Industrial Fuel Use Act. The heart of the Fuel Use Act was Section 102, Part 2, which stated the desire "to conserve natural gas and petroleum for uses other than electric utility or other industrial or commercial generation of steam or electricity, for which there are no feasible alternative fuels or raw material substitutes…(and) to prohibit or, as appropriate, minimize the use of natural gas and petroleum as primary energy sources."

[29] U.S. Department of Energy, Energy Information Administration, *Electric Power Annual*, "Net generation by gas-fired steam units and by gas-fired gas turbine/internal combustion units by census region

and state, 1976-1981," from Federal Power Commission Form 4.

[30] U.S. Department of Energy, Energy Information Administration, *Electric Power Annual 2000*, Volume 1, pp. 26-27.

[31] Various issues of U.S. Department of Energy, Energy Information Administration *Monthly Energy Review* and *Energy Statistics Sourcebook*.

[32] Herman Kahn, 1976, *The Next Two Hundred Years: A Scenario for America and the World* (New York: William Morrow & Co. Inc.).

[33] A.B. Lovins, "Putting central power plants out of business," 7 July 1998 presentation to Aspen Institute Energy Forum, Rocky Mountain Institute Publication #E98-2, Snowmass, Colorado 81654, www.rmi.org, and references cited in its bibliography.

[34] Dr. John D. Edwards, adjunct geology professor, Energy and Minerals Applied Research Center (EMARC), Department of Geological Sciences, University of Colorado, Boulder, Colorado. From chart "Estimates of 21st century United States energy supplies."

[35] Gas Research Institute, 1999, *Policy Implications of the GRI Baseline Projection of U.S. Energy Supply and Demand to 2015*, March, 1999, p. 6.

[36] Robert A. Hefner III, 1985, "Onshore natural gas in China," presented at World Bank energy round table discussion on gas development in less developed countries, Paris, March 25-26, 1985.

[37] Daniel Yergin, 1991, *The Prize: The Epic Quest for Oil, Money & Power* (New York, Simon & Schuster).

[38] U.S. Department of Energy, Energy Information Administration, 1999, *International Energy Annual*, Table 1.3, "World dry natural gas consumption, 1990 – 1999" – shows total world consumption increasing from 72.9 Tcf in 1990 to a world record consumption of 84.2 Tcf in 1999; (www.eia.doe.gov/emeu/iea/table13.html, 11/20/2001)

[39] The International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, is a nongovernmental, multidisciplinary, international research institution, founded in October, 1972, by the academies of science and equivalent scientific organizations of 12 nations from both East and West, with a goal to bring together scientists from around the world to work on problems of common interest, particularly those resulting from scientific and technological development.

[40] Cesare Marchetti and Nebojsa Nakicenovic, 1979, "The dynamics of energy systems and the logistic substitution model," RR-79-13, 73 p., International Institute for Applied Systems Analysis, Laxenburg, Austria. Also, Nebojsa Nakicenovic, 1986, "Patterns of change: Technological substitution and long waves in the United States," WP-86-13, 32 p., International Institute for Applied Systems Analysis, Laxenburg, Austria.

[41] U.S. Department of Energy, Energy Information Administration, 2000, *International Energy Outlook*, p. 10.

[42] Amory B. Lovins, 1999, "A strategy for the hydrogen transition," presented to the 10th Annual U.S. Hydrogen Meeting, National Hydrogen Association, Vienna, Virginia, April 7-9, 1999.

About the Author

Robert A. Hefner III is Owner and Managing Partner of The GHK Company, a private natural gas exploration and production firm with offices in Oklahoma City. Mr. Hefner appeared 18 times before Congressional committees testifying on energy matters in the 1970's and 1980's and was influential in bringing about constructive changes in Federal policy related to natural gas pricing and deregulation. The GHK Company, founded by Mr. Hefner in 1959, is known for its pioneering deep, high pressure natural gas development in the Anadarko Basin of Oklahoma, where the company led the industry in technological innovation to successfully drill and produce many of the world's deepest and highest pressure natural gas wells and the 1997 discovery of a large natural gas field – the Potato Hills field – in the Ouachita overthrust of southeastern Oklahoma. Additionally, Mr. Hefner is Chairman of the Board and CEO of Seven Seas Petroleum Inc., a publicly traded (AMEX: "SEV") oil and natural gas exploration and production company with offices in Houston, Texas, and international operations in Colombia.

THE GHK COMPANY

6305 Waterford Boulevard, Suite 300
Oklahoma City, Oklahoma 73118-1116 USA
Telephone: 405/858-9800 • Telefax: 405/858-9898
E-Mail: ghk@ghkco.com