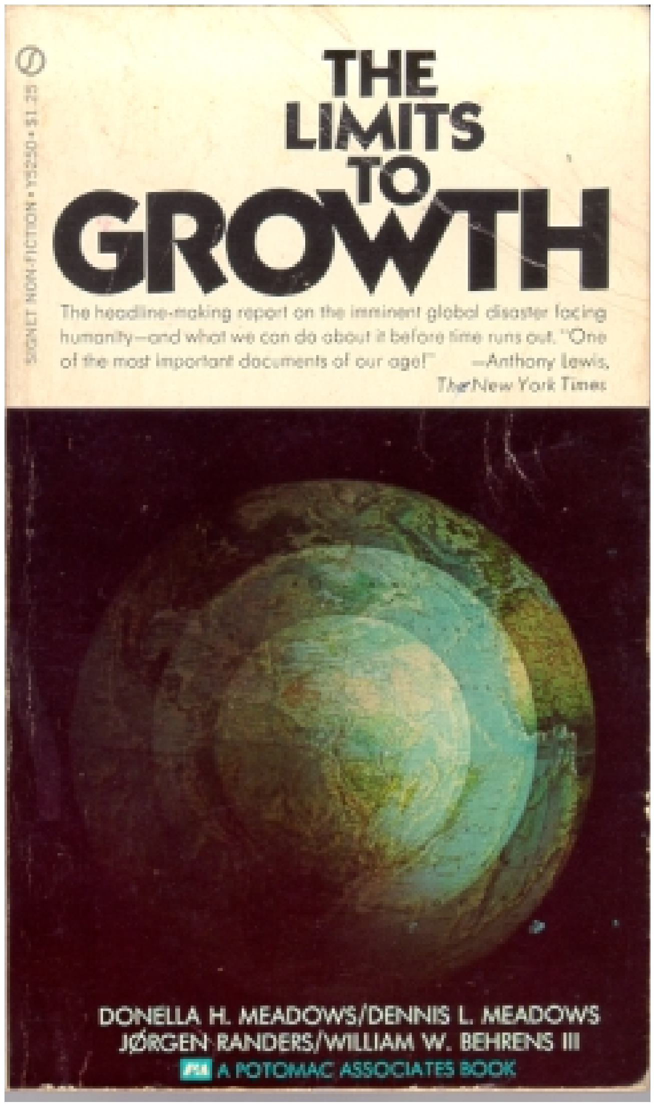
Revisiting The Limits to Growth:

Could The Club of Rome Have Been Correct, After All?



An Energy White Paper
by
Matthew R. Simmons

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THE PRICE OF PROGRESS

When each of us as an individual decides to buy something, we first consider the price. Yet society at large has long bought the idea of continual growth in population and production without adding up the final reckoning.

Now a team of M.I.T. scientists, with the aid of a giant computer, has completed a study of the future if present growth continues. Their inescapable conclusions are beyond anyone's grimmest fears. *Possibly within as little as 70 years, our social and economic system will collapse unless drastic changes are made very soon.*

The Limits to Growth has made headlines the world over. Its shock waves have caused our most cherished assumptions to come crashing down. It is a book that we can ignore only at our peril.

"If this book doesn't blow everybody's mind who can read without moving his lips, then the earth is kaput."

- Robert C. Townsend
Author of *Up the Organization*

Revisiting The Limits To Growth: Could The Club Of Rome Have Been Correct, After All?

In the early 1970's, a book was published entitled, The Limits To Growth, a report of the Club of Rome's project on the predicament of mankind. Its conclusions were stunning. It was ultimately published in 30 languages and sold over 30 million copies. According to a sophisticated MIT computer model, the world would ultimately run out of many key resources. These limits would become the "ultimate" predicament to mankind.

Over the past few years, I have heard various energy economists lambast this "erroneous" work done. Often the book has been portrayed as the literal "poster child" of misinformed "Malthusian" type thinking that misled so many people into believing the world faced a short mania 30 years ago. Obviously, there were no "The Limits To Growth". The worry that shortages would rule the day as we neared the end of the 20th Century became a bad joke. Instead of shortages, the last two decades of the 20th Century were marked by glut. The world ended up enjoying significant declines in almost all commodity prices.

Technology and efficiency won. The Club of Rome and its ”nay-saying” disciples clearly lost!

The critics of this flawed work still relish in pointing out how wrong this theory turned out to be. A Foreign Affairs story published this past January, entitled <u>Cheap Oil</u>, forecast two decades of a pending oil glut. In this article, the Club of Rome's work was scorned as being the source document which led an entire generation of wrong-thinking people to believe that energy supplies would run short. In this Foreign Affairs report, the authors stated, "….the "sky-is-falling school of oil forecasters has been systematically wrong for more than a generation. In its dramatic 1972 <u>The Limits to Growth</u> report, the group of prominent experts known as The Club of Rome wrote that only 550 billion barrels of oil remained and that they would <u>***run out by 1990***</u>."

This past May, Rice University's Baker Institute held an energy forum entitled "Running on Empty?" where the topic of future energy reliability was carefully addressed. John Lichtblau, Chairman of the Petroleum Industry Research Foundation (PIRINC) made reference to this work in his keynote remarks. In a comment on how virtually all global forecasts of resource-constrained oil production turned out to be wrong, he said “Many of you still recall the widely quoted, very prestigious “Club of Rome” report of 1972 which predicted a fundamental resource constraint on oil supplies ***by the end*** *of the 20th Century*.“

For a publication that is almost 30 years out of print, it is fascinating that anyone still even remembers what the book said. I have occasionally been privately amused at the passion this Club of Rome work still evokes. As I have heard this study thoroughly discredited, I have wondered whether the anger this book still creates is the equivalent of getting livid at a bartender “the morning after,” when one’s headache was so wicked. Could the core angst this work still generates result from a backlash or an embarrassment by these same critics for embracing these shortage concepts and then being proved wrong?

The first time this “Club of Rome” topic caught my attention was after I addressed the International Association of Energy Economists at their annual meeting in Dallas, Texas, on Election Day, 1994. At this program, I spoke of the pending end of all three “bubbles” which had kept such an overhang on energy supplies and kept prices so low: the oil bubble, the gas bubble, the drilling rig bubble (there had been a huge surplus of equipment.) I also addressed the pending volatility in our energy market now that NYMEX pricing had taken over (I called it a new driver of the Energy Bus.) I thought it was a pretty good talk, But, the question and answer session brought forth not a single question. There was total silence from an obviously disbelieving audience. So I clearly missed the mark.

As I was leaving the hotel where the program was held, someone approached me and said, “I listened to your talk!” He paused. I was unsure whether to answer with “Thanks!” Before I could respond, the person then said, “Your thesis was interesting. You are obviously a Malthusian; a “Club of Romer” or a classic chronic believer in shortages!”

I knew then that my message had been totally missed. My talk never made any reference to any form of shortages. I was merely warning that era of the vast energy excesses was almost gone. In an attempt to put my talk into more simplistic language, I responded “No. In fact, I am not a Malthusian at all, I am an Agrarian. I study cycles of commodities. Most happen to be agricultural. The patterns are always the same. Demand for a particular crop ends up growing too fast. Supplies then get short and the price soars. The farmer quickens his planting cycle to capture these high prices just as demand is starting to fall due to being too high. This creates a larger glut. Prices then plunge. The farmer stops planting. As supplies then dwindle, low prices begin to stimulate demand. As a result, commodities swing back and forth, rocketing from peak to bottom and back to peak. It happens to virtually all agricultural products."

I continued, "the only difference between agriculture and energy is that it takes a few months to plant wheat compared to around seven years to plant and then harvest a new energy field. So the cycles are simply longer! Therefore, ten years from now, all you guys will be discussing the likelihood of $200 oil just as demand is dropping and supplies are on the rise!"

I was quite pleased with this quick response and thought it also captured the essence of what I had tried to tell this skeptical audience earlier that afternoon. But the person to whom I delivered this impeccable logic merely responded, "I'll be damned, I could have sworn you were a classic Malthusian!" and then walked away.

Through this humorous exchange, I was accidentally introduced to the whole Club of Rome notion. While I vaguely remember hearing about the work in the early 1970's, before this Dallas encounter, I had never focused on what it was all about.

Since becoming aware of this Club of Rome work in 1994, I continually hear the "Club of Rome" shortage thesis raised by various energy economists who thoroughly condemn the work as being absolutely wrong. But I have never given any thought to what the Club of Rome's specific predictions actually were, nor have I ever known who this "mysterious" Club plotting the end of the world even was.

The primary reason I have never pursued more knowledge about this work is that I have never subscribed to the theory of the world ever encountering a permanent energy shortage. "Running out of oil" has never borne any relationship to my growing concern over the past decade that "not all is well in the energy world."

My energy worries have always centered on the simple prospect that demand could some day start outstripping supply. This is a totally different problem than running out of energy. Both are definite problems, they merely address different issues.

The two problems actually bear no relation to one another. Running short of daily supply is a little like food and famine. The world has never run out of food, yet we have suffered regional famines since the beginning of time. These are merely logistical distribution problems.

My curiosity about what the Club of Rome actually predicted in this The Limits to Growth book was triggered this past spring after hearing a talk by James Wolfenson, head of the World Bank, at a Global Harvard Business School Conference in Berlin. Mr. Wolfenson gave the keynote opening address to a group of 1200 HBS alumni from around the world, gathered to discuss "A World Without Walls: The Challenges of a Global Economy."

His talk focused on the acute need for the affluent population of the globe to never overlook or forget the less fortunate parts of the world. As he eloquently stated, there are only 1.2 billion people now living in the highly developed countries of the world. 250 million are in the United States, 500 million living in the expanded Europe and 350 million in Canada, Mexico and the Pacific Rim countries of the OECD. For this group, affluence is not only on the rise, it has also never been better.

But Mr. Wolfenson then warned of the risks inherent by overlooking the 4.8 billion people living in the less developed or transition economies of the world. An astonishing 2 billion of these people live on less than $2 a day! One billion live on less than $1 a day! Abject poverty abounds throughout these less fortunate countries. In our modern global society, with global telecommunication, Mr. Wolfenson warned that it is not reasonable to even think that we can maintain this great gap between the well to do and the impoverished for another 50 years.

In Wolfenson's opinion, the great challenge of the next several decades is to narrow this prosperity gap. Doing this will not be an easy task. But it must be done.

As I heard these grim statistics, it forced me to re-think an in-depth research I did in the summer of 1997 on the "Insatiable Energy needs of China."[1]

[1] China's Insatiable Energy Needs white paper published by Matthew R. Simmons in August 1997.

The prime conclusion I reached after doing this China research which entailed an extensive analysis of what happens to energy use when a poor country begins to prosper, is that energy growth always goes hand in hand with countries switching from being poor to becoming even slightly affluent.

As I finished this China study, it left me wondering whether the world really had the sufficient resource base to allow China to achieve its dream of economic success. From the work I did on per capita energy use, if China ever becomes the equivalent of Japan in 1960, let alone finally convert its vast body of people to the prosperity of the United States today, this transition would consume so much energy that it raises the question of whether such added energy really exists. At the least, it would strain the world's energy resources to its limits.

Within months of finishing the China Energy Report, the Asian 'flu invaded the world. Suddenly, the notion of China (or any Asian country) continuing to grow began to seem remote. So I unintentionally forgot the primary conclusions of this China study.

On my way back from Berlin, I kept thinking about the implications of the poor population of the globe finally becoming normal citizens of the world. This led me to muse about the whole Club of Rome issue. The more I mused, the more I began to wonder whether this group might have been correct in their concerns after all. Perhaps they were only wrong in their timing by 30 to 50 years. Or perhaps this group envisioned that by 2000, the world would have closed the gap between the rich and the poor, thus creating the shortages which their report warned would occur.

As soon as I returned to the U.S., I had our librarian find a copy of the book which the Club of Rome produced almost 30 years ago.

WHAT THE LIMITS TO GROWTH ACTUALLY SAID

After reading "The Limits to Growth," I was amazed. Nowhere in the book was there any mention about running out of *anything* by 2000. Instead, the book's concern was entirely focused on what the world might look like 100 years later. There was not one sentence or even a single word written about an oil shortage, or limit to any specific resource, by the year 2000.

The members of the "Club or Rome" were also not a mysterious, sinister, anonymous group of doomsayers. Rather, they were a group of 30 thoughtful, public spirited-intellects from ten different countries. The group included scientists, economists, educators, and industrialists. They met at the instigation of Dr. Aurelia Peccei, an Italian industrialist affiliated with Fiat and Olivetti.

The group all shared a common concern that mankind faced a future predicament of grave complexity, caused by a series of interrelated problems that traditional institutions and policy would not be able to cope with the issues, let alone come to grips with their full context. A core thesis of their work was that long term exponential growth was easy to overlook. Human nature leads people to innocently presume growth rates are linear. The book then postulated that if a continuation of the exponential growth of the seventies began in the world's population, its industrial output, agricultural and natural resource consumption and the pollution produced by all of the above, would result in severe constraints on all known global resources by 2050 to 2070.

The genesis of this book was a series of early meetings being held by The Club of Rome in 1968. These meetings culminated in a decision to initiate a remarkably ambitious undertaking. The task was to examine the complex problems troubling "men of all nations; poverty in the midst of plenty, degradation of the environment, loss of faith in institutions, uncontrolled urban spread, etc."

"Phase One" of the project of the predicament of mankind took shape in 1970. The group commissioned a team of Economic Modelers at MIT to forecast, in approximate terms, what pressures the globe would undergo if the current growth trends continued for another 100 years. This research was financed by the Volkswagen Foundation.

At the time, the technique of conducting computer based integrated modeling was quite new. The technique was called "System Dynamics", where various inter-related elements and positive and negative feedback loops influence the various ingredients and outputs of the model.

The initial results of this modeling work were sufficiently alarming that Club of Rome participants decided to publish them, and call the book The Limits to Growth. The book was published by Potomac Associates, a non-partisan research and analysis organization seeking to encourage lively inquiry into critical issues of public policy.

The book painstakingly acknowledged that the model's work was still "preliminary." Much more detailed analysis was needed to hone in on the issues this model raised. The decision to publish the results, as rough as they were, was driven by a desire to quickly get the issues into the public domain. This would hopefully command critical attention to the work and spark debate in all societies about the changes needed to avoid the catastrophic elements that the model indicated would occur by 2070, absent any changes.

While many readers concocted various “imaginary” assumptions, the book’s conclusions were quite simple. The first conclusion was a view that if present growth trends continued unchanged, a limit to the growth that our planet has enjoyed would be reached sometime within the next 100 years. This would then result in a sudden and uncontrollable decline in both population and industrial capacity.

The second key conclusion was that these growth trends could be altered. Moreover, if proper alterations were made, the world could establish a condition of “ecological stability” that would be sustainable **far into the future**.

The third conclusion was a view that the world could embark on this second path, but the sooner this effort started, the greater the chance would be of achieving this “ecologically stable” success.

The book, in its entirety, is beautifully written. It takes only a few hours to read. I would highly recommend it to anyone. It is an interesting mixture of simple, tried and true economic laws, combined with a terrific dose of logic. Without a doubt, there are some serious doomsday elements laid out which our world would face if the conclusions of this modeling work were ignored, and key trends continue to rise at exponential vs. linear rates. But, the book essentially lays out an optimistic outlook on how easily these limits to growth can be altered if a real effort to accomplish this is made at an early stage, rather than attempting such changes too late.

The most amazing aspect of the book is how accurate many of the basic trend extrapolation worries which ultimately give raise to the limits this book expresses still are, some 30 years later. In fact, for a work that has been derisively attacked by so many energy economists, a group whose own forecasting record has not stood the test of time very well, there was nothing that I could find in the book which has so far been even vaguely invalidated. To the contrary, the chilling warnings of how powerful exponential growth rate can be are right on track. The thesis that it is easy to misjudge this type of growth has also been proven by the volumes of misguided criticism that the report engendered.

The world is now 30 years into this 100-year view. It did grow as fast as the book warned. The gap between rich and poor never narrowed. Instead, the gap between the “haves” and the “have-nots” grew by a significant measure. It is interesting to contemplate how horrified the book’s authors would be today, given the population trends that happened post 1972. The current strain on many of our precious resources is already becoming serious. It would have been far worse by 2000, given the rate of expansion which happened to the world’s poor population, had these people also begun to significantly improve their standard of living at the same time. An accidental safety valve for many potentially scarce resources turned out to be the widening of the rich/poor gap.

THE WORLD IN 2000

We are now almost one-third of the way around The Club of Rome's 100 -year track. In 1970, the world population totaled 3.4 billion. Of this, 1.2 billion were living in "more developed" countries while 2.2 billion resided in "less-developed" countries. The rich/poor split was 35/65.

Eight of the 20 most populated countries were modern industrial societies. Their combined population totaled 787 million, which then made up 25% of the globe. Europe's "Big Four" (England, Germany, France, and Italy) had 161 million people. All ranked in the top 20.

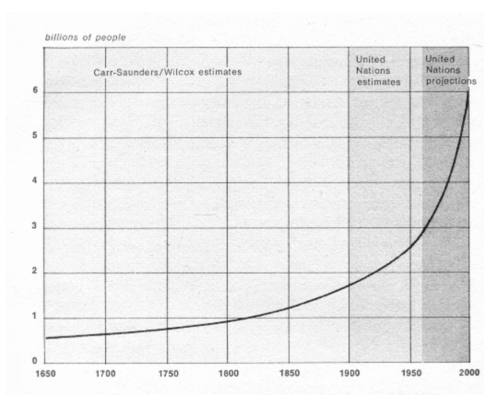
Three decades later, the world's total population approximates 6.4 billion. Given the inaccurate census data for many fast growing poor countries of the world, it could be even higher. The population growth of Europe's Big Four was one of the slowest in the world. Yet, even these countries grew by 61% to 260 million. However, three of the Big Four now rank outside the top twenty as various much faster-growing poor countries have taken their place.

In 2000, the population of China and India alone are the size of the entire less developed population of the globe 30 years ago. In three decades, the rich/poor gap has widened from 35/65 to 20/80! Since all the poor populations of the globe are expanding fast, this gap is likely to grow even wider as the remaining 70 years of the Club's timeframes unwind, unless measures are quickly taken to change this alarming trend.

The text in The Limits to Growth mentioned the possibility that global population might total 7 billion by the turn of the Century. The book also contained a graph showing the exponential growth of the world since 1690. According to this trendline, the world population would reach 6 billion in 2000 (see Exhibit 1.)

EXHIBIT 1

World Population



Source: The Limits To Growth by Donella H. Meadows/Dennis L. Meadows and Jørgen Randers/William W. Behrens III.

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The most up-to-date U.S. Census Bureau estimate for the actual world's population in 2000 is 6.4 billion, almost equi-distant between these two estimated numbers. (Since the quality and accuracy of the data for the fastest growing regions of the world could easily be off by 10 to 15%, with any error likely to be understating the real total, we might be a lot closer to 7 billion then anyone knows.)

The birth rates in many affluent countries steadily fell over the past thirty years while China enacted its one-child policy. Otherwise, the world population would already be about 2.3 billion higher than it is today.

Pakistan and Bangladesh are the poorest countries on the globe. In 1970, they ranked 9th and 10th as the highest populated countries on earth with 132 million people. Thirty years later, these two impoverished countries have both notched up, ranking number seven and eight in the world with a combined population of almost 300 million people, greater than the USA. Over the past three decades, both these countries have virtually become the poster children of the poorer countries of the globe.

The book detailed the economic and population growth rates for 10 countries in 1968 and how this translated into a GNP per capita in each country. The report then used simple arithmetic to calculate extrapolated values for GNP per capita from 1968 to the year 2000. While their text states, “the values shown… will almost certainly not actually be realized. They are not predictions. The values merely indicate where the general direction of our system, as it is currently structured, is taking us. The report demonstrated that the process of economic growth, as it is occurring today, is inexorably widening the absolute gap between the rich and the poor nations of the world.“ Exhibit 2 and 3 detail the 1968 data and the extrapolated GDP to 2000.

EXHIBIT 2

Economic And Population Growth Rates

Country	Population (1968) (Million)	Average Annual Growth Rate Of Population (1961-68) (% Per Year)	GNP Per Capita (1968) (U.S. Dollars)	Average Annual Growth Rate Of GNP Per Capita (1961-68) (% Per Year)
People’s Republic Of China	730	1.5	90	0.3
India	524	2.5	100	1.0
USSR	238	1.3	1,100	5.8
U.S.	201	1.4	3,980	3.4
Pakistan	123	2.6	100	3.1
Indonesia	113	2.4	100	0.8
Japan	101	1.0	1,190	9.9
Brazil	88	3.0	250	1.6
Nigeria	63	2.4	70	0.3
Federal Republic Of Germany	60	1.0	1,970	3.4

Source: The Limits To Growth by Donella H. Meadows/Dennis L. Meadows and Jørgen Randers/William W. Behrens III.

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EXHIBIT 3

Extrapolated GNP For The Year 2000

Country	GNP Per Capita (In U.S. Dollars[1])
People's Republic Of China	100
India	140
USSR	6,330
U.S.	11,000
Pakistan	250
Indonesia	130
Japan	23,200
Brazil	440
Nigeria	60
Federal Republic Of Germany	5,850

Source: The Limits To Growth by Donella H. Meadows/Dennis L. Meadows and Jørgen Randers/William W. Behrens III.

[1] Based on the 1968 dollar with no allowance for

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While the authors themselves failed to appreciate the power of combining the extrapolated population growth with industrial growth, it is remarkable to look at how these numbers finally turned out. 2000 is no longer a forecast, it is here. As detailed in the following Exhibits IV, several countries' actual per capita GNP were, in fact, ahead of the extrapolations detailed in The Limits to Growth. On balance, the ten countries came close to meeting a projection which the authors of The Limits to Growth did not think could really happen in just 30 years.

As the authors of The Limits to Growth so plainly said three decades ago, exponential growth rates can be very powerful. They can create growth curves which suddenly mushroom, as 3% increments of small numbers suddenly become a 3% increase of a much larger base. This mushroom growth can quickly become almost overwhelming until powerful forces of physical limits, the finally unseen consequences of such growth rates, suddenly appear "out of nowhere", bring these trends to an abrupt halt.

EXHIBIT 4

Comparison Of Extrapolated 2000 Per Capita GNP To 1999 Actual GNP

	In 1968 U.S. Dollars	
	Extrapolated Estimate	1999 Actual
China	100	240
India	140	112
U.S.	11,000	9,080
Pakistan	250	110
Indonesia	130	210
Japan	23,200	9,700
Brazil	440	900
Nigeria	60	100
Germany	5,850	6,806

Note: USSR not used since dissolution makes numbers difficult to get accurate comparability.

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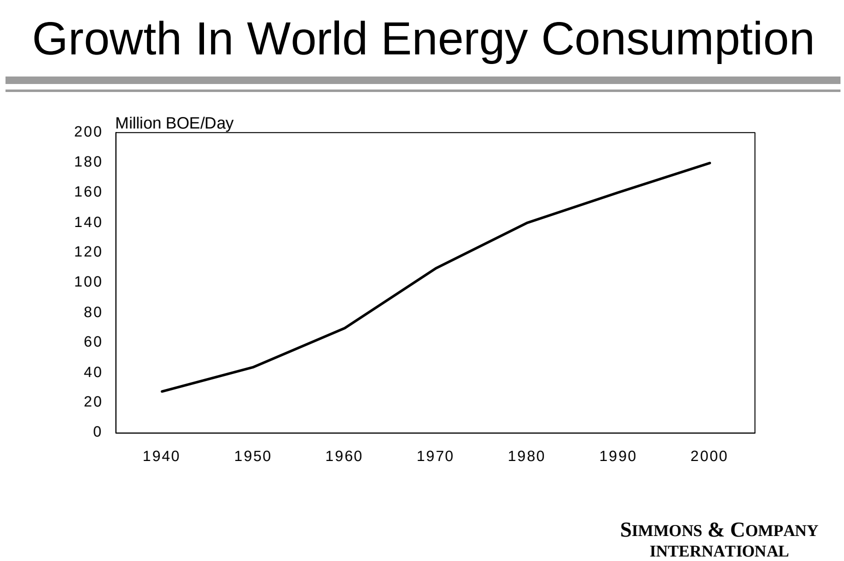
From an energy perspective, the world was consuming 111 million barrels of oil equivalent (BOE) per day in 1970 as The Limits to Growth was being written. The world's energy growth had already soared from under 30 million BOE in 1940 to 67 million BOE in 1960 and almost doubled that in another 10-years. By 1980, energy growth totaled 147 million BOE per day, in 1990 it reached 164 million BOE per day and is fast approaching 180 million BOE per day in 2000. Table 1 below illustrates this growth.

TABLE 1



While the world has clearly not run out of energy by 2000, this past energy consumption growth occurred while the FSU, third largest energy user on earth in 1970, ultimately collapsed, with its energy use falling by one-third over the past decade. Had the FSU continued its consumption growth of the 1980's, the world would be approaching a daily energy consumption of 200 million BOE per day as we enter a new century.

As shown in Exhibit 5, many of the developing countries had growth rates between 3% and 6% over the past 30 years and many of these countries still barely use any energy in per capita terms, relative to the prospering parts of the world. Had the gap between the rich and the poor narrowed over the past 30 years, and the FSU prospered at the same time, the world could have easily reached an energy consumption rate of between 220 to 240 million BOE per day by 2000, assuming such vast energy additions could have been supplied.

EXHIBIT 5

Primary Energy Consumption

(Million tons of energy in barrel of oil equivalent)

Country	1972	1980	1990	1999	CGR
North America	1,948	2,419	2,133	2,432	+ 0.08%
Latin America	126	341	369	497	+ 3.0%
Europe	1,523	169	1,741	1,801	+ 0.6%
Middle East	79	117	254	380	+ 6.0%
Africa	96	164	206	261	+ 3.8%
Japan	311	360	428	507	+ 1.8%
Australia	64	86	101	117	+ 2.3%
Asia	214	338	551	878	+ 5.4%
China	335	453	668	753	+ 3.1%
USSR	837	1,169	1,398	908	0.3%
Total	5,631	6,904	7,856	8,534	1.6%
Million BOE/Day	117	144	164	178	

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Given the massive increase in total energy use that actually occurred in just 30 years, it is also enlightening to examine the world's energy mix over this same period. Exhibit VI details the various components of the world's energy mix in 1972, 1980, 1990, and 1999. Oil use fell from 46% of total energy use in 1972 to 41% in 1999, but almost this entire decline happened between 1972 and 1980, as the price of oil grew ten-fold. Since then, oil has remained in a relatively stable band.

EXHIBIT 6

World Energy Mix

	1972	1980	1990	1999
Petroleum	46%	43%	40%	41%
Natural Gas	19%	19%	23%	24%
Total Hydrocarbon	65%	62%	63%	65%
Coal	29%	29%	28%	25%
Nuclear	0.7%	3%	7%	8%
Hydro	0.6%	6%	2%	2%
Total	100%	100%	100%	100%

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Natural gas use increased from 19% in 1972 to 24% in 1999, coal fell from 29% to 25%. Nuclear had an explosive growth, as this new energy source was just being introduced in 1972. By the end of the 20^{th} Century, nuclear comprised 8% of the world's total energy use. Though this affected only a handful of countries that actively pursued a nuclear energy plan as part of their long-term energy strategies.

It is also interesting to contemplate the possible strains on our oil and gas resources had nuclear not been commercialized, particularly if the gap between rich and poor been narrowed over this period of time.

Exhibit 7 details the growth in the world's petroleum use over the past 60-years as oil's use grew from just over 5 million barrels a day in 1940 to 75 million barrels a day in 2000. Since petroleum is still the only energy that creates transportation fuel, it should continue to grow well into the middle of the 21st century.

EXHIBIT 7

Worldwide Oil Consumption

	Million Bbls/Day						
	1940	1950	1960	1970	1980	1990	2000
U.S.	3.1	7.1	12.3	14.4	16.5	16.3	19.0
Canada	0.2	0.4	0.9	1.5	1.9	1.7	1.8
Western Europe	0.8	1.5	4.2	12.6	13.9	13.4	14.6
Japan	0.1	0.1	0.6	4.4	4.9	5.3	5.8
Australasia	0.1	0.2	0.3	0.7	0.8	0.8	1.0
Total "OECD"	4.3	9.3	18.3	33.6	38.0	37.5	42.2
Latin America[1]	0.3	0.9	1.7	3.5	4.6	5.0	6.6
Africa M.E.F. Asia	0.3	0.8	1.6	2.8	6.3	10.8	16.4
China	0.1	0.1	0.2	1.0	1.8	2.3	4.6
Total	0.7	1.8	3.5	7.3	12.7	18.1	27.6
USSR/Eastern Europe	0.4	0.9	2.8	7.4	10.9	9.8	5.2
Total	5.3	12.0	22.1	39.5	61.6	65.4	75.0

Source: BP Statistical Review Of Energy.

[1] Including Mexico.

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While it is staggering to see a non-renewable energy such as petroleum grow in use from 5 to 75 million barrels per day, just think what this number would have been in 2000 had the rich/poor gap of the world merely stayed at the 35/65 rate of the 1970's.

There are lots on non-energy facts and figures that highlight the remarkable progress the world made between 1970 and 2000, and how many more goods and foodstuffs we now consume.

Technology has made the greatest strides imaginable over the past 30-years, creating inventions never even dreamed of in 1970! But the number of malnourished people living below poverty lines has also soared over this same period. Globally, the net amount of land under crops is growing far more slowly than population. As the world's population grows, less renewable fresh water is available for each person. Desalinized seawater has so far kept this issue from becoming a crisis.

The role of fish in the human diet is also noteworthy. Fish have historically served as an inexpensive and widely available source of proteins and essential nutrients, including a type of fatty acid critical to the development of infant brains.

Over the past 30-years, the global fish catch has managed to remain quite stable. But much of this apparent stability came through a widespread use of aqua-culture which now provides one fish out of every three the world now consumes. Meanwhile, the composition of the wold fish catch is steadily shifting to smaller and less appetizing fish. Some high protein species already seem headed for commercial or even biological extinction.

So the world made it safely though the end of the 20th century. But various signs in all the trouble areas which The Limits to Growth spoke of are not terribly comforting to a premise that the world can safely glide through another 30 years, let alone to 2050 or 2070.

The most profound message which The Club of Rome passionately urged people to consider is the power of this type of exponential growth and the danger of the gap that existed between the world's rich and poor. That message is still alive and well. On September 26, 2000, the World Bank's top economists issued yet another warning of the urgent need to begin reducing what used to be a rich/poor gap but has now evolved into a rich/poor gulf.

According to these economists, while the global economy grew by 2.3% a year between 1965 and 1990, the gap between rich and poor countries is **10 TIMES** wider than what it was 30 years ago. Both were measured in per capita terms, and the gap between rich and poor is also growing within many affluent countries.

Why is this message so mute to so many? Will it take a hasty wake-up call to finally create the meaningful questioning of how this enigma is solved? The Club of Rome got the whole picture right. It was the rest of us who missed the mark!

THE BOOK AND ITS CONTROVERSY

Why did this book become so controversial and why do so many articulate and seemingly knowledgeable people still lash out at its content as being wrong, when in fact, all the major conclusions are precisely on track? So far, not a single observed trend has emerged to allay the worries and concerns laid out by the Club of Rome. Why was the book greeted with such a firestorm of criticism, instead of invoking the thoughtful debate which the authors so hoped would occur?

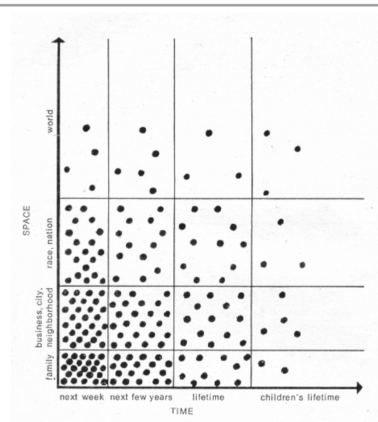
I can only surmise at some answers, as I had never followed the debate over the course of so many years.

My guess at the answer lies in two areas: First, it is a natural part of human nature to ignore the impact of events whose consequences fall far into the future. The here and now dominates the way most people naturally think. If a seer wandered into a town predicting a massive flood a decade from now, and the next summer turned out to be particularly dry and arid, it is human nature to belittle the seer as being wrong, ignoring the fact that his prediction was still nine years hence. This human nature phenomenon used to be cartooned in an advertisement run by New England Life. The ad showed two gentlemen at a prestigious men's club, with brandy in hand. One asks, "Why would anyone want to buy life insurance?" As this question is raised, a massive bull moose trophy had already fallen from the club's wall and was only inches away from crashing onto the questioner's head! We are brought up to think that cause and effect has immediacy to it. Human nature is not good at coping with time-delayed reactions, particularly when the delay is possibly decades away.

The authors of <u>The Limits to Growth</u> deal with this phenomenon of short-term focus through a graph depicted in Exhibit 8.

<u>EXHIBIT 8</u>

Human Perspectives



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It shows the relationship between "time" and "space". In the lower left-hand corner, family represents the closest limit for space, while "one week" being the closest limit for time. The furthest right hand quadrants represent the world for space and 100 years for time. The author's contention is that almost everyone is preoccupied by short limits in both space and time (e.g. what will I eat today?) Few ever think about what could happen to the entire world in far distant periods of time. It was the upper right hand corner of space and time that the authors addressed. It seems clear that few readers of the book focused on this global view and lengthy time. Instead, they read into the book a different message, letting imagination drift back to the lower left corner of this graph.

A major event then fueled further confusion about the real issues of the book. The Limits to Growth ended up being published shortly before the world experienced the Oil Shock of 1973. In the ensuing panic that the 1973 Oil Crisis brought forth, the "100-year" message that the authors of this book tried to warn about (so that meaningful changes in population growth and industrial consumption might begin in order to avoid the dangers implied by this work far into the future) got blurred into an immediate panic that a tiny blip in oil supplies was possibly the arrival of such shortages, some 100 years earlier than this “mysterious” or even clandestine Club of Rome was trying to discuss.

My other guess is that some of the worst and most vocal critics of this book were people who most passionately embraced the concept of immediate shortages facing the world through the 1970’s. After all, by 1980 there were many prominent energy analysts who stridently embraced the idea that $50 to $100 oil was almost inevitable. When these high prices then failed to materialize, and as the gap between slipping demand and rising supply created an oil “bubble”, this enabled oil prices to stay within a $15 to $20 per barrel range for the better part of two decades, the embarrassment of being wrong turned the whole group of energy experts into angry critics of The Limits to Growth and passionate believers that prices would stay low forever. It must have been easy to shift part of the blame for why they had been so wrong to the stupidity of The Club of Rome. This is my equivalent of blaming the bartender for a hangover!

Sadly, the dialogue and increased in-depth analysis that The Club of Rome so hoped would begin as a result of their publication never occurred in the face of growing criticism. Phase One of the “predicament of mankind” accidentally became the final chapter of this thesis. As the discredit of this work grew, few even took time to measure the pace of change. Even fewer remembered the real message of the book.

The Club of Rome still exists. It did not "wither away," although its own web site acknowledges that most people assume it ceased to function after the death of its charismatic founder, Aurelio Peccei, in 1984. It ended up commissioning more than a dozen other reports, since Limits was first published; though, none ever attracted the widespread attention of The Limits of Growth.

Membership to The Club of Rome is still limited to one hundred members. Meetings are still held at the invitation of its members. Its most recent report was published in 1995 and dealt with the world's unemployment dilemma. "Interim" reports on the problems of governability or the lack thereof and on the global warming problem were presented at its last "annual meeting" held in Puerto Rico in 1996.

So the Club is intact, but the passionate concerns spelled out by The Limits to Growth have clearly cooled. Lost in time is whether the issues raised in 1972, creating such intense debate when finally published, were actually correct and lurk as an unseen but smoldering ember.

EXTRAPOLATING THE WORLD BEYOND 2000

30 years have now elapsed since the original research of the book was first done. The world is now 30% of the way towards the doomsday scenario depicted by trend-lining the extrapolated growth of the previous 100 years. As the book accurately predicted, population growth expanded. This was almost inevitable as most parents of 2000 were already born when the book was first written.

What can we infer about the state of the world over the next 30 years from continuing this extrapolating exercise? Is it realistic to assume that the gap between the rich and poor will never narrow? Could the world remain at peace if the gap never narrows or even widens? And, if it does narrow, as the World Bank head warned must occur to keep the world prosperous and peaceful, are we really certain that the world has sufficient resources in place to accommodate such changes?

These are the issues that should now be dominating the think tank discussions of the world's public policy planners. At least the energy aspects these issues raise deserve close examination. To extend the analyses embodied in The Limits to Growth out another 30 to 50 years no longer takes a supercomputer. Any hand held calculator can now do compounding growth rates. When a simple extrapolation in the growth trends for population, industrial activity, consumption of both agricultural and natural resources and the resultant pollution is done, the alarms raised are more discomforting today, with the benefit of an added 30 years, than the authors of The Limits to Growth contended three decades ago.

However, we still have “70-years” to go before the 2070 limit, which the MIT model suggested was an end to more growth, is reached. Perhaps it is irrelevant that all the mileposts raised as red flags in The Limits to Growth have so far been met. After all, there is ample time to correct any seriously dangerous trend. Correct?

In the book’s chapter defining the deceptive powers of exponential growth and the apparent suddenness with which it approaches a fixed limit, the authors describe the French Riddle of the Lily Pond. In this riddle, the lily pond has a potentially virulent lily that apparently will double in size each day. If the lily grows unchecked it will cover the entire pond in 30 days, choking off all other forms of life in the water by the time it covers the entire pond. If a skeptic waited until 50%

of the pond was covered before taking any remedial action to save the pond, when would he act? The answer: on the 29th day of the month! But by then, would be too late.

The world can debate when corrective action needs to begin, if exponential growth suddenly shows all of the classic signs of pending overshoot. But everyone should agree that waiting until the "proverbial 29th day" is a classic and unrepentable blunder of the highest order.

THE LIMITS TO ENERGY GROWTH

I have no good data or knowledge about agricultural or non-energy consumption data. A casual reading of the possible future limits to water, arable land, fish stocks, etc. causes one to question how the world could even cope with continued population growth an a narrowing of the rich/poor gap.

But simply focussing on the energy issues which should concern the world argues that the world probably cannot wait another 30 years to begin pondering whether we could begin to experience problems and sheer limits to non-renewal energy consumption. The lead times for any corrective actions or alternative energy alternatives are simply too great.

Take the energy needs of China as an example of the problem. This giant population pool is struggling to remove the shackles of poverty suffered throughout the 20th Century. There is a case to be made that by 2030, or at least by 2050, China could become the Japanese Miracle of 1960, or even what Japan is like today. At the least, China could become the equivalent of a Thailand, Greece or Turkey today.

If such a transformation were to take place, are the world's resources sufficient for this miracle to safely occur?

The arithmetic is easy to do. Over the past 30 years, China's population has grown from 850 million people to 1.25 billion. Extrapolate this growth to 2030 and there will be almost 2 billion people. If China climbs the ladder from near poverty today to even the lowest end of the OECD countries' energy consumption, this means that China's energy consumption would grow more than six-fold to over 100 million BOE per day, or two-thirds of the entire world's total energy use today.

If China's population nears 2 billion by 2030, and China retains its current energy mix, where almost 75% comes from using a particularly dirty coal, its coal usage would increase to a level 50% greater than all the coal now consumed by the entire world! The implied pollution this would create is precisely the type of pollution dangers implied by the Club of Rome 30 years ago. Since China's enormous coal usage already irritates eyes throughout Japan when the winds blow eastwards, using so much added coal could literally darken Asian skies.

If China weans itself meaningfully from its high rate of coal use, and simultaneously improves its economy, the growth this implies for added consumption of oil and gas is simply staggering. Even the most avid "cheap oil forever" advocates would have a hard time convincing themselves that such an explosive growth could really happen. This is a classic example of System Dynamics working as they should.

If India also made a similar climb up the ladder of economic success, the numbers for added energy use would rocket off the charts. But China and India are but two of many countries that still qualify as genuine "energy pigmies."

Exhibit 9 shows the power of energy extrapolation from seven of the leading countries that qualify as "energy pigmies." The seven include China, India, Indonesia, Pakistan, Bangladesh, Philippines and Egypt. In 1970, the population of these seven countries was 1.7 billion. In 2000, they now represent 2.9 billion people. Their total energy consumption now totals 25.4 million BOE per day. While this is a lot of sheer energy volume, it amounts to a miniscule 3.2 barrels of oil equivalent energy per capita each year, one thirtieth of what the U.S. now consumes.

EXHIBIT 9

Impact Of Seven “Energy Pigmy” Countries

	2000		Extrapolated Growth At 2030[1]				
			Popultaion				
	Population (Millions)	Energy Consumption (Million BOE/D)	Growth Rate	People In 2030	Energy Growth Rate	Per Capita	Total BOE/Day
China	1,262	15,680	1.5%	1,942	0.2%	4.8	25,540
India	1,014	5,750	2.0%	1,853	2.8%	4.8	24,370
Indonesia	224	1,670	2.0%	406	3.6%	7.8	8,680
Pakistan	141	770	2.6%	305	2.9%	4.7	3,930
Bangladesh	123	210	2.2%	236	1.8%	1.0	650
Phillipines	81	460	2.5%	170	3.4%	5.7	2,650
Egypt	68	900	2.3%	135	1.3%	7.1	2,630
Total	2,913	25,440		5,047			68,450

[1] Expotated growth in 2030 uses 1970 through 2000 growth in population to 1970 through 2000 growth in per capita energy consumption.

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If the 1970-2000 growth in population for each of these pigmy countries is extrapolated to 2030, the population of these seven “pigmies” will exceed 5 billion. If their growth in per capita energy use from 1970 to 2000 is also extended to 2030, these seven countries, alone, would consume an additional 68 million barrels of oil equivalent energy per day. More staggering is the thought that such growth could take place and still leave these energy pigmies on an energy diet of under 5 barrels of oil equivalent per year. This would leave these countries at only one-quarter of the low end of the OECD energy use in 2000.

To fully appreciate the magnitude of what the Limits of Growth authors called "a classic over shoot – where growth finally and suddenly overwhelms the system," simply assume that by some economic miracle, these seven energy pigmies find a way to all become the equivalent of the least prosperous countries of the OECD today (which consume around 20 BOE energy on a per capita basis in 2000.) This change, alone, would equate to over 100 million BOE per day of energy consumption in 2030, almost one half of what the entire world now uses.

Nigeria is another classic example of a 21st century energy pigmy. Its statistics were excluded from my "group of seven" simply due to limited data on Nigeria's energy use over the past 30 years. But, good statistics exist for Nigeria's current energy needs.

As Africa's largest country, Nigeria has seen its population grow from 51 million in 1970 to 123 million today. Despite it's size, Nigeria's current total energy consumption is less than 500,000 BOE per day. This equates to a meager 1.3 BOE per person each year. Despite producing close to 2 million barrels of oil per day, the country is mired in poverty. It faces a serious energy crisis due to declining electricity generation. Its total installed electrical generating capacity is less than 1% of that of the United States. But in July 2000, only 25% of this tiny power capacity even worked. The balance is in a chronic state of disrepair.

If Nigeria finally turned its economy around, like so many other role models have done over the past 50 years, the exponential energy needs of just this one country are profound.

Here is how Nigeria's numbers work. Assume that Nigeria's past 30-year population growth continues for another 30 years. By 2030, Nigeria would have 300 million people. If its GDP and energy use grew to what Mexico now enjoys (10 BOE per capita in 1999), Nigeria's energy consumption would grow by almost 20 fold to over 8 million BOE per day.

These numbers also highlight the possible export squeeze which many major energy exporters could face if their populations continue to grow while their GDP improves.

Nigeria's total economy is now fueled by its oil and natural gas exports. For these exports to remain static, Nigeria's oil and gas output would have to rise almost five-fold in the next 30 years. A handful of other oil producers have been able to experience such meteoric production growth, but they all started with an insignificant base. Since Nigeria is now one of the ten top energy producers in the world, the likelihood of them quintupling their current output has to be a genuine stretch. More likely is a scenario where rapid increases in the country's prosperity finally turns the country from being a major energy exporter to a net energy importer, as China suddenly experienced over the past decade.

Nigeria is not the only big energy exporter facing this same risk. This issue could become a problem for the entire group of OPEC producers. All have seen dramatic growth in their population. In 1970, the OPEC countries' population totaled 245 million. By 2000, their population grew to 524 million. If each country's 30-year population growth is extrapolated to 2030, these countries will support over 1.1 billion people. Exhibit 10 details the population growth of the OPEC producers from 1970 through 2000 and the population demographics which an extrapolation of these growth rates produces by 2030.

The implications of this explosive population growth creates an interesting future energy dilemma. Focus on just one of the OPEC countries as a classic illustration of some possible limits to future growth.

EXHIBIT 10

OPEC Countries' Population Growth

Country	1970	1980	1990	2000	Extrapolated Population In 2030
	In Millions Of People				
Indonesia	123	155	189	225	412
Nigeria	51	70	92	123	297
Iran	29	39	56	66	150
Algeria	14	19	25	31	69
Venezuela	10	15	19	24	58
Iraq	9	13	18	24	64
Saudi Arabia	6	10	15	22	81
Libya	2	3	4	5	13
Kuwait	1	1	2	2	6
UAE	--	1	2	2	7
Total	245	326	422	524	1,157

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Saudi Arabia had only 6 million people in 1970. By 2000, their population grew to 22 million. 43% of Saudi Arabia's 22 million people are 14 years old **or less**. The country's fertility rate is 6.3 children per female. If these trends continue, Saudi will have 45 to 50 million people by the year 2030. If Saudi Arabia's population growth from 1970 to 2000 continues unabated, the country will have 80 million people by 2030. On the surface, these numbers sound impossible but they merely highlight how hard it is to gauge exponential rather than linear rates of growth.

Most people still think Saudi Arabia is a very rich country. To the contrary, its economy is now in shambles as a result of the population explosion which has already occurred. The July 2000 Foreign Affairs had an article highlighting the social and financial pressures already facing this key energy supplier entitled "Saudi Arabia Over a Barrel". Saudi's domestic debt in 2000 already exceeds more than 100 percent of its GDP. Its budget deficit in 1998, when oil prices collapsed, was nearly 11% of its GDP. Saudi's 2000 budget has government expenditures growing by 12%, so even considerably higher oil prices will still produce a deficit forecast at 15% of total budget.

Major Saudi cities routinely experience regular power brownouts in the summer months, and the desalinization plant in Jiddah, the country's second largest city, cannot keep up with water demand.

If Saudi modernizes its economy to a level which the United States now enjoys, its increased electricity needs would propel its internal energy use from just over 2.1 million BOE per day to over 12 million BOE per day by 2030. If Saudi's 50 (to possibly 80) million people also want to drive, the oil consumption this implies makes it far-fetched to think that Saudi could also continue to be the rest of the world's swing oil producer too. I suspect the demographic numbers for Saudi Arabia would truly shock the authors of The Limits to Growth. But these numbers are real facts and the future they portend is profound from an energy perspective.

Saudi's demographics are not an exception to the rest of the OPEC countries. A careful analysis of the OPEC countries' population, their current electricity use (as a proxy for total energy use) and the age and "fertility" rate for each country portrays the possible energy squeeze the world could experience if the population of these countries continues to grow and eventually narrow the gap between the rich and the poor. Exhibit 11 details this data.

With the exception of Kuwait and the United Arab Emirates, every OPEC producer has a far lower GDP per capita than any of the prosperous countries of the OECD. Many still have 25 to 50% of their population living below the poverty line. Their average electricity use per capita is only 15% to 20% of what the U.S. now enjoys.

All of these countries have a burgeoning population of people under 14 years old, and their senior citizens (those older than 65) make up only 2% to 5% of the population base. Many of the countries also have a current "fertility rate" of 3 to 6 children per female.

Exhibit 11

OPEC'S Population & Energy Demographics

Country	Population (1988)	GDP	Per Capita	Population Below Poverty (%)	Electricity Consumption	Electricity Use	Population Under 14 Years	Population Over 65 Years	Fertility
Algeria	31.0	140	4,600	23	18.5	N/A	37%	4%	3.3
Libya	5.0	38	6,700	N/A	17	3.4	36%	4%	3.8
Iran	65.0	339	5,000	53	80	1.2	36%	4%	2.5
Iraq	22.0	52	2,400	N/A	28	1.3	44%	3%	5.1
Kuwait	2.0	44	22,700	N/A	23	11.5	32%	2%	3.2
Nigeria	114.0	106	966	34	14	0.1	45%	3%	6.0
Qatar	0.7	12	17,100	N/A	5	7.1	27%	2%	3.4
Saudi	21.5	186	9,000	N/A	95	4.4	43%	3%	6.3
UAE	2.3	40	17,400	N/A	18	7.8	31%	2%	3.5
Venezuela	22.0	195	8,500	31	73	3.3	33%	5%	2.6
Indonesia	216.0	602	2,830	N/A	67	0.3	30%	5%	2.6
Equador	12.0	59	4,800	35	8	0.7	35%	5%	2.6

Source: U.S. Energy Information Agency.

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What these numbers suggest is that some, or possibly all, OPEC producers might end up consuming all of the energy they now export, even if they vastly increase their respective energy supplies. Some of these countries will undoubtedly switch from being energy exporters to becoming energy importers, assuming some other countries end up with enough spare capacity to still be an energy exporter by 2030!

Is this OPEC scenario a mere fantasy or a “sky is falling” scare tactic? Only time will tell. But it must be highly unrealistic to assume that another 30-years could elapse with these struggling countries continuing to supply the rest of the world with precious energy whilst also still being mired in poverty.

If OPEC’s internal energy use gradually erodes its ability to export, this raises an extremely serious energy question. Could the rest of the world ever find a substitute from anywhere else?

Might the world find a host of other countries that become the “OPEC’s” of 2020 to 2050? Will new forms of energy easily substitute this lost supply? Or, will the rest of the world become far more energy efficient by the time these changes occur? Again, only time will finally tell the real story, but these are precisely the mind-boggling issues which the Club of Rome hoped would be resolved.

<u>The Limits to Growth</u> laid out in some detail how abrupt the arrival of a growth overshoot can be. Imagine the impact on the world’s energy markets if all of the OPEC producers simultaneously

became energy neutral and then potential energy importers, due merely to a combination of rapid people growth and rising per capita energy use both occurring within a similar time period.

Energy Mix and Pollution: The Ultimate Limit to Growth?

When The Limits to Growth was first written, man's concern about ecology, the environment and pollution was in its infancy. The first Earth Day was held only two year's before the book's publication. As environmental awareness grew, it remained localized to only the OECD countries for much of the past thirty years. I understand that Kazahstan's first appointed Minister of Ecology, speaking at an energy forum in late 1992, said that even the terms "environment" and "ecology" were only introduced into the Russian language in 1988.

There are still enormous gaps in our knowledge of many key pollution issues. The extent to which pollution results from run-offs into/from river flows, waste disposal from fertilizers and even from methane emissions like cows is still barely understood.

Carbon dioxide seems to be one form of pollution creating the greatest scientific concern for its potential to trap heat close to the earth's surface.

Population growth clearly enlarges the scale of carbon dioxide emission, even if per capital consumption rates of pollution emitting items around the world had peaked and were now on the decline.

Unfortunately, the opposite is the case. There is a tremendous inequity in today's global emissions. One-fifth of the world's population released over 60% of all measured carbon emissions, while a much poorer one-fifth of the globe's population released less than 2%. This tiny emission is not the result of any concise effort to curb pollution. It merely speaks to the abject poverty and miniscule industrial and energy use from a significant part of the globe, some thirty years after The Limits to Growth first raised these pollution issues.

The one area which attracts the highest level of pollution concern is the globe's energy usage. As issue which gets far less notice is the "energy mix" which each country now has and the future possible shifts in this energy mix.

The pollution impact of energy mix is at the heart of the pollutive impact of a growing population that uses more and more energy. If the wrong form of energy, like coal, for instance, comprises the bulk of all incremental energy growth, the probable impact this would have on our atmosphere, absent some remarkable technical breakthroughs in clean coal energy creation, is truly frightening.

Because this issue is so serious, it is worth examining the impact on possible future levels of energy consumption and the impact this has on pollution, given various scenarios of the world's future energy mix.

If these issues are ignored, this could end up creating a genuine crisis for mankind, which suddenly shows up in a classic "overshoot."

If any reasonable energy consumption number is calculated for the year 2030, other than a nonsensical assumption that the poor population of the globe never improves or grows in number, the resultant volumetric energy growth will be staggering. If the world is fortunate enough to find a way to actually produce such vast sums of added energy, a secondary problem emerges. The pollution created by this added energy could become overwhelming or even life-threatening.

These added energy volumes put a sharp focus on the type of energy "mix" that the world will use thirty to fifty years from now. If coal retains its current mix, absent some revolutionary improvement in the emissions that it produces, the world's atmosphere will obviously be very different than it is today. But, every percent decrease in coal use puts an added strain on the alternate barrels of oil equivalent energy that would take coal's place.

Take natural gas as a prime example since it is currently the cleanest form of energy that can now be a realistic substitute for coal. Assume no growth in energy and assume also that coal usage, which now accounts for about 40% of the world's energy source, drops by only 5% and is substituted by natural gas. This minor change would require the equivalent of almost twice as much natural gas as Canada now consumes. If the world's total energy use increases by 40 to 100 million BOE per day and coal usage drops by even 5% or 10%, the necessary natural gas supply additions this shift implies start to go haywire.

While I have never been a believer that the world will face any true energy shortages in terms of running out, as opposed to allowing daily supply fall short of daily demand, feeling comfortable that the world could actually find a way to produce two or five times more natural gas in 30 to 50 years does arouse some curiosity as to whether the reserve base is sufficient for this to happen. After all, natural gas is still a "non-renewable" resource. But these enormous volume additions are precisely what an extrapolation of some simple trends imply.

As more and more natural gas is used to supply these increases in population growth and the poor countries are fortunate enough to have meaningful GDP improvements, and as pollution forces a conversion from coal to natural gas, there must be a risk that we suddenly use so much natural gas that the world's supply literally runs out. This is not an event likely to happen in 2005 or even 2010, but if it is even remotely a risk, solving it needs to be addressed today.

The French Riddle of the Lily Pond is still alive and well. It takes decades of planning to combat not having enough environmentally friendly energy, like natural gas. If we wait until "the 29th day" when the lily has one more day's growth before finally covering the pond, coursing a different path will take place too late.

Finding solutions to this type of energy dilemma is not an easy task. No "silver bullets" exist. A simple solution is to ban further energy use. But, this naïve assumption leaves too much of the world prematurely trapped as energy pigmies. As The Limits to Growth pointed out almost 30 years ago, "One of the best indications of wealthy human population is the amount of energy consumed per person." That statement is even truer in 2000 than it was in 1972!

It is simply intolerable and totally unrealistic to ban wealth creation for the 4.8 billion people not as fortunate as the remaining 1.2 to 1.6 billion who guzzle energy at a rate of 10 to 30 times the consumption rate of the poor.

It is also naïve and even less probable that the affluent people will voluntarily decide to dramatically reduce their energy use in order to "make way" for the less fortunate to improve their lifestyles.

The Limits to Growth should have forced these thought provoking, tough questions to the forefront of current energy discussions. They are real issues with few realistic answers.

Despite all the advances in technology and knowledge between 1972 and 2000, there are no better solutions to the dilemmas posed in The Limits to Growth today than there were in 1972.

The authors of The Limits to Growth pointed to the dilemma surrounding pollution as a possible restraint to the world's growth in 1972. At that time there was a serious lack of knowledge about what the appropriate upper limits of pollution growth in the world's delicate ecological structure might be. In 1972, man's concern for the effect of this action on the natural environment was still very embryonic. Scientific attempts to measure the environmental impact of human consumption had just begun.

30 years later, the environment's debate has become far more heated. Millions of trees have been cut merely to produce the papers written about the environment! But clear, solid, scientific "proofs" for where pollution limits kick in are still unclear. Not much progress was made on defining what the genuine upper limits are to energy pollution, let alone all the other forms of pollutants created by people and expanding industrial activity. Perhaps this void is yet another fallout of the lack of the "follow-through" which The Limits to Growth authors so hoped would occur.

The only certainty in the current pollution debate seems to fall back to the improbable assumption that exponential growth can continue on its present course for quite a few more years before colliding with some immovable limits. Whether these limits occur by 2030, or even before, or whether the world can reach the 2070 timeframe, which The Limits to Growth addressed, is still unknown. Unlike the French Lily Pond Riddle, science has yet to define the equivalent of the virulent lily's growth.

From an energy perspective, there must be some practical limits to the pollution fallout from a possible doubling, tripling or even quadrupling current energy use in today's forms of energy. If the coal mix does not decline, we must face some genuine doomsday scenarios.

THE NEED FOR NEW ENERGY ALTERNATIVES

This whole topic raises the question of "what other form of energy is next?" If non-renewable energy remains "non-renewable" and if pollution emissions are a risk of material concern (particularly from coal), then the world must begin to find realistic sources of new renewable or alternative energy. We cannot wait until the non-renewable energy cupboard is either empty or too dirty to use any longer.

In 1972, The Limits to Growth authors pointed to three obvious energy alternatives: nuclear, wind and solar. At the time, each held great promise as the future for clean energy growth.

Nuclear energy became a reality. It was only an energy sliver in 1972, but by 2000, it has grown to 8% of the world's total energy use. It became the only significant new energy source "native to the 20th Century." It offered an even far cleaner way to create electricity than using natural gas.

Sadly, the era of nuclear energy seems to have "come and gone" in the blink of an eye. Less than a decade after nuclear energy was first introduced, the Three Mile Island disaster occurred. Within a year, the U.S. saw its last order placed for a new nuclear power plant. Other countries continued to expand their nuclear use. But even France, Germany and Japan, the most progressive nuclear users, are now under fierce pressure to not only drop any further expansion in nuclear use, but are also debating whether their existing base of nuclear supply should be maintained.

In the United States, not only have no new plants been ordered in over 20 years, we are now beginning to dismantle our current nuclear base. It has been decades since any blueprints have been developed for a new generation of nuclear power. Left to its current course, nuclear energy is being buried almost before it reached adolescence in the grand scope of energy time.

The final nuclear irony is that no solution was ever found to the one perplexing problem nuclear energy faced in 1972. Disposing of expended nuclear waste was an unsolved riddle when The Limits to Growth was published. It remains as serious of a riddle today. Scientists now debate how harmful expended nuclear waste might really be, but so far, there is not even any acceptable permanent burial grounds for this spent waste. Everyone seems to share a genuine "not in my backyard" concern to disposing of spent nuclear waste.

If nuclear energy has no growth role in the 21st Century, this puts an enormous focus on the other three horsemen of renewable energy: wind, water and sun. Sadly, all three have their own "Achilles' heel".

Water, i.e. hydro-electric power through building dams, is a time-tested reliable and clean form of electricity creation. However, most of the obvious dam sites in many parts of the world have already been erected. And, hydro-electric power also comes at a devastating ecological cost unless dammed water merely covers non-useable land.

In the current energy long-range planning, few new dams are even envisioned. The few that are now underway, like China's Three Gorges, are under savage environmental attack. A growing band of environmentalists are now launching a movement to begin "breaching" the current dams so fish spawning can better thrive over the next 100 years. Like nuclear, this form of energy might now start to wane.

If water like nuclear, also has no additive role to the 21st Century's energy mix, this leaves wind and solar as the remaining solutions – absent perfecting new forms of energy like fuel cells and cold fusion.

Wind and solar have been around for a long time as energy sources, even though both became ways to create electricity only a few decades ago. Despite a lengthy period of research, both have severe limits to creating any sizeable energy output. Neither is "dispatchable," a term used in electricity circles to connote the ability to turn on a generator when energy is needed and then immediately send the required energy to an energy consumer. Both are extremely costly on a Btu of energy equivalent. Neither has been able to "scale" to a level to create meaningful energy pools.

Since the sun does not always shine, nor the winds always blow, their dispatch will remain irregular until a technology to store massive amounts of electricity is created. No real research into this energy need is even taking place today. Despite all the research and development poured into wind and solar energy, both remain as costly to produce as they were some 20 to

30 years ago. Some critics also claim that both wind and solar use more energy in merely building each form of power generation than either produce in a year or two. Both also bring their own form of pollution - visual, and in the case of wind, noise.

In 1999, all forms of "renewable energy" (excluding hydro) generated only one-tenth of 1% of America's electricity. Of this tiny amount, geothermal accounted for almost half. Wood, the world's oldest energy form, and waste being burned accounted for almost all the remaining renewal energy. As the 20th century came to an end, wind and solar collectively only created one-tenth of 1% of **renewable electricity** in the U.S. What this means, in simple arithmetic, is that the two "promising new energy techniques," heralded to hold such promise when The Limits to Growth was first published, still account for only **1000th of 1%** of U.S. electricity generation! To say that no progress was made in this taxing energy issue since The Limits to Growth first hit the bookstands is a colossal understatement.

There is always hope that a totally new form of energy becomes commercial long before any sheer limits begin to curtail the world's growth. Fuel cells and cold fusion both hold great promise as breakthrough new energy forms. But neither is close to proving they work on any scale or affordable price.

Fuel cell energy is “right on our doorstep” according to some proponents of this new technology. But many questions still plague this “new technology” that was actually invented 161 years ago and was put into space over 30 years ago.

The questions involve safety, cost, **and** the sheer availability of fuel to put into the cells. Natural gas is the primary feedstock presumed to create the hydrogen to then create this new form of energy. Given the other growth pressures which natural gas faces, the availability of spare natural gas might be a foolish assumption.

Cold fusion might suddenly become a brand new energy source. But, little is yet know about how it is even formed. Since it took 30 years to commercialize the atom, after it became a viable weapon, it would be foolish for energy planners to assume something like cold fusion could be developed into something significant in a far shorter time span. It is also worth noting that even after nuclear became commercial, it took another 20 years before it grew to only 8% of the world's total energy mix.

When it comes to creating new energy, the only certainty we know, more than a century after energy technology created the combustion engine and the refinery system's ability to crack oil into finished products, along with the great strides of manufactured affordable electricity, is that only **ONE** really new energy was commercialized in 100 years. And nuclear then began dying before even reaching adolescence.

WE MUST NOW TAKE LIMITS TO ENERGY GROWTH SERIOUSLY

The population of the world is still on a projected growth path. Only widespread war or a massive plague can turn back the fast paced growth still happening in so many developing parts of the world. Hopefully, technological advances in water desalinization, agriculture and other areas of possible limits will allow the world to grow while still avoiding the Limit risks which the Club of Rome worried about some 30 years ago. But energy limits must be a genuine concern, if the rich/poor gap is finally narrowed. Whether the world can continue its current growth path and avoid a serious energy crunch, squeeze or even chronic shortages through 2010, let alone 2030, is an issue which got largely ignored over the past 30 years. Whether there is anyway to guide the world to true global prosperity by 2050 or 2070 is an issue which should now be taxing all the world's best minds.

It is clear that the skeptics and scoffers of the Club of Rome's The Limits to Growth got the real message of The Limits to Growth wrong, at least from an energy perspective. They turned out to be as wrong about The Limits to Growth as they were wrong about the entire energy picture as the 20st Century came to a close. These name-plate energy economists ended up spending too much time criticizing this work <u>and</u> attributing doomsday dates that were never even part of this written work. They then spent far too much time pontificating on how energy was gradually becoming less important to the wonders of a New Economy and would obviously cost less as time went by.

Instead of rolling up their collective sleeves to begin addressing serious energy issues, these kibitzers spent their precious hours attacking the few voices of energy sanity. Over the years, the energy economists' incorrect dismissal of this important work was not only a mistake but their criticism also turned somewhat mean-spirited and at times even shrill! What a sad conclusion for such a well-intended work to finally produce.

Lurking in the backdrop of this silly, misinformed chirping was a body of statistics, all in the public domain, that were proving that many of the key issues raised by <u>The Limits to Growth</u> were not only serious, but the magnitude of the problem was growing as the gap between the rich and the poor widened and the poor population expanded at a much faster pace than the rich.

Perhaps the ultimate irony capping all the other mistakes which too many energy planners made as the 20th Century came to an end is that the work they lambasted so viciously turned out to be true.

There is obviously no certainty that the world will really run out of any precious resource by 2030. There is also no "magic" to using 2030 as a "doomsday date." The only reason I keyed so many energy extrapolations to a 2030 date is that it doubles the timeframe already spent since The Limits to Growth was first published. If you extend the time line towards 2050 or even 2070, the dates which the MIT models found too scary, and any of the current demographic, industrialization or energy usage trends continue, the numbers this model creates are almost too overwhelming to even comprehend. The feedback mechanism described by MIT's System Dynamics Model of the early 1970's is still alive and well. Before any source of energy finally runs out, or the pollution such vast added volumes or energy use imply suddenly poisons the earth, some natural break will undoubtedly stop the economic progress which devours a precious and dwindling energy supply.

Focus on a country like Nigeria, for instance. If Nigeria's rapid use of energy suddenly transformed the country into an oil importer, the jolting impact this would likely have on its economy would probably bring its growing prosperity to a halt, reversing its internal energy consumption. Negative feedback does work. But these abrupt halts to further growth were precisely what The Limits to Growth encouraged the world to find ways to avoid.

Examine carefully the demographics of the entire Middle East and ponder how any of these countries can safely plan on being energy exporters through 2030, let alone 2050 to 2070. If these countries finally use up so much energy that they have nothing left to export, is this the "final event" which The Limits to Growth warned us about?

The Limits to Growth was never meant to be a doomsday book. Rather it was hoped that it would trigger a change in the flow of human trends to avoid such a doomsday. But, the sponsors of this project were clear that it was simply a non-starter to leave the world's wealth so unevenly distributed. They were equally clear that "short of a world effort, today's (1972) already explosive gaps and inequities will continue to grow. And the outcome of this trend can only be a disaster."

They were also clear that the closer we got to the material limits to the planet, the more difficult this problem would be to tackle. (The old French Lily Pond Riddle coming back to haunt us once more.)

These civic-minded people who sponsored the modeling work and the authors who then wrote the book were also convinced that the issues raised by The Limits to Growth had to be met by "our" generation. The problems were too serious and the correction time too long to pass these thorny issues onto a "next generation."

The book closes on a poignant note: "Our posture is one of very grave concern – but not of despair……It may be within our reach to provide reasonably large populations with a good material life plus opportunities for limitless individual and social development."

Hopefully this optimism is still warranted, though the challenge has already been passed to a new generation and **NO** progress has so far taken place.

It would be naïve, in my opinion, to assume the gap between rich and poor could stay as it is now, and even more naïve to assume this gap can grow without finally creating massive civic turmoil. If the gap gets too great, the poor will finally "come over the walls of prosperity" and attempt to redistribute this wealth. History has shown this to be the case, time after time. Most of our worst wars were not ideological battles but true fights over the redistribution of wealth.

But closing the rich/poor gap needs very carefully implementation, as the exponential changes in both energy resources and a staggering number of other factors, including the pollution these increases imply, will strain the world's logistic and resources availability to its limits.

Phase One of the predicament of mankind never really made it to Phase Two. Instead, rather than merely ignoring this work and forgetting its chilling conclusions if the issues raised were forgotten, too many "experts" decided to use this thoughtful work as an easy target of intellectual scorn.

As a serious student of energy for the past 30 years, and a strong believer that compounding historical trends are often a far more reliable way to project the future than any alternate method, the world simply cannot continue the population growth in the poor parts of the world and also have these impoverished people climb the ladder of affluence. The energy usage these numbers imply do not match any sound plan for ever supplying the attendant energy this scenario creates.

Is there time to begin the thoughtful work which the Club of Rome hoped would take place post 1972? I would hope so. But, another 10 years of neglect to these profound issues will probably leave any satisfying solutions too late to make a difference. In hindsight, The Club of Rome turned out to be right. We simply wasted 30 important years by ignoring this work.

APPENDIX 1

Current Worldwide Energy Use

	BOE Per Day (In Millions)
OECD	105
FSU	19
Developing Countries	54
Total	178

	Energy Mix (BOE In Millions)
Oil	72
Coal	44
Natural Gas	43
Nuclear	14
Hydro	5
Total	178

Source: BP Energy Statistics.

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APPENDIX 2

Total Worldwide Energy Consumption

	In Million Tons Oil Equivalent						
	1940	1950	1960	1970	1980	1990	2000E
U.S.	600	825	1,100	1,665	1,850	1,930	2,250
Western Europe	400	450	700	1,120	1,280	1,740	1,810
"USSR"	125	160	475	820	1,170	1,400	920
Rest Of World	300	400	925	1,745	2,600	2,785	3,590
Total	1,425	1,835	3,200	5,350	6,900	7,855	8,570
Million Barrels Of Oil Equivalent Per Day	29,700	38,200	66,600	111,400	146,700	163,600	178,500

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APPENDIX 3

Middle East: The Sleeper In Energy Use

	1970	1980	1990	2000	2030(E)
Population	60	91	132	168	344
Energy Consumption (Million Tons Oil Equivalent)	66	117	212	388	1,652
BBOE/Day (In Millions Of Bbls)	1,376	2,438	4,406	8,079	34,390
BOE Per Capita Per Year	8.4	9.8	12.2	17.5	36.5 (E)

Source: Population: U.S. Bureau of Census. Energy Consumption: BP Amoco.
(E): Extrapolates 2.5% per annum per capita increase 1970 - 2000 to 2030.

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APPENDIX 4

Some OECD Countries

	1970[1]	1980	1990	2000[2]
United States				
U.S. Population	205	228	250	276
Energy Consumption	1,527	1,851	1,931	2,249
Energy Demand Per Capita (BOE)	56.6	61.7	58.7	61.9
United Kingdom				
U.K. Population	55.6	56.3	57.6	59.5
Energy Consumption	186.0	203.8	212.6	226.9
Energy Demand Per Capita (BOE)	25.4	27.5	28.1	29.0
Spain				
Spain Population	33.6	37.5	39.4	40.0
Energy Consumption	45.5	76.5	89.0	121.5
Energy Demand Per Capita (BOE)	10.3	15.5	17.2	23.1

[1] Assumes 1970 - 1972 = 5% per annum 1,864.
[2] Assumes 2000 = 102% of 1999.

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APPENDIX 5

Middle East Population

	1970	1980	1990	2000
Iran	28.9	39.3	55.7	65.6
Iraq	9.4	12.3	18.1	22.7
Saudi Arabia	6.1	9.9	15.8	22.0
Yemen	6.3	8.6	12.0	17.5
Syria	6.2	8.8	12.4	16.3
Jordan	1.5	2.2	3.2	5.0
Oman	0.8	1.1	1.8	2.5
UAE	0.3	1.0	1.9	2.4
Kuwait	0.7	1.4	2.0	2.0
Qatar	0.1	0.2	0.5	0.7
Israel	2.9	3.6	4.5	5.8
Lebanon	2.3	3.1	3.2	3.6
West Bank	0.7	0.9	1.3	2.0
Total	60.0	91.3	132.4	168.1

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APPENDIX 6

The Middle East Energy Supply

	In Million Barrels Of Oil Equivalent Per Day				
	1970	1980	1990	2000	2030 Est.
Consumption					
Oil	935	1,625	3,390	4,554	26,400
Natural Gas	367	710	1,770	3,351	10,000
Coal	--	--	48	119	--
Hydro	17	21	21	21	--
Total	1,319	2,356	5,229	8,045	36,400
Exports - Oil	15,200	11,600	14,200	18,700	25,000

Source: Historical: BP Amoco Energy Statistics.
Futures Historical Extrapolation.

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APPENDIX 7

Barrels Of Oil Equivalent

(MM/Day)

	1989	1999
Total Energy Demand	162 MM/Day	177.7 MM/Day
OECD	92.0	105.4
FSU	28.6	18.9
Rest Of World	41.4	53.4
Energy Mix (Percent)		
Oil	64.3%	72.1%
Natural Gas	36.2%	43.0%
Coal	47.3%	44.3%
Nuclear	10.5%	13.6%
Hydrocarbon	3.8%	4.7%
Total	100.0%	100.0%

	Energy Mix (Ex-FSU)	
	1989	1999
Oil	55.7%	68.3%
Natural Gas	24.3%	32.9%
Coal	40.8%	40.8%
Nuclear	9.3%	12.5%
Hydrocarbon	3.4%	4.3%
Total	100.0%	100.0%

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