"Ere many generations pass, our machinery will be driven by power obtainable at any point in the universe...it is a mere question of time when men will succeed in attaching their machinery to the very wheelwork of nature."

- Nikola Tesla

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ENERGY INDUSTRY

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ZPOWER STRATEGY DOCUMENTS

- ❑ **Corporate Profile**
- ❑ **Overview**
- ❑ **Global Marketing Strategy**
- ❑ **Invention Program**
- ❑ **Technology**
- ❑ **Energy Revolution**
- ✓ **Energy Industry**
- ❑ **Zero Point Energy**

TABLE OF CONTENTS

1.0 THE CHALLENGE

1.1 INTRODUCTION

How do we provide a quality standard of living for over five (5) billion people and protect the environment at the same time?

Quality of life is a function of our health, the air we breath, the food we eat, the water we drink, our shelter from radiation and exposure, and the quality of our environment. However, to enable all people to have access to basic services or infrastructure of clean water, safe sanitation, healthy food and health care requires energy. Yet most of the world's energy is produced and used in an unsustainable manner, threatening our very existence and the complex eco-systems that support life on earth.

Decisions on the source and type of energy used in the generation of electricity are made based on the following criteria:

- Availability of resources (reserves)
- Cost and return on investment (ROI)
- Resource security (protection of national economic interest)
- Environmental issues

The problems associated with these four points are detailed in the following sections.

The reality is that a large part of the human race is today gripped by widespread poverty, which can only be improved through an absolute minimum level of energy use as an input to a range of activities that provide the most basic of services for secure and stable human existance.

R.K.PAUCHAURI, DIRECTOR, TATA ENERGY RESEARCH INSTITUTE, NEW DELHI.

1.2 ENVIRONMENTAL

About eighty percent (80%) of current electricity production on this planet is from non-renewable resources which in almost all cases, cause environmental degradation.

The Atmosphere

- Energy supply and use accounts for approximately two thirds of all greenhouse gas emissions. Carbon dioxide from fossil fuel burning is responsible for most of this.
- The increase in concentrations of carbon dioxide and other greenhouse gases in the atmosphere will raise average temperatures on earth. Carbon dioxide concentration in the atmosphere has increased twenty-six percent (26%) in the last two hundred (200) years. The eight (8) warmest years on record have occurred since 1980 (Source: World Meteorological Organization). While there is uncertainty about the consequences of global warming, there is great cause for concern. Greenhouse warming is expected to put at risk low lying areas due to rising sea levels.

Without altered policies, pollution from fossil fuel generation of electric power will rise tenfold in the next forty years, from vehicles more than fivefold, and from industrial emissions and wastes also more than fivefold as demand for industrial goods multiply.

WORLD BANK, WORLD DEVELOPMENT REPORT, 1992

Forests and ecosystems may not adapt easily to shifts in climate zones, resulting in changing patterns of land use, and loss of biodiversity and agricultural production.

- Acid rain, formed from the mixture of water and oxides of Sulphur and Nitrogen, resulting from burning fossil fuels, especially coal, is associated with the killing of forests, polluting of waterways especially lakes, and accelerating the deterioration of buildings. An estimated 1 billion people live in cities that exceed World Health Organization (WHO) standards for sulphur dioxide.

Nuclear Safety and Wastes

- The fuel from nuclear plants is toxic for hundreds of thousands of years, creating a financial and environmental burden and potential time-bomb for future generations. Unless public concerns about safety and waste disposal can be overcome, there appears to be an uncertain future for nuclear energy.
- The transport of nuclear fuel and waste, both by land and by sea is attracting increasing public opposition, due to the possibility of accidents and the resultant catastrophic contamination.
- Deforestation, desertification, and topsoil erosion are often related problems resulting from a variety and combination of causes:
  - firewood - the only energy source for about half the world's population.
  - population pressure, requiring greater output from ever decreasing productive land.
  - clearing of forests either for timber or to grow cash crops for export, necessary for many developing countries to reduce foreign debt.
- Oil spills from tanker accidents continue to cause major ecological damage. The world remains dependent on oil for transport and to a much smaller degree in the generation of electricity.

1.3 HUMANITARIAN

The lack of energy in developing countries has a major impact on the following 'quality of life' indicators:

- World Hunger: Thirty-five thousand (35,000) children die of hunger and hunger associated diseases every day -- fifteen (15) million per year. In a world that already produces enough food for all, the infra-structure to adequately serve the hungry is closely linked to the availability of energy in general and electricity in particular.

If you know the enemy and know yourself, you need not fear the result of a hundred battles. If you know yourself but not the enemy, for every victory gained you will also suffer a defeat. If you know neither the enemy nor yourself, you will succumb in every battle.

SUN TZU - 500 BC

- Inadequate access to electricity inhibits efficient food production and distribution systems: irrigation, transport, manufacturing and packaging, delivery, refrigeration and waste disposal,
- Clean Water and Sanitation: 1 billion people in developing countries do not have access to clean drinking water and 1.7 billion lack access to sanitation. Shortage or total lack of energy is a major inhibitor to supporting the infrastructure for clean water, (pump, filter and purification) and safe sanitation.
- Overpopulation: The world population has doubled to over five point four (5.4) billion since 1950 and is expanding at almost one hundred (100) million people per year.
- Rapid population growth can exacerbate the mutually reinforcing effects of poverty and environmental damage. The poor are both victims and agents of environmental damage.
- By the year 2020 the global population is projected to reach eight point five (8.5) Billion people.
- Ill-health associated with the mining and processing of fossil and nuclear fuel is well documented in medical literature. Low emission standards and polluting practices in energy generation in less developed countries are often associated with cancer and lung disease. An estimated three hundred thousand to seven hundred thousand (300,000 - 700,000) lives could be saved each year by adopting World Health Organization standards on emissions.
- Excessive urban particulate matter levels are responsible for premature deaths and for half of all childhood coughing.
- Four hundred to seven hundred (400 - 700) million people, mainly women and children in poor rural ares, are affected by smoky indoor use of biomass fuels (such as wood, straw and dung).
- Poverty persists in countries with low energy consumption per capita ratios resulting in high infant mortality rates and reduced life expectancy.
- Lack of refrigeration has an impact on health care delivery systems.

"Providing access to sanitation and clean water would be the single most effective means of alleviating human distress."

WORLD DEVELOPMENT REPORT, WORLD BANK 1992

1.4 ECONOMIC AND FINANCIAL

- Excess in-built reserve and spinning capacities have traditionally been necessary to ensure high levels of reliability. This results in poor utilization of capital, invested in plant which is idle for a substantial portion of time.
- The adverse economic effects of power supply interruptions can equal five to one hundred (5 – 100) times the average electricity tariff. In India, for example, the value of lost industrial output caused

by power shortages is estimated at six ($6) billion a year (10% of the total annual industrial output).

- Dependency on imported energy resources, especially oil, has led, in many countries, to crippling debt burdens; the threat of disrupted supply was the direct cause of the Gulf War in 1991.
- The high cost of renewable energy (with the exception of hydroelectricity) currently tends not to be competitive with base load power from non-renewable sources. This accounts for the high non-renewable component in energy source projections well into the 21st century.

In seeking to establish their electric power priorities, developing countries and nearly all the former Eastern Bloc nations, face a particularly severe triple-bind set of problems:

- Firstly, there exists a serious lack of capital to develop generation, transmission and distribution facilities for providing increasing amounts of electric power, regardless of costs and efficiencies. Under most "business-as-usual" projections, approximately one hundred ($100) billion per year will be required for power systems expansion in developing countries in the 1990's. But the combination of traditional internal and external sources of investment funds will be able to provide only about twenty to twenty-five ($20-25) billion per year.
- The average developing country spends one quarter of its public budget on the power sector. Other sectors such as health and education are competing for the same scarce resources.
- Secondly, existing electric utility companies suffer from stagnant or deteriorating performance, both financial and technical. This in turn reinforces the lack of investor confidence.
- Thirdly, they are now coming under increasingly severe environmental constraints.
- Inequitable availability of electric power around the planet. The developed countries, twenty-five percent (25%) of the world population, consumes seventy-five to eighty percent (75-80%) of the total global electric energy production.

1.5 TECHNICAL

- The World Energy Council projected the energy requirements for the year 2020. If we continue to have only moderate economic growth energy requirements will increase fifty percent (50%). Over ninety percent (90%) of this energy growth will occur in the less developed countries. The problem will be meeting this growth in a sustainable manner.

- Technology transfer from developed to developing countries remains a large stumbling block to the development of sustainable energy supply.
- Electricity cannot be stored efficiently in large quantities.
- In order to maintain reliability, load profiles dictate that power generation capacity has to be based upon potential peak loads with a significant safety margin, not average loading. A high percentage of reserve generating capacity is tied up in very expensive plant operating at sub-optimal efficiency.
- The marginal cost of peaking power is much higher per Kwhr than the cost of base load power. Utilities, therefore, are constantly seeking solutions to reduce this cost differential by load levelling, storage of low cost power sources for use at peak times and the use of quick response flexible generation.
- Many untapped large scale renewable resources (ie hydro) for electricity production are physically remote from high demand locations - cities and industrial centers. Most are located in Less Developed Countries with their resultant cost, investment and delivery problems.
- Many renewable sources eg wind, solar, and tidal are intermittently available. This adds further to the technical and cost considerations of the development of these power sources.
- The inefficiencies in generation and distribution of todays generating capacity is unable to reliably meet todays demand even though there is no global shortage of primary energy now and none is anticipated to 2020.

1.6 POLITICAL AND INSTITUTIONAL

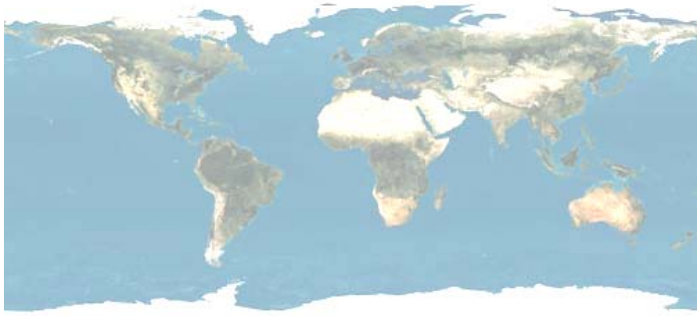
- The high political and economic consequences of interruption of energy supplies often results in energy decisions being political. Resource Security is a major national priority for most nations. Consequently there is often a heavy cost to the nation, consumer and the environment.
- Historically, electrical energy has been generated by investor or government owned utilities, each having an exclusive franchise to sell electricity within a politically defined geographical territory. These boundaries have often proved significant obstacles to optimal energy choices. Whilst many nations have reluctantly become reliant on imports of raw energy supplies such as oil, coal and uranium, very few have allowed electricity imports to account for more than just a few percent of their peak load.
- Large electrical systems have to be highly regulated to ensure reliability and security of supply. This often leads to inefficient

monopolies, poor financial performance of utilities and environmental damage.

- Inadequate tariffs are a major factor in poor financial performance of utilities. In have developing countries, tariff levels have generally remained below long-run marginal costs.
- Subsidies on energy worldwide amount to some two hundred thirty ($230) billion per annum as compared with US arms expenditure of approximately three hundred ($300) billion. Historically, developing countries have kept energy prices low firstly in the belief that low energy prices spur economic growth and secondly to maintain political support. These subsidies need to be funded from other sectors of already fragile economies and perpetuate inefficient and polluting practices. Removal of subsidies worldwide is considered one of the highest priority energy policies of the World Bank.
- Technical and operational inefficiencies in developing countries are often dwarfed by accounting failures, uncollected revenues, and theft. This has a major impact on world financial institutions and further inhibits investment.
- It is generally agreed that some forms of economic instruments be applied to reflect the environmental and societal costs of power generation. However disagreement over exact policies (eg carbon tax), levels and the lack of international agreement again perpetuates inefficient and polluting practices.
- The uneven distribution of energy resources exacerbates political tension. The oil crisis of 1973 foreshadowed possibly the largest redistribution of wealth ever and a major shift in political influence.
- Vested interests perpetuate the status quo in an industry that due to the size of investment has always moved slowly. Failure to respond urgently to the environmental challenges could be catastrophic.

We receive 20,000 times more energy from the sun alone, than we currently use.

MEDARD GABEL, EARTH, ENERGY AND EVERYONE



2.0 TRENDS AND PROJECTIONS

2.1 OVERVIEW

In addressing the challenge of sustainability, there are several major trends and projections that have the greatest bearing. The argument can be simplified as follows:

1. World population is growing at unprecedented rates.
2. Poverty is increasing at a similar rate.
3. Energy consumption must increase if poverty is to be overcome.
4. Current and projected energy consumption shows a significant increase in energy from non-renewable sources (especially coal and other fossil fuels).
5. The Intergovernmental Panel on Climate Change (IPCC) recommended a large reduction in emissions if atmospheric concentrations of greenhouse gases are to be stabilized.

The World in Crisis

The current trends and "business as usual" projections point to a seriously unsustainable and deteriorating state of the world. The Chinese word for crisis is two characters, one meaning danger and the other opportunity. The following trends demonstrate the danger that faces the planet, and the ZPower Solution (addressed in other strategy documents) will demonstrate the opportunity for addressing the crisis.

The first five trends/projections are the major factors (noted above) in the present crisis. These are supported by additional trends and projections, which will follow.

Conclusion

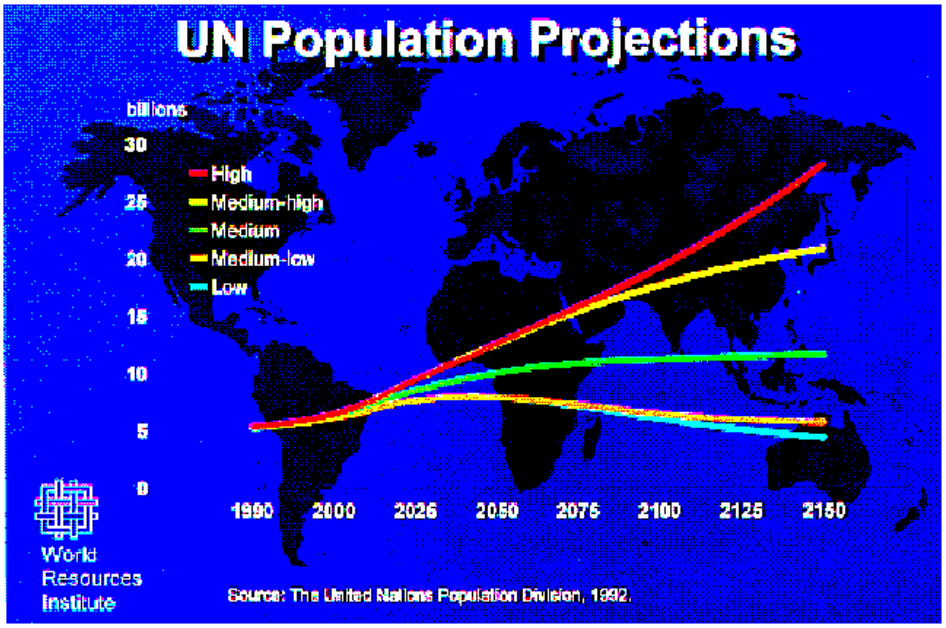
The conclusion reached from these trends and projections is that only a radical reduction of population growth and fossil fuel consumption combined with an equally progressive program of the transition to sustainable energy sources, will avert an ecological catastrophe.

2.2 TREND/PROJECTION 1 – POPULATION

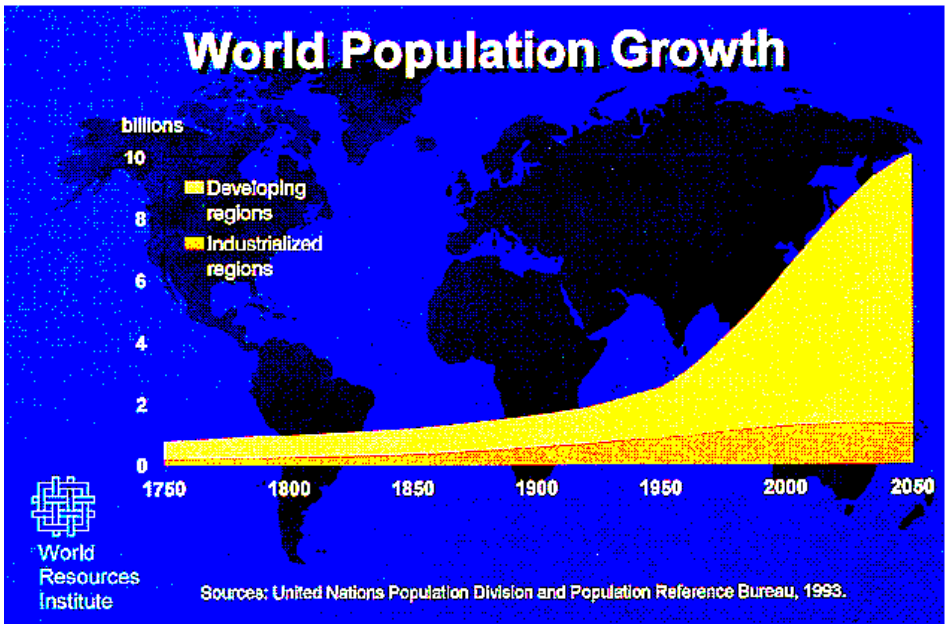
Our global population continues to grow at an accelerated rate. We now add approximately one billion people in just one decade. The world population has grown from two point five (2.5) billion in 1950 to five point four (5.4) billion in 1993. Ninety-five percent (95%) of the projected population increase will come from the developing countries. Just as noteworthy, once a society reaches an

adequate living standard, the rate of growth levels off and populations stabilize. Demographers predict the world population stabilizing at levels of at least ten (10) billion and possibly as high as twenty-three (23) billion.

If fertility and mortality had remained constant at 1990 levels we would reach twelve (12) billion people in 2028. Current projections say it will take a little longer. The U.S. Census Bureau projects a world population of about nine point four (9.4) billion in 2050. Twelve billion is the maximum population that some experts think Earth can sustain, based on our present technology.



SOURCE: UNITED NATIONS POPULATION DIVISION (UNPD), LONG-RANGE WORLD POPULATION PROJECTIONS: TWO CENTURIES OF POPULATION GROWTH, 1950-2150 (UNPD, NEW YORK, 1992).



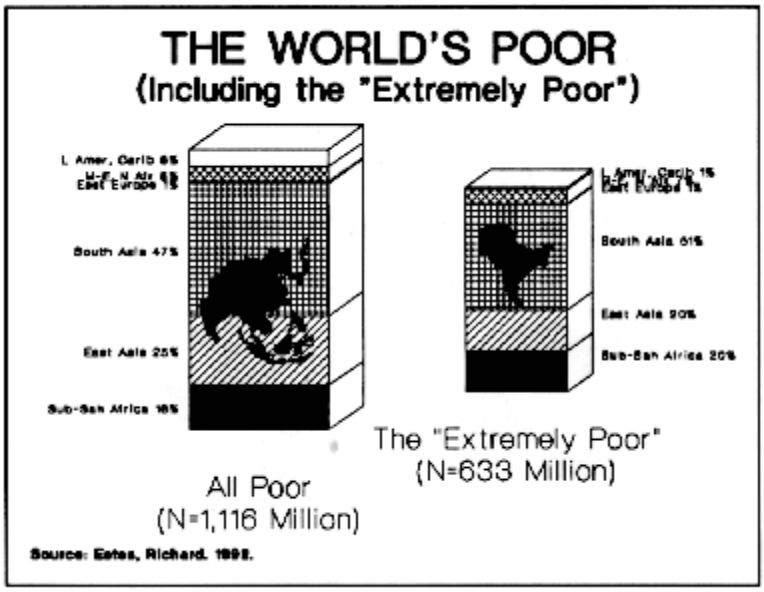
SOURCES: UNITED NATIONS POPULATION DIVISION (UNPD), LONG-RANGE WORLD POPULATION PROJECTIONS: TWO CENTURIES OF POPULATION GROWTH, 1950-2150 (UNPD, NEW YORK, 1992); AND CARL HAUB, DIRECTOR OF INTERNATIONAL EDUCATION, POPULATION REFERENCE BUREAU, WASHINGTON, D.C., 1993 (PERSONAL COMMUNICATION).

World Vital Events Per Time Unit: 1997			
Natural Time unit	Births	Deaths	Increase
Year	133,276,003	54,097,809	79,178,194
Month	11,106,334	4,508,151	6,598,183
Day	365,140	148,213	216,927
Hour	15,214	6,176	9,039
Minute	254	103	151
Second	4.2	1.7	2.5

SOURCE: U.S. BUREAU OF THE CENSUS, INTERNATIONAL DATA BASE

2.3 TREND/PROJECTION 2 – POVERTY IS INCREASING

Reducing poverty remains a tremendous challenge for governments of developing countries. It is estimated that 1.1 billion people still live in absolute poverty, that is, on less than $1 a day. If current trends continue, this figure will rise to 1.3 billion by the year 2000. If the poverty benchmark is doubled, the estimated number of poor also doubles, indicating that about two of every three people in the developing world together consume less than $2 a day.



The purpose of development is to alleviate poverty. Some progress has been made in developing countries over the last 25 years:

- Average consumption per capita in real terms has risen seventy percent (70%).
- Average life expectancy has risen from fifty-one to sixty-three (51-63) years.
- Primary school enrollments have reached eighty-nine percent (89%).

If these gains were evenly spread, much of the world's poverty would be eliminated. Instead, more than one-fifth (1/5) of humanity lives in acute poverty (in 1990 prices the poverty line is approximately two hundred forty (US$420) annual income per capita). The numbers of poor have increased at almost the

rate of population growth from slightly more than a billion in 1985 to more than 1.1 billion in 1990.

Estimating poverty in the developing world, 1985 and 1990						
	Number of poor (millions)		*Headcount index (percent)*		*Poverty gap index (percent)*	
Region	*1985*	1990	*1985*	1990	*1985*	*1990*
Aggregate	1,051	1,133	30.5	29.7	9.9	9.5
East Asia and the Pacific	182	169	13.2	11.3	3.3	2.8
Eastern Europe	5	5	7.1	7.1	2.4	1.9
Latin America and the Caribbean	87	108	22.4	25.2	8.7	10.3
Middle East and North Africa	60	73	30.6	33.1	13.2	14.3
South Asia	532	562	51.8	49.0	16.2	13.7
Sub-Saharan Africa	184	216	47.6	47.8	18.1	19.1

SOURCE: WORLD BANK, IMPLEMENTING THE WORLD BANK'S STRATEGY TO REDUCE POVERTY: PROGRESS AND CHALLENGES (WASHINGTON, D.C.: WORLD BANK, 1993).

2.4 TREND/PROJECTION 3 – PROJECTED GLOBAL ENERGY CONSUMPTION

The world will require large increments of energy supply over the next two decades. World energy use is projected to grow by about two (2) percent per year through 2015, resulting in total consumption in excess of 542 quadrillion British thermal units (Btu). Between 1993 and 2015 energy consumption is expected to increase by 193 quadrillion Btu--an amount nearly equal to the world's total energy consumption in 1970.

Economic growth is the main factor driving growth in energy demand. Between 1970 and 1993 world gross domestic product (GDP) rose from $12 trillion (1990 U.S. dollars) to $23 trillion. By 2015 world GDP is expected to almost double again, rising to $45 trillion.

Despite anticipated future energy efficiency gains, world energy demand is expected come mostly from the developing countries. Developing countries will soon become the largest market for commercial energy. The huge disparities of per capita consumption between OECD countries and the developing countries is very significant.

Doubling of consumption at constant time intervals can bring disaster with shocking suddenness. Even when a nonrenewable resource has been only half used, it is still only one interval away from the end.

E. O. WILSON

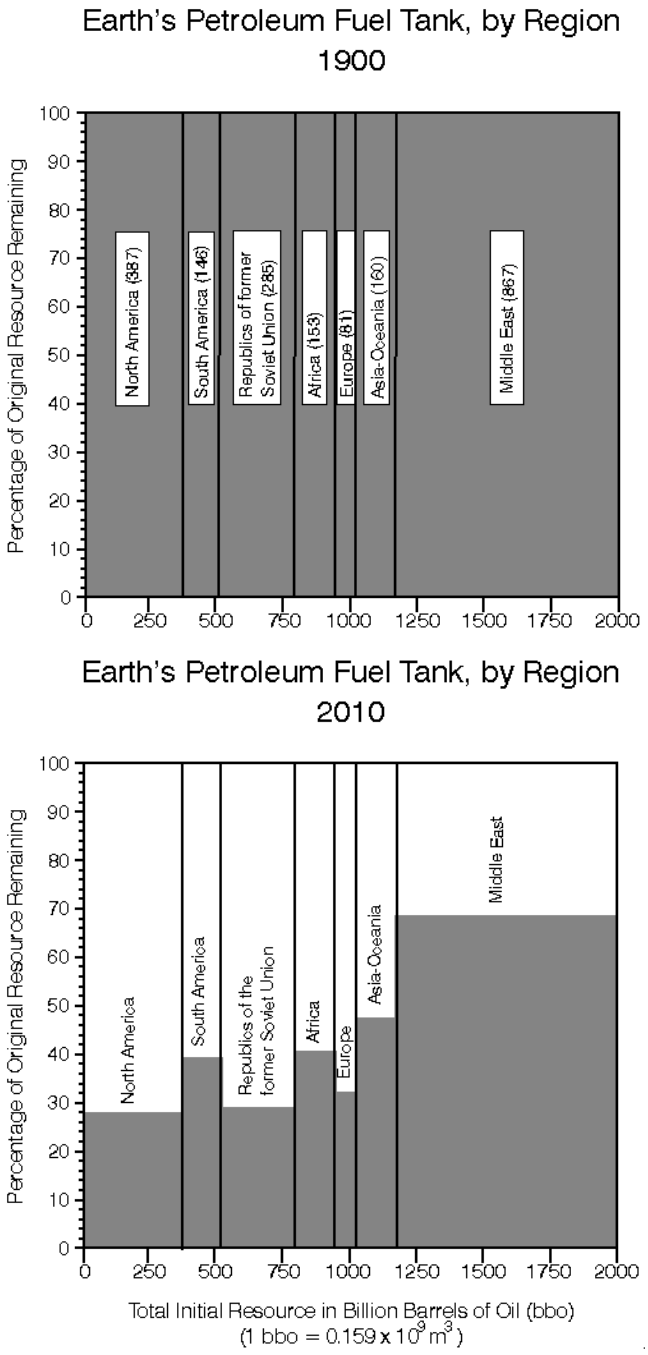
2.5 TREND/PROJECTION 4 – FUTURE RESERVES OF OIL AND OTHER NON-RENEWABLE ENERGY SOURCES

For the modern industrial economy, petroleum (oil) has been particularly important because it can be refined into useful fluid fuels (especially gasoline, fuel oil, and kerosene) that have a high energy content per unit of weight and are relatively safe to store, transport, and utilize. In fact, the whole industrial economy of the world is designed primarily around oil-based commercial energy. The future of oil is therefore very important both to development prospects generally and for food production in particular.

Much is known about the future availability of oil. Petroleum geologists have determined by four independent methods that the total amount of oil in Earth when we first started using it in 1900 was about 2,000 billion barrels. This total includes all of the oil known in 1900, all that has been discovered to date, and reliable, stable estimates of all of the additional oil that will be discovered in the future.* In other words, 2,000 billion barrels is all we ever had or will have.

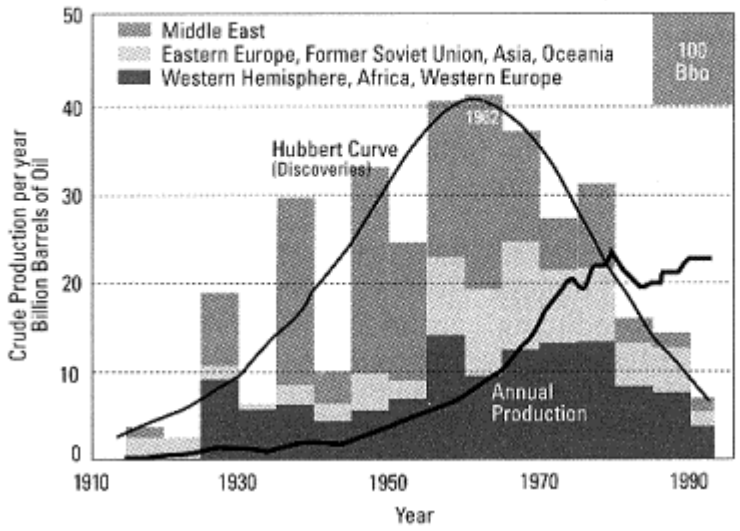
Since 1900, oil has been steadily drawn from Earth's fuel tank, and this production has lowered the overall level in the tank and altered the relative level in the regional compartments. If current rates of production were to continue unchanged until 2010, the relative levels in the regional compartments would be as shown in the above figures. (If the rates of production were to increase to assist in the economic development of the countries of the South, the levels would be still lower.) The shaded area in figures represent oil remaining; the white area represents the now-empty part of Earth's fuel tank. The regional distribution of oil shown in the figures have significant implications for the world energy market. By 2010, approximately half of the oil remaining will be in a single compartment, the one in the Middle East. As long as several producing regions control more than half of the total resource, the international market can be expected to respond effectively to occasional disruptions in production. By 2010, however, any dislocations in the Middle East must be expected to have global consequences that will be beyond the control of other producing regions.

How long will the fuel in Earth's oil tank last? It is possible to give a reasonably precise answer to this question based on what we know about petroleum and its use. Petroleum



THE OUTER BOUNDARY OF THE ABOVE FIGURES REPRESENT THIS INITIAL RESOURCE IN "EARTH'S FUEL TANK." THE WIDTH OF THE VARIOUS COMPARTMENTS IN THE FUEL TANK INDICATE THE INITIAL RESOURCE -- KNOWN AND YET-TO-BE-DISCOVERED -- IN NORTH AMERICA, SOUTH AMERICA, THE REPUBLICS OF THE FORMER SOVIET UNION, AFRICA, EUROPE, ASIA-OCEANIA, AND THE MIDDLE EAST. SOURCE: MASTERS, C. D.; ROOT, D. H.; AND ATTANASI, E. D. 1991. "RESOURCE CONSTRAINTS IN PETROLEUM PRODUCTION POTENTIAL." SCIENCE. VOL. 253. 12 JULY 1991. PP. 146-152.

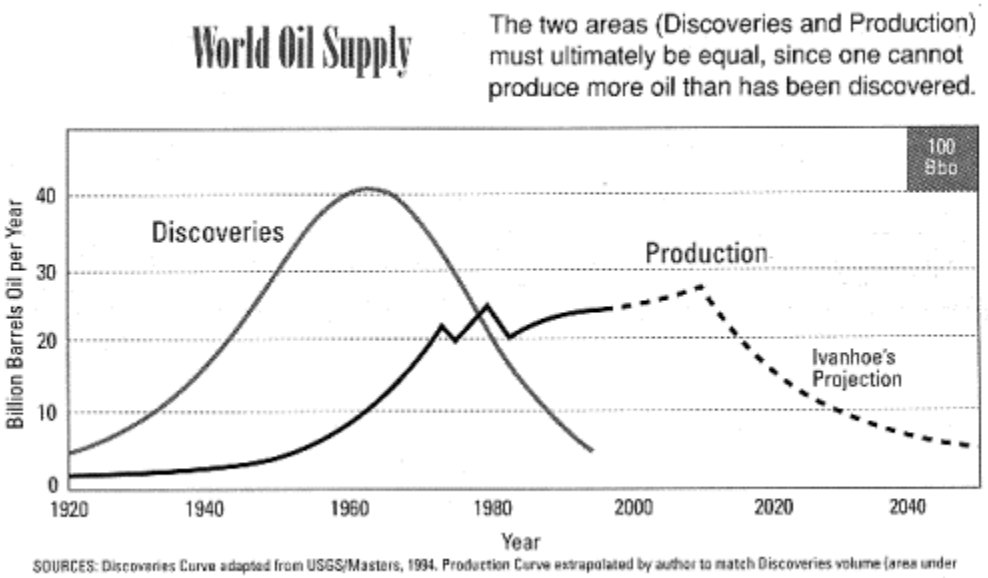
production began at zero in 1900 (when petroleum was first produced commercially), and increased at about 7 percent per year through 1973 (see Figure 16). Although sudden price increases in 1973 and 1979 broke the exponential trend in petroleum production, some increase in production is still expected over the next few decades.



Hubbert Curve is M. King Hubbert's weighted average of global oil discovered.

SOURCE: Adapted from USGS/Masters, 1994. "Hubbert's Curve" added by author.

Ultimately, however, petroleum production must peak and return to zero when all of Earth's total supply of 2000 billion barrels has been used. By about 2025 a rapid decline in petroleum use must begin. Within the lifetime of a child born today, virtually all of Earth's petroleum will be burned, and Earth's fuel tank will have gone from full to empty.



The two areas (Discoveries and Production) must ultimately be equal, since one cannot produce more oil than has been discovered.

SOURCES: Discoveries Curve adapted from USGS/Masters, 1994. Production Curve extrapolated by author to match Discoveries volume (area under Discoveries Curve).

Percentage of Crude Oil Remaining:	52%
Years Until Half of Crude Oil is Gone:	3
Years Until 80% of Crude Oil is Gone:	23

SOURCE: MASTERS, C. D.; ROOT, D. H.; AND ATTANASI, E. D. 1991. "RESOURCE CONSTRAINTS IN PETROLEUM PRODUCTION POTENTIAL." SCIENCE. VOL. 253. 12 JULY 1991. PP. 146-152.

The industrial style development characteristic of the North is fundamentally a process of replacing human labor -- man, woman, and child power -- with other

forms of power derived from commercial energy sources. The energy is needed not only for daily ongoing activities such as powering factories, household conveniences, transportation systems, and energy processing, but also in the construction and maintenance of buildings, roads, equipment, and other economic infrastructure and capital that is now so characteristic of the "developed" countries of the North.

To build industrialized economies modeled on the North, the countries of the South would require enormous quantities of a particular type of energy-fluid fuels.

2.6 TREND/PROJECTION 5 – CLIMATE CHANGE / POLLUTION

The "Greenhouse Effect" is a natural phenomenon and a beneficial one, which warms the earth and makes it habitable. Too much warming, caused by human generated carbon dioxide from fossil fuel burning and by deforestation, could cause a global climate change.

A number of so-called "greenhouse gases" have the property of allowing high frequency solar radiation to pass through the atmosphere to the surface of Earth where the radiation is absorbed, providing warmth to Earth. These gases (carbon dioxide, chlorofluorocarbon 12, methane, chlorofluorocarbon 11, nitrous oxide, ozone (stratosphere), ozone (troposphere), and other chlorofluorocarbons) block the transmission of low frequency heat radiation back into space. The net effect of the greenhouse gases is to trap solar energy and keep the temperature of Earth within a range in which approximately three (3) million species can live. Increased concentrations of greenhouse gases can disrupt the operation of the planet's temperature-regulating systems and cause the temperature of Earth to rise.

Currently, the concentrations of all greenhouse gases are rising. Most alarming are the growing concentrations of carbon dioxide. Northern transportation and industry are the principal sources, but Southern deforestation is also very significant.

The Intergovernmental Panel on Climate Change (IPCC) was set up in 1988 to assess the scientific information that is related to the various components of the climate change issue and to formulate realistic response strategies. One hundred and seventy five (175) scientists from twenty-five (25) countries contributed to the scientific assessment and their recommendations formed the basis of the Framework Convention on Climate Change signed in Rio de Janeiro in 1992 by one hundred fifty-four (154) nations. Although no emissions levels nor timetables were agreed upon by those 154 nations, the principles of protection of the atmosphere were established.

Carbon Dioxide, Years Until Doubling :		60
Predicted decline in production of cereal grains (rice, corn, wheat,	in developed countries	-23.9%

etc.) as a result of climate change (climate effects only) by 2060 :		
	in developing countries	-16.3%
Additional decline in grain production from physiological effects of CO2 :	in developed countries	-3.6%
	in developing countries	-10.9%
Number of people at risk of hunger in 2060 :	without global warming	640 million
	with projected warming	680 to 940 million

SOURCE: MILLENIUM INSTITUTE: STATE OF THE WORLD: GREENHOUSE GASES: 10 JANUARY 1997

If world energy consumption reaches the projected levels, world carbon emissions are expected to increase by 3.4 billion metric tons--or at a rate just over 2 percent per year--through 2015. In that case, world carbon emissions in 2015 would exceed 1990 levels by 54 percent. Oil and coal will contribute about 1.3 and 1.2 billion metric tons, respectively, to the increase, and natural gas will provide the remainder. Carbon emissions will grow at a slower rate than energy consumption, reflecting more rapid growth in the use of natural gas than other fossil fuels

Carbon emissions from energy use in OECD countries are expected to increase by 902 million metric tons to about 3.9 billion metric tons by 2015, or by about 1 percent a year. Petroleum products, used principally in the transportation sector and having few substitutes, will account for nearly half the increase in emissions. Natural gas will become a relatively more important source of emissions as it replaces coal, which is "dirtier" with respect to carbon dioxide (as well as sulfur dioxide and nitrogen oxide). Nonetheless, coal will remain an important source of emissions, primarily because of its role as an economical fuel for baseload electric power generation.

By 2000, carbon emissions in non-OECD countries are expected to surpass those in the OECD, even though developing countries will use less energy than industrialized countries at that time. Non-OECD emissions are expected to increase by 2.3 billion metric tons to a total of almost 5.5 billion metric tons in 2015. Their growth represents about two-thirds of the projected increase worldwide. The sizeable rise in emissions from non-OECD countries is a result of their heavy dependence on coal, the most carbon-intensive of the fossil fuels, especially in the non-OECD Asia region, which has the highest expected rate of economic growth. Carbon emissions in non-OECD Asia are projected to increase from

"Carbon dioxide emissions globally are likely to rise over the next 30 years. For the Enhanced Economic Development case which is dominated by energy growth in the developing countries (and therefore implies a disproportionate increase from fossil fuel sources), carbon dioxide emissions could - as we indicated earlier - rise 92% in the 30 years to 2020. This conclusion underlines the strategic dilemma. Economic growth and commercial energy provision are vital to alleviate poverty in the developing countries. If the overwhelming bulk of that commercial energy provision is fossil fuel based, and fossil fuel combustion is finally indicted by good science as the cause of unacceptable global warming and climate change, then the developing countries face the continued struggle of huge numbers of the unacceptably poor and deprived."

WEC COMMISSION, ENERGY FOR TOMORROW'S WORLD, 1992.

1.3 billion metric tons in 1993 to 3.1 billion metric tons in 2015.

Air Pollution

The World Health Organization (WHO) and the United Nations Environment Program joined forces in 1992 to publish a study of air pollution in twenty (20) of the world's twenty-four (24) mega-cities (urban areas with more than 10 million people now or by the year 2000). Every city studied had at least one major pollutant that exceeded WHO guidelines, fourteen (14) cities had at least two (2), and seven (7) cities had at least three (3).

The Rising Global Temperature

The causes and long term prospects for global temperature rises are still the subject of scientific and political debate. However there is little doubt that global average temperature has been rising. Since 1980, there have been eight of the hottest years in the last century.

Ice core measurements show that there have been significant temperature variations on Earth (ice ages and interglacial periods) and that carbon dioxide and methane levels in the atmosphere have varied in concert with global temperature. Recent concentrations of these greenhouse gases have soared much higher than they have been since long before the appearance of the human species.

Conclusions of the IPCC Scientific Assessment

A high degree of consensus emerged from the scientists involved and the "Scientific Assessment" is an authoritative statement of the views of the international scientific community at this time on the problem. None of the observations proves that the earth is warming because of atmospheric increase in greenhouse gases. Even if warming is occurring, the meaning of global climate change for human activity or ecosystem health is not known for sure. Some politicians have escalated that uncertainty to a state of high confusion.

It is important to state what is known with certainty:

- It is certain that human activities, especially fossil fuel burning and deforestation, are increasing the atmospheric concentrations of greenhouse gases, the major ones being carbon dioxide, methane, chlorofluorocarbons, and nitrous oxide.
- The greenhouse gases trap heat that would otherwise escape into space. Trapped heat will increase the temperature of the earth over what it would otherwise be.
- The warming will be unequally distributed, more near the poles than near the equator. Because the earth's weather is mainly driven by temperature differences, winds, rains, and ocean currents will shift in strength and direction.

- On a warmer earth the ocean will expand and sea levels will rise. If the warming is sufficient to melt polar ice in large quantities, sea levels will rise significantly.

The conclusions of the assessment are as follows:

- On doubling carbon dioxide, the global mean surface temperature rise is unlikely to lie outside the range of 1.5 to 4.5oC.
- Global mean surface air temperature has increased by 0.3 to 0.6oC over the last 100 years.
- Future warming rates of about 0.2 to 0.5oC (average 0.3oC) per decade are expected.
- the increase in sea level due only from oceanic thermal expansion ranges from 2 to 4 cm per decade.

The uncertainties lie not whether human activity is affecting the atmosphere, but in "to what extent". The uncertainties are in the following three main areas:

- What the global temperature would be without human interference.
- How exactly a warming planet would affect temperatures, winds, currents, precipitation, ecosystems, and the human economy in each specific location on earth.
- The third uncertainty lies in the mechanisms of feedbacks. There may be self correcting, or negative feedbacks, that will stabilize the greenhouse gases or the temperature eg oceans. Or there may be positive feedbacks that exacerbate the problem. Some scientists fear that this may lead to a non linear situation when warming may suddenly race out of control.

HUMANITARIAN INDICATORS

2.7 TREND/PROJECTION 6 – THE LINK BETWEEN ACCESS TO ENERGY SERVICES AND QUALITY OF LIFE

Energy is the common denominator that runs through every facet of a developed society from powering our industry to transport, heating, cooking, lighting, and purifying the water we drink. Few would dispute that it is largely the availability or unavailability of affordable energy which separates the developed from the under developed world. Most “quality of life” indicators improve as per capita energy consumption increases. In developed countries improved “quality of life” indicators can be de-linked from increased energy consumption, but with improved efficiency and reductions in energy intensities, remain to a degree dependent on access to energy services.

In an article "A Model for the Quality of Life as a Function of Electrical Energy Consumption" (Energy (1991) 16(4):739-745) Alam and his co-workers from Bangladesh, studied the data from 112 countries. They found that their "physical quality of life index" (using average life expectancy at age 1 year, infant mortality, and literacy rates) is related exponentially to the per capita electrical energy consumption in kilowatt hours.

The major "quality of life" indicators are Life Expectancy, Infant mortality and Literacy.

Life Expectancy

In the chart below it can be seen that significant improvements in life expectancy can be achieved with a relatively small per capita electricity consumption. World Bank statistics also indicate a significant transition towards lower fertility when life expectancy reaches 53 years.

Infant Mortality

Infant mortality rates are highest in developing countries largely attributable to poverty and lack of access to clean water and safe sanitation. Infant mortality rates drop as energy consumption per capita rises.

SOCIAL, POLITICAL AND INSTITUTIONAL ISSUES

Energy demand is very complex; it is significantly influenced by attitudes, values and various aspects of socially dominated behavior. The massive price rises of fuel in 1990, just prior to the Gulf War resulted in very small changes in energy use. Consumers often do not have even crude price information at time of use, so they are clearly not making economic judgements about the marginal utility of competing calls on their dollar.

Much of the analysis of energy use is based on the assumption that energy is a commodity and energy users act as consumers. Stern and Aronson (1984) state that there are at least four different views of energy, and at any time for an individual, regulatory body or government, there is likely to be an amalgam of the factors.

In the words adopted by the ESD Working Group on Energy Use (Australia), the views on energy are:

- "Energy is just a commodity: energy (or fuels) is seen as tradable, just like soap powder or beer. According to this view, consumers choose whether to buy energy or not as an economic decision, within the framework of a market, which is usually regulated by either the government or a supply cartel."
- "Energy is a social necessity: services provided by energy for lighting, warmth, cooking and transport are seen as a social right,

with the implication that society has the responsibility to ensure that these rights are satisfied."

- "Energy is a natural resource: fuels are classified as renewable or non-renewable, exhaustible or inexhaustible, polluting or non-polluting, with energy use seen as a process in the context of the biosphere."
- "Energy is a strategic material: providing economic comparative advantage; national self reliance in energy is seen as an important factor in achieving political independence."

Many of the political and institutional problems (and achievements) concerning energy have their roots in these four attitudes to energy. Institutions, policies and pricing are all affected.

The Summary of Energy Sector Characteristics in Developing vs Developed Countries (overleaf), shows simplistically the various institutional and operational backgrounds from which to address the environmental and development problems facing the world.

Many of the problems of utilities in developing countries are institutional. Lack of accountability and transparency result in poor management of the utilities or the state fuel companies that frequently supply them.

	Developing Countries	OECD Countries
Energy consumption	Low per capita High growth rates	High per capita Low growth rates
Energy prices	Low Subsidized	Market based
Market structure for energy use	Protect industries Public monopolies Bias against efficiency in financing	Competitive markets Easy entry and exit
Energy supply-side institutions	Public monopolies Command and control regulation Opaque accountability	Public and private enterprises Transparent regulation Checks and balances
Information barriers	Relative lack of intermediation of information, technology, and finances	Market-based information technology and financial Intermediation

SUMMARY OF ENERGY SECTOR CHARACTERISTICS IN DEVELOPING VS DEVELOPED COUNTRIES

2.8 TRENT/PROJECTION 7 – TARIFFS FOR ELECTRIC POWER

Currently underpricing of electricity is the rule rather than the exception. Subsidies for all energy, for example cost developing governments more than $230 billion a year - more than four times the total world volume of official

development assistance. The former USSR and Eastern Europe account for $180 billion of this.

From 1979 to 1988, OECD tariffs rose in real terms by 1.4% a year compared with a fall of 3.5% a year in developing countries. Many developing countries sell electricity well below cost.

Subsidies and underpricing have the following causes and effects:

- Usually the result of government interference, in the belief that price increases will exacerbate inflation and adversely affect international competitiveness.
- In such cases utility managers have little say in management or investment decisions.
- The economic costs to the economy are considerable, and have to be found from other sectors of often already strained economies.
- The environmental costs are also significant, in that demand and the resultant pollution increases.
- Developing countries use about 20% more electricity than they would if consumers paid the true marginal cost of supply.
- Underpricing discourages investment in new cleaner technology and perpetuates polluting and inefficient practices throughout the sector from supply to end use.
- The revenue base is undermined, reducing the ability of utilities to provide and maintain supply.

2.9 TRENT/PROJECTION 8 – GROWING ENVIRONMENTAL AWARENESS

As environmental degradation increases all over the world, to be "green" is now mainstream. Today's children are better educated on environmental issues taught in schools; there are growing numbers of environmental and humanitarian non-government organizations (NGOs). In developed countries there is increasing stringency in environmental impact assessment of development projects. An increasing environmentally conscious general public is raising the pressure on the regulatory authorities and utilities to minimize global, regional and local effects.

There is a limited but growing understanding of global interdependence and the need for global partnership to achieve a sustainable future for the world.

However it is generally not understood how energy underpins almost all aspects of our quality of life in a developed society, nor the link between access to energy and reversal of environmental degradation.

2.10 TREND/PROJECTION 10 – INCREASINGLY STRICT

ENVIRONMENTAL LEGISLATION

In many parts of the world environmental legislation is becoming increasingly stringent to protect local environments and also the "Global Commons" such as the atmosphere, oceans, biodiversity etc. Examples of these are:

- The Montreal Protocol, for protection of the ozone layer.
- The Climate Change Convention
- The Biodiversity Convention
- Various treaties to protect the oceans from toxic waste dumping, overfishing etc.
- An international treaty is being prepared to address the growing problem of desertification.

Standards tend to be higher in developed countries where basic human needs have been met. The converse is also very evident: until survival needs are met, protecting the environment remains a very low priority. Until one's stomach is full and he's sheltered from the environment, he's not concerned about any environmental sustainability.

3.0 WHO HAS THE PROBLEM

3.1 OVERVIEW

Globally speaking, the entire planet shares the problem of unsustainable human activity. Many of the problems are global in nature; others have a regional or local impact, and others still are related to the economic development of nations.

Global problems include:

- Greenhouse effect
- Climate change
- Nuclear safety
- Nuclear waste
- Nuclear weapons proliferation
- Technical issues are common to most utilities
- World debt
- Population explosion
- Poverty

Regional and local problems include:

- Poverty and poor of quality of life
- Acid rain, damage to lakes, rivers and forests
- Nuclear accidents
- Nuclear waste disposal and "NIMBY" (not in my back yard)
- Oil spills
- Deforestation
- Topsoil erosion
- Desertification
- Uneven distribution of energy resources
- Hunger
- Wars

In Developed Countries the general population has the problem of environmental degradation resulting from the electricity industry generating approximately eighty percent (80%) of its energy from non-renewable sources.

In Less Developed Countries the problem centers around poverty, lack of available power and resultant environmental degradation. In these countries, their priorities start with basic subsistence; protection of the environment is often considered of secondary importance.

The threat of the greenhouse effect is that no nation can escape from its impact on its own; slowing it requires concerted international action.

WORLD ENERGY: BUILDING A SUSTAINABLE FUTURE; STOCKHOLM ENVIRONMENT INSTITUTE 1992

The most important opportunity relates to poverty reduction: not only is attacking poverty a moral imperative, but it is also essential for environmental stewardship.

DEVELOPMENT AND THE ENVIRONMENT, WORLD DEVELOPMENT REPORT, WORLD BANK 1992

3.2 RECOGNITION OF THE PROBLEM

There is growing awareness of the dilemma between development and protection of the environment. Below is a sample of opinions of a few major institutions regarding energy.

The United Nations Conference on Environment and Development, UNCED, (also known as the Earth Summit) was held in Rio de Janeiro, Brazil in June 1992 as the culmination of over two years of international activity. This was the largest gathering of Heads of State ever.

- Energy continues to be a live issue and is central to the negotiations and implementation of the Framework Convention on Climate Change signed in Rio.
- For many countries the two year process prior to the Earth Summit was the first time they had even formulated an environmental policy.

The World Energy Council, at the 15th Congress, titled "Energy and Life" in Madrid in September 1992 concluded with 'The Madrid Declaration', headed The Central Issues:

"However, despite...many conflicting pressures on us, this Congress has demonstrated a remarkable coherence in the face of all these uncertainties and challenges. This coherence is based on the widespread acceptance of three basic propositions:

1. "The first priority we must address is the relief of poverty in the developing world, where one billion or more people face a short life of disease and abject social conditions. Their plight can only be relieved by economic development of the right kind. Energy supplies are fundamental to securing that economic development, and increasing use of energy resources to support this process in unavoidable, even though some regions may have little or no energy growth per capita in the future.
2. "Economic development, through the increasing use of energy resources, and protection of the natural environment which are not, as once thought, in unalterable opposition, a conflict of good and evil. They are two sides of the same coin called "sustainability". Thus it can be argued that an increasing standard of living in developing countries may bring with it some prospect of slowing down population growth, itself a major engine for greater resource use and environmental degradation. It also provides better means to care for the local environment, so often ravaged by the consequences of poverty.
3. "For the next three decades or so, there is no prospective global shortage of energy resources as such. But as yet neither is there any rapidly emerging or revolutionary technical answer to enhance energy supply or environmental protection. This means that we must face the challenge head-on of the unequal distribution of

The primary goal of the Summit will be to lay the foundation for a global partnership between developing and more industrialized countries, based on mutual need and common interests, to ensure the future of the planet... We need to find a viable and equitable balance between environment and development.

MAURICE STRONG, SECRETARY GENERAL, UNCED

energy supplies and the global nature of much environmental detriment with what we've got."

The world's seven largest electricity companies formed the E7 in 1992 to address global issues relating to electricity, and have resolved to participate actively in the international debate on the environment and development including the issue of global warming. Their joint statement of April 9, 1992, titled "Citizens of the World" states:

"In view of the international debates and scientific advances of recent years, the E7 utilities are convinced that, despite remaining differences in scientific opinions, preventive measures are necessary at world level to avoid deterioration of the climate and of the environment. Such measures require a common strategy.

"All the world's countries legitimately desire to improve their living standards by developing electricity infrastructure. This desire will be fulfilled compatibly with the global environment if developed countries cooperate with each other and with developing countries on programs of demand management, environmental protection and efficient supply.

"The E7 companies believe that achieving optimal utilization of environmental resources requires greater technological transfer to developing countries. Future action plans should be applied to the areas where they can be most effective. A wider range of action plans is available than simple fiscal regulation; technological transfer is just an example of one such action plan.

"As citizens of the world, in harmony with their respective national governments and related domestic and international organization, the E7 companies strongly wish that the experience, competence and know-how of their companies should serve more efficient generation and use of the world's electric energy."

The International Conference on Large High Voltage Systems (CIGRE) is a permanent international association, whose purpose is the development of technical knowledge and exchange of information between all countries as regards generation and transmission of high voltage electricity. In recognition of the current dialogue concerning the environment and development, CIGRE has set up a working group on to address the particular electrical needs of “Developing Countries and Newly Industrializing Countries".

The World Bank in their World Development Report, 1992, state in the chapter on energy:

"How far can the developing countries avoid repeating (past) experience and benefit from the ways in which the richer countries have learned to reduce pollution from energy use and industrial production even as output expands? At present the omens are poor. Current levels of air pollution, water pollution, and hazardous wastes in developing countries pose serious threats to human health, productivity and welfare. These types of pollution arise mainly from industrial production. If growth continues at present rates or higher - as it must if poverty is to diminish - then, on present trends, increased energy use and industrial production will add enormously to pollution."

The Stockholm Environmental Institute Publication “World Energy: Building a Sustainable Future” States as follows:

“As the 20th century draws to a close, both individual countries and the world community face a number of challenging problems relating to the supply and use of energy. These include local and regional environmental impacts, the prospect of global climate and sea level change associated with the greenhouse effect, and threats to international relations in connection with oil supply or nuclear proliferation. For developing countries, the financial costs of providing energy to provide basic needs and fuel economic development pose an additional burden.”

Utilities, and the concept of ‘suppliers of energy services’: Carl Weinberg is the Manager of Research and Development for Pacific Gas and Electric Company, California, a utility at the forefront of current thinking. He quotes:

“Clearly we are dealing with the idea of ‘enoughness’. Provide the need and the service with the minimum among of electricity. This requires and minimum amount of generation, requiring the minimum amount of natural resources (fossil fuel, iron ore, etc.). And the fewer natural resources you use, the close you come to ‘sustainability.’”

“Under this model, the utility is no longer a supplier of electricity, but a suppliers of services. A satisfier of needs – heat, light, refrigeration, cooling. Utilities can play a major role (towards a new strategy of ‘enoughness’ and ‘sustainability’), but all involved utilities, regulators and customers must reach consensus on a new set of rules, a new social contract.”

As the science and technology consultant to the editorial staff of Fortune magazine, Richard Buckminster Fuller and his researchers harvested all the statistics for the magazines tenth anniversary issue "USA and the World", February 1940. In that issue Fuller described and was able to prove that:

"The amount of energy being electrically generated and consumed became the most sensitive indicator of the economic health of any industrial economy."

4.0 APPENDIX 1 – ENERGY INDUSTRY ARTICLES

1. Energy for Planet Earth, Scientific American, September 1990
2. Energy in Transition, Scientific American, September 1990
3. Energy for the Developing World, Scientific American, September 1990
4. Energy from Fossil Fuels, Scientific American, September 1990
5. Energy for Industry, Scientific American, September 1990
6. Energy for Buildings and Homes, Scientific American, September 1990
7. Energy for Motor Vehicles, Scientific American, September 1990