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# Energy, Development and Environment Nexus: A Review

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**Abstract**
Since the beginning of the economic era, human beings have exploited and used different sorts of energy which renovated living conditions for billions of people enabling them to relish a level of comfort and flexibility unprecedented in human history which enabled to perform productive tasks. For most of the past century constant growth in energy consumption has been closely knotted to intensifying levels of wealth and commercial prospect. Demand for energy is growing rapidly in developing countries due to rapid population growth and rapid economic expansion. This is forecasted to lead to a near doubling in primary energy use, much of it is unsustainable, in the coming couple of decades. Due to this high demand, 50% of primary energy is utilized in developing countries and will be responsible for 52% fossil fuel related Carbon dioxide emission by 2030. Energy services are provided with least cost and are environmentally friendly when derived from clean and renewable energy resources. On the contrary, unit cost of energy services provided from non-network sources are costly and polluting to the environment. The link between energy and climate change is that climate change engrosses the energy sector predominantly closely because energy is central both to the problem and its resolution.
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## 1. Introduction

The capacity to harness and use numerous sources of energy has renovated living conditions for billions of people since the beginning of the industrial era, enabling them to enjoy a degree of comfort and mobility incomparable in human history and freeing them to perform ever more productive tasks. The steady increase in energy demand has been closely related to increasing levels of development and economic opportunity in most of the world for much of the last 200 years (TWAS 2008).

Today, however, mankind finds itself facing a massive energy challenge. There are at least two important aspects to this challenge. It has become apparent, on the one hand, that existing energy consumption practices are environmentally unsustainable. In particular, overwhelming dependency on fossil fuels threatens to change the climate system to a degree that could have significant repercussions for the integrity of critical human and natural systems. Around the same time, energy access proceeds to distinguish the ‘haves' from the 'have-nots'. According to some figures, a significant proportion of the world's population of more than two billion people still needs access to one or more forms of basic energy services, including electricity, renewable cooking fuels, and adequate means of transport.

Total energy production and usage increased more than 50-fold between 1850 and 2005, from a global total of approximately 0.2 billion toes (tons of oil equivalent) to 11.4 billion toes (IEA 2008). Much of this rise took place in developed societies, which had come to rely heavily on the ready availability of resources. People in these communities today consume more than 100 times the amount of energy that our ancestors used before people learned to take advantage of the energy capacity of fire on a per capita basis (UNDP 2000).

As populations have evolved, they have not only used more energy, but they have used energy in various ways, usually, swapping: as household incomes increase, from conventional fuels such as wood, crop residues and dung to commercial forms of energy (i.e., fuels that can be purchased and sold) such as oil, gas, propane and electricity. As most commercial sources of energy are derived from fossil fuels (in particular, coal, petroleum and natural gas), the consumption of these fuels grew much more rapidly rising by about 20 times in the 20th century alone. Non-renewable, carbon-emitting fossil fuels currently account for about 80% of the world's primary energy requirements (IEA 2007).

Overall, a minimum of one-fourth of the world’s 6.6 billion people are unable to require advantage of the essential amenities and opportunities made possible by modern sorts of energy (TWAS 2008). Inequities in per capita electricity use are even larger than the inequities in per capita primary energy use. In 2005, the typical citizen within the OECD countries used 8,365 kwh of electricity. Against this, the typical citizen in China used 1,802 kwh, the typical citizen elsewhere in Asia used 646 kwh, the typical citizen in Latin America used 1,695 kwh and the average citizen in Africa used 563 kwh (TWAS 2008). These estimates and projections clearly indicate unsustainable utilization of energy resources and complex energy footprint within the developed world, which generally discarded the assumptions of stewardship and sustainability.

 

No energy production or conversion technology is without risk or waste. Somewhere along all energy chains: from the extraction of resources to the supply of energy services, pollutants are produced, emitted, or disposed of, often with severe impacts on human health and therefore the environment. The combustion of fossil fuels is liable for most urban pollution, regional acidification, and risks of human induced global climate change. The utilization of atomic power has created variety of concerns about the security of nuclear installations, the storage and disposal of high-level radioactive material, and therefore the proliferation of nuclear weapons. The manufacturing of photovoltaic panels generates toxic industrial waste, and in some developing countries the utilization of biomass contributes to desertification and biodiversity losses.

At the global level, the energy system: supply, transformation, delivery and use are the dominant contributor to climate change, representing around 60 per cent of total current greenhouse gas (GHG) emissions (IPCC 2001). Present patterns of energy production and consumption are unsustainable and on both local and global scales, endanger the environment. Fossil fuel combustion emissions are a significant contributor to the unstable impacts of climate change as well as to urban air pollution and land and water acidification.

For a rising population with higher aspirations for well-being, the challenge for the 21st century is how to evolve sustainably and preserve the quality of life. The need for adequate and sustainable energy sources to provide the economic activity that underpins these demands is at the heart of this challenge.

### *1.1. Energy and development*

In the past 50 years, the planet has generally seen tremendous growth and advancement. Living conditions have changed, individuals have been healthier and longer-lived, and human wellbeing has been greatly improved by science and technology. The availability of ample and cheap energy sources, especially in the form of crude oil, has undeniably donated to these achievements (IEA 2006).

For sustainable growth, proper functioning of the economy and human well-being, adequate global energy supplies are important, both for the world as a whole and for individual countries. Thus, it is important to ensure and secure the continuous availability of energy in the quantities and forms needed by the economy and society.

Nevertheless, while all these advances are very motivating, they are no cause for complacency. Life is a continual process of conversion and transformation of resources. Civilization's achievements have largely been accomplished by the highly effective and systematic harnessing of diverse sources of energy to expand human abilities and creativity. For continued human progress and economic growth, energy is equally indispensable. To eliminate hunger, enhance human health and increase living standards worldwide, the provision of adequate, affordable energy is crucial. And it will be hard to resolve environmental issues without economic development.

For growth, energy is central. Through its role as a production input, and as a direct component of human well-being, it has a key role in economic growth. There are many ways in which improved energy availability or efficiency may improve productivity and thus provide physical and/or human capital resources effectively.

Transmission mechanisms are likely to vary across stages of growth - growing energy supply and versatility in more advanced developed countries may encourage the use of modern machinery and techniques that extend the efficient capital-labour ratio, as well as increase workers' productivity. Whereas energy supply shifts in less developed countries are economical for household labor, here the availability of energy will increase the efficiency of industrial labor in the formal and informal sectors.

Human operations and most issues of sustainability are closely related to the use of energy. It is easy to imagine the world (humans, structures and environment) as a flow of and connected by energy. Energy is a critical component of productivity factor (capital, labor, land), it can limit well-being, lacking energy imposes time on households and labor burden. The key issues of sustainability (poverty alleviation, health education, economic development) and climate change are directly related to energy production and use. And some of the other significant issues of sustainability (freshwater, land use, integrity of the environment, agriculture) are directly/indirectly connected to energy production and use.

### *1.2.* The contribution of energy to economic development

Numerous studies have shown that access to energy services is definitely linked to human development. To better understand the role of energy in human development, the International Energy Agency recently developed the Energy Development Index, which measures a country’s progress in its transition to modern fuels as well as the degree of maturity of its energy end-use (Raskin 2006).

While energy usage and economic growth are being decoupled at higher levels of development, modest rises in energy use are also correlated with drastic changes in the quality of life for the world's poorest people. Consumption of energy strongly correlates with both welfare and economic development. Modern energy services at the local level help reduce the burden of women's, improve health and education, and stimulate micro-enterprises. At the national level, by promoting industrial growth and offering access to foreign markets and trade, energy services promote economic development.

In the global fight against poverty, energy services are more critical than ever because these services underpin

 

economic development, creating employment where they are most needed. Without electricity, even small-scale village and household enterprises in developing countries, which are the main source of income for the poor in those countries, most economic activity would be unlikely.

The importance of energy services for social development is echoed in the connotation between energy consumption and human development. Studies show the robust parallel between commercial energy consumption and UNDP's Human Development Index.

This index is composed of human development indicators that reflect achievements in the record basic human capabilities: leading a long life (life expectancy), being knowledgeable (educational achievement), and enjoying a decent standard of living (income, measured in purchasing power parity terms) (IEA 2007).

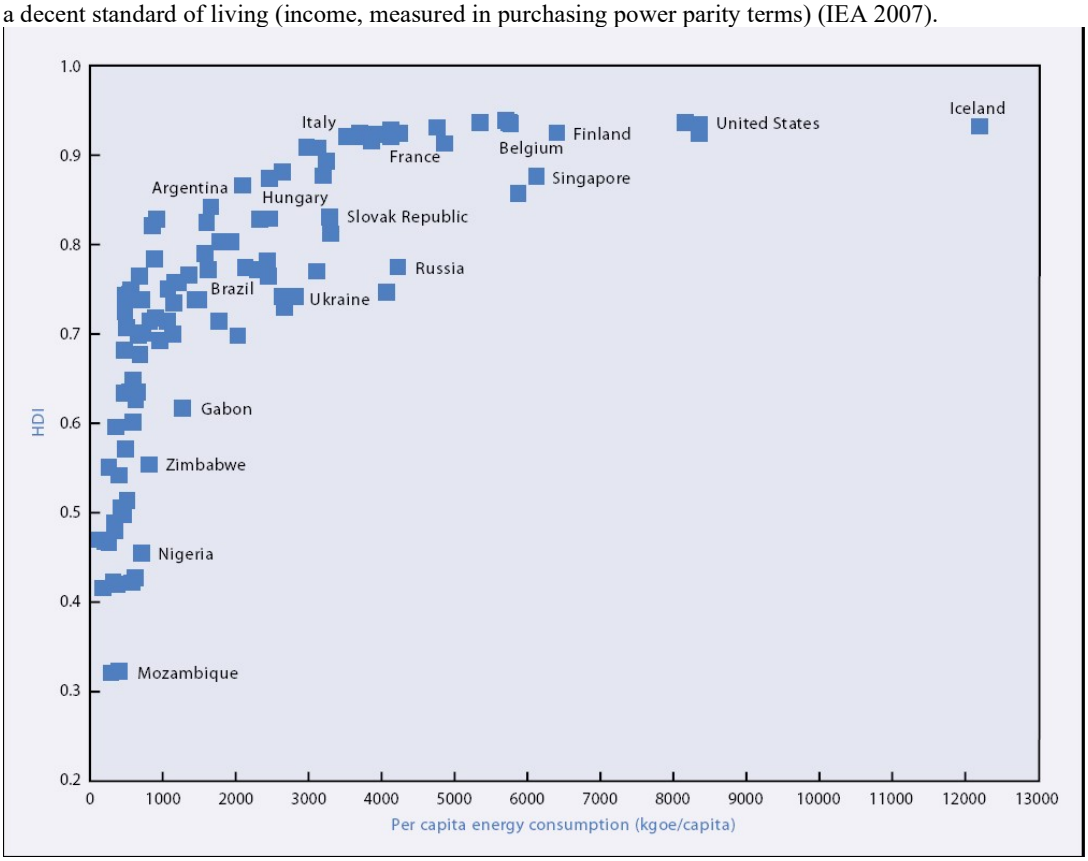


Figure 1: Relationship to HDI and per Capita Energy use: Adapted from (UNDP 2004).

The absence of consistent energy services imposes tremendous costs on industry and commercial businesses, reducing their productivity and hence their ability to grow and provide jobs. This condition enshrines poverty, restricts the availability of social services, limits women's opportunities, and erodes environmental sustainability.

Energy preferences can have large macroeconomic impacts, affecting governments' ability to meet the immediate needs of their poorer people. The effect of reliance on energy imports on low-income countries and poor households is becoming increasingly alarming during times of high and unpredictable oil prices. Although a handful of low-income countries are net oil exporters, the majority are not and many suffer from energy import bills, which account for a large percentage of both GDP and total export earnings. Thus, a competitive and diversified energy mix is essential to the growth of domestic industry and jobs, national economic health, and the availability of public funding to achieve the MDGs.

Modern energy services, such as lighting, cooking, heating, cooling, transport, electricity and electronic communications, are important for increasing efficiency, creating businesses, creating jobs and incomes, access to clean water and sanitation, health and education. Energy must play a more prominent role in strategies for achieving the Millennium Development Goals,

As mandated by the Millennium Development Goals of the United Nations, the provision of modern energy services is essential for the eradication of extreme poverty. This includes the implementation as rapidly and cost-effectively as possible of energy technologies. Although adequate attention has yet to be paid to the importance of expanding modern access to energy for the achievement of the MDGs, a number of recent publications published in parallel with the Millennium Project Study have discussed it. For the most part, the energy demands to fix MDGs are technologically neutral, i.e., access to safe and inexpensive energy, not the actual source of that energy,

 

is most important.

### *1.3. Energy and the Sustainable Development Goals (SDGs)*

Access to energy resources is vital to the progress of human growth, the social inclusion of the poorest and most disadvantaged in society, and the achievement of many of the SDGs. In September 2015, the Sustainable Development Goals, officially known as the 2030 Plan for Sustainable Development, were adopted by 193 countries - both developing and developed countries. The 17 new SDGs are aimed at ending poverty, improving health and equality between men and women, protecting the environment and ensuring stability and prosperity for everyone. For the first time, the SDGs provide an aim focused explicitly on ensuring entree to accessible, reliable and modern energy for everyone by 2030, signaling a recognition of the value of access to modern energy services in its own right, and of the centrality of energy in achieving many of the other development goals (IEA 2017).

Lack of access to modern energy can make it difficult or impossible for a country to confront the myriad challenges that it faces, such as poverty, air pollution, low levels of life expectancy and lack of access to essential healthcare services, delivering quality education, adaptation and mitigation of climate change, food production and security, economic growth and employment, sustainable industrialization and gender inequality.

Lack of access to modern energy will make it difficult or impossible for a nation to tackle the myriad challenges it faces, such as poverty, air pollution, low life expectancy and lack of access to critical health services, quality education, climate change adaptation and mitigation, food production and security, economic development and jobs, sustainable industry and gender inequality.

#### 1.3.1. Energy access and gender equality

While insufficient access to modern and sustainable sources of energy has an effect on both men and women, disparities in social status and gender roles mean that women frequently suffer unevenly from lack of access to energy. Women prefer to be responsible for gathering and storing fuel for cooking and cooking themselves in developing countries. Households spend an average of 1.4 hours a day collecting fuel, a burden created primarily by women and children (Practical Action 2016).

The loads they bear may also have an effect on their physical well-being; women carry loads weighing as much as 25-50 kilograms in Africa (UNEP 2017). Lack of access to safe, modern cooking stoves and fuels and reliance on the traditional use of biomass for cooking also mean that household air pollution affects women and children) the most.

Women often spend a few hours doing household tasks indoors, such as cleaning and washing cloths, which take longer to do without access to modern resources.

Providing access to modern, sustainable and secure energy sources has the ability to enhance women's and children's well-being and to create new economic opportunities for women. It is possible to channel time saved by access to modern energy into schooling, social and family activities, and economic opportunities.

Women are often best placed to identify, champion, and deliver solutions for energy access. The evidence suggests that there are significant advantages to involving women in the development of modern energy access technologies and programs from start to finish and empowering women to become more involved in the provision of energy services (ARE 2017; UNIDO 2013). This is partly because they have specific local knowledge about how household needs could be served by various options.

##### 1.3.1.1. Energy access and health

Health is another area in which there is an especially important link with access to energy. The use of candles, kerosene and other polluting fuels for lighting has serious health consequences: solid biomass and coal are also used for cooking (often in an enclosed space without proper ventilation). Together, they account for an estimated 2.8 million premature deaths worldwide each year (IEA 2017).

Energy access also provides access to improved maternal care medical facilities, allowing for refrigeration of medicines and sterilization of equipment. Facilitating drug development, production and distribution. Providing access to health education media. In particular, it allows access to the latest medicines and expertise through telemedicine systems based on renewable energy. Other synergies between access to energy and health are present. Many individuals take for granted that healthcare facilities rely on energy to function and provide vital services.

Nearly 60% of health facilities in sub-Saharan Africa do not have electricity, while only 34% of hospitals and 28% of health facilities in sub-Saharan Africa have reliable access to electricity on average (WHO and World Bank 2014). An approximate 60% of refrigerators used in health clinics in Africa have unreliable electricity, resulting in nearly half the loss of vaccines, while 70% of electrical medical devices used in developed countries malfunction, with poor power quality being a major contributing factor (UNEP 2017; WHO 2010). In addition, the lack of electricity means that medical workers often have to work with flashlights or kerosene lamps.

Efforts to improve access to clean cooking have an immense potential to enhance the quality and health of indoor air, particularly for women and children. Significant particulate matter is released by incomplete combustion of solid biomass in a three-stone fire, which is the most common traditional cooking method.

 

1.3.1.2. Access to energy and education

Access to energy in the form of lighting enable classes to be taught early in the morning or late at night. Energy access facilitates the introduction of ICTs into the classroom such as computers and televisions. Electrified schools can enable principals to recruit and retain better qualified teachers, to improve quality education, test scores and graduation rates.

1.3.1.3. Access to energy and poverty alleviation

Usually, poor households and communities rely on a variety of energy sources, using one heating fuel, another for cooking or illumination, another for farming or other productive activities. The actual (per unit costs of these alternative energy sources are often high compared to those of electricity or gas distributed to wealthier households through networks. In addition, these sources of energy also have high non-monetary costs.

For example, when women and children spend several hours gathering firewood or dung for heating and cooking, they have less time for education or other productive activities to grow. And it can have significant health and environmental effects for the use of conventional energy sources.

Meeting the needs of the poor for renewable energy, in turn means seeking technical and structural advances that minimize the cost of accessing and using energy resources and adapt them to the needs of households and communities with low incomes. This requires some understanding of how they are actually receiving services and the nature of their desire for better services.

Energy services such as lighting, heating, cooling and electronics and motive power are delivered in the most cost-effective and convenient manner, and with the least local emissions, when they are generated by electricity or gas supplied via networks. This is because the unit cost of energy from non-network sources is high compared to that of energy supplied through networks. This will significantly increase the efficient income of low-income households by switching from conventional to modern fuels. (UNDP 2004).

*1.4. Energy poverty*

In various parts of the world, the use and quality of energy differ significantly. The estimated annual intake of modern energy per capita (i.e., excluding conventional biomass and waste) in 2005 was 1,519 kilograms of oil equivalent (kgoe). Although the average is 5,228 kgoe in high-income countries, it is just 250 kgoe in low-income nations. 10.6% of the overall global supply of primary energy is accounted for by conventional biomass and waste. In low-income countries, these sources constitute 49.4% of the supply on average, with some countries touching 90% of the supply (Flavin and Aeck 2008). The only widely accessible and sustainable source of energy for the world's poor is "traditional biomass," including fuelwood, crop residues, and animal waste. Sometimes, even these primitive fuels are not accessible to the poorest section of the population. Opportunities for economic growth and better quality of living are limited without modern energy. Women and children in unindustrialized nations agonize excessively, as they spend much of their time collecting wood.

Approximately two billion people around the world do not have access to electricity in their homes, representing just over a quarter of the world's population (IEA 2007). This lack of power deprives individuals of essential necessities such as ventilation, lighting, and communications. The majority of those deprived of electricity live in South Asia and sub-Saharan Africa, according to the same study.

Energy production is correlated with both positive and negative results. On the one hand, it is widely recognized that an appropriate and efficient supply of energy resources, such as heat, light and motive power, is a precondition for sustainable economic growth in the sense of the global economy. In addition, increased access to energy resources is positively associated with enhanced human welfare.

However, in recent years, with rising international awareness of the ongoing climate change process (also known as 'global warming'), the most significant challenge to the global environment today, the negative effects of energy use have gained widespread attention. The primary focus has been on the emissions into the atmosphere of toxic gases ('greenhouse gases') from the burning of fossil fuels. Such emissions have risen more than four-fold since the middle of the 20th century at a global level. In response, the international community signed the UN Framework Convention on Climate Change in the early 1990s and the adopted the Kyoto Protocol (which came into force in 2005) to slow down and reverse the high levels of atmospheric GHG concentrations.

*1.5. Growing energy demand and addressing energy poverty*

Energy leads to a virtuous cycle of human, economic and social changes required for sustainable growth. Sufficient renewable energy supplies are the cornerstone for raising living standards, improving the quality and quantity of human resources, improving industry and the natural environment, and improving the efficacy of government policies.

In many areas of the world, however, energy scarcity remains a major concern for human health, economic growth and environmental sustainability. Approximately 1.6 billion people lack access to electricity, and 2.5 billion people rely on conventional biomass for cooking and heating, mainly in rural areas of Sub-Saharan Africa, South and East Asia and Latin America. Due to exposure to indoor air pollution from cooking and heating with

 

conventional, inefficient biomass stoves, around 1.3 million people, mainly women and children, die prematurely every year (Legros et al. 2009).

Due to rapid population growth (especially in Africa) and rapid economic expansion, energy demand is exponentially increasing in developing countries (especially in China and India). In the next two decades, this is expected to lead to a near doubling in the use of primary energy, most of it unsustainable, by developing countries. As a consequence of this development, by 2030, developing countries will account for 50% of primary energy usage and 52% of energy-related CO2 emissions.

*1.6. Energy and sustainability*

The relations between energy and economics were a prime concern in 1970s. At the time, linkage between energy and the environment did not receive much attention.

The relation between sustainable development and the use of resources, particularly energy resources is of great significance to societies. Attaining sustainable development requires that sustainable energy resources be used, and is assisted if resources are used efficiently. (IEA 2006).

The world energy assessment describes sustainable energy as energy produced and used in ways that support human development over the long term, in all its social, economic and environmental dimensions. This is not meant to refer solely to a continuing supply of energy, but to the production and use of energy resources in ways that promote, or at least are compatible with, long term human well being and ecological balance.

In order to achieve sustainable growth, Bruntland found a secure and sustainable energy path to be essential. Energy fuels economic growth and social advancement, while current energy production and usage practices have resulted in a plethora of environmental issues, including, though not limited to, local and regional emissions, desertification and climate change.

For economic growth and the transition from subsistence agricultural economies to modern industrial and service-oriented societies, adequate and affordable supplies of energy have been crucial. Energy is vital to improving social and economic well-being and is important for the development of most industrial and commercial wealth. It is essential to eradicate poverty, to improve human welfare and to increase the standard of living. But for growth, it may be essential; energy is only a means to an end. Good health, high standards of living, a healthy economy and safe environment are achieved at the end of sustainable energy hierarchy. No source of energy is good or bad in itself; gas, solar, nuclear, wind or any other is good or bad, and each is only beneficial to the degree that this end can be achieved. (Flavin and Aeck 2006).

Much of the existing energy supply and usage is known to be environmentally unsustainable, dependent, as it is on limited fossil fuel resources (UNEP 2002). There is no energy generation or conversion technology without risk or without waste. Contaminants are produced, released or disposed of somewhere along all energy chains, from resource extraction to the provision of energy services, often with severe health and environmental impacts. Even if a technology does not release hazardous substances at the point of use, its manufacturing or other aspects of its life cycle may be correlated with pollution and waste. Fossil fuel combustion is largely responsible for urban air pollution, regional acidification and the risk of anthropogenic climate change.

Around one-third of the world's population also depend on the use of non-commercial fuels and animal power. There is no access to electricity for some 1.7 billion people. There are no safe and stable energy sources in many parts of the world (IEA 2007). This lack of access to modern energy resources, which is an important part of sustainable growth, significantly limits socio-economic development. Nevertheless, thanks to advanced technology and a better understanding of the consequences and impacts of energy and energy systems, a developing country can now transition from an agricultural to an industrial economy at a much lower cost and with less disruption to the environment than it has suffered in today's developed countries during its transition.

There are two essential features in the relationship between energy production, consumption and sustainable growth. One is the value of sufficient energy services to meet basic human needs, to enhance social security and to achieve economic development: energy, in short, as a source of prosperity. The other is that energy production and use should not jeopardize the quality of life of current and future generations and should not exceed the ecosystem's carrying capacity.

As noted, energy systems must not overload the carrying capacity of ecosystems in order to be considered sustainable. Nor should the use of scarce resources threaten the capacity of future generations to fulfill their requirements for energy service. Therefore, the key strategies for sustainable energy production are the effective use of resources, clean conversion processes and the timely development of inexhaustible supply choices, such as renewable forms or nuclear energy based on breeding or fusion.

It will involve the judicious use of capital, technology, adequate economic incentives and strategic policy planning at local and national levels to achieve sustainable economic growth on a global scale. The impacts of chosen policies and initiatives would also need to be periodically reviewed to see whether they encourage sustainable development or whether they can be changed. It is crucial that a country's state of development can be planned and that its progress or lack of progress towards sustainability is monitored.

 

## 2. Sustainable energy technologies

The different energy supply technologies that will play a role in a carbon constrained future are important to eradicate the twin problem associated with energy use. Sustainable energy is the provision of energy that meets the needs of the present without compromising the ability of future generations to meet their needs. Sustainable energy sources are most often regarded as including all renewable energy sources, such as hydroelectricity, solar energy, wind energy, wave power, geothermal energy and tidal power. It usually also includes technologies that improve energy efficiency.

### *2.1. The key elements of sustainable energy*

The key elements of sustainable energy as identified by The Bruntland report are: sufficient growth of energy supplies to meet the needs of humanity (including an allowance for development in non-developed countries), increase and improvement in energy efficiency and conservation measures, shifting the current energy mix more toward renewable resources; public health recognizing the safety risks posed by energy uses and production of the biosphere and elimination of local pollution problems.

## 3. The impact of energy production and use on the environment

There are neither healthy nor sustainable current patterns in energy consumption: economically, environmentally or socially. The potential for sustained economic growth is threatened by energy and environmental issues and leads to political and economic uncertainty. A large range of stresses are imposed on the environment by the production and consumption of resources.

According to the World Energy Outlook (IEA 2007), if governments around the world continue with current policies, the world's energy needs would be 55 % higher in 2030 than in 2005, with China and India accounting for much of this rising demand. Some 84% of the increase in primary energy demand will have to come from fossil fuels. Energy production and use, particularly of fossil fuels, have a number of environmental impacts including air pollution, greenhouse gas emissions and adverse impacts on ecosystems (EEA 2008).

Man has lived in harmony with nature for millions of years. But an era of ever-growing fossil fuel combustion started with the Industrial Revolution, and the discovery and production of resources to fuel the revolution, resulted in water pollution, air pollution, deforestation, and rising concentrations of atmospheric carbon dioxide.

The planet faces twin challenges associated with energy. The first is not having sufficient and safe supply of energy at reasonable rates and that there is an environmental damage caused by too much consumption (IEA 2006).

For the world, energy and climate change have continued to be major issues. The production and consumption of almost any kind of energy has impact on the environment. Emissions of pollutants to the environment are associated with the production, supply and consumption of energy sources and services worldwide: air, soil and water, causing environmental damage that impacts on the health and well-being of all living things. It is clear that global climate change concerns have focused particular attention on atmospheric emissions of carbon dioxide (CO2) and other greenhouse gases (GHGs). Historically, fossil fuel combustion has been and continues to be a major cause of the increased atmospheric concentration of GHG.

Coal, which is relatively plentiful and inexpensive compared with other fossil fuels, is widely used in many countries for the production of electricity. All aspects of its use are destructive to the environment. First, coal mining itself is an extremely polluting activity that is harmful to human health as well.

Coal combustion creates higher levels of CO2, nitrous oxides and oxides of sulfur than any other sources. Sulphur and nitrous oxides interact with ambient moisture to create Sulphuric and Nitric acid in the air, in addition to leading to elevated GHG concentrations. Sometimes referred to as 'acid rain,' this phenomenon can destroy forests and water supplies, as well as their associated plant and animal life, even at great distances from the source of the original emissions. Coal combustion also creates particulate matter that can be transported for hundreds of kilometers in the air.

### *3.1. Greenhouse gas emissions*

Energy related greenhouse emission (GHG) emissions remain dominant, accounting for 80% of global emissions with the largest emitting sector being electricity and heat production, followed by transport (IEA 2007).

*Carbon dioxide*

Carbon dioxide (CO2) is by far the most important greenhouse gas. Analysis of ice cores from Greenland and Antarctica reveals that the atmospheric pre-industrial carbon dioxide concentration was about 280 ppmv (parts per million by volume). In the year 2000, the concentration was just over 30 percent higher at 368 ppm (IPCC 2001). The largest source of carbon dioxide emissions is fossil fuels, which account for about 80% of the world's energy supply. According to the International Energy Agency, in the year 2000, emissions of carbon dioxide attributable to energy amounted to 24 billion tonnes, or 6.5 billion tonnes when measured as carbon. About 40% each came from coal and oil and 20% from fossil gas (also known as "natural gas"). It is estimated that shifts in land use (mainly deforestation) have led to approximately one quarter of global carbon dioxide emissions over the last 20

 

years, or about 1.5 billion tonnes of carbon per year.
Once released from fossil storage, carbon dioxide remains in the atmosphere for a very long time and can affect the climate long into the future.

*Nitrous oxide*

A greenhouse gas with an average pre-industrial concentration of 270 ppb is nitrous oxide (N2O). The concentration in the year 2000 was 316 ppb, a rise of 17%. Nitrous oxide stays in the atmosphere for a long time, about 120 years on average. According to international estimates, between 1970 and 1995, emissions increased by 40 per cent, although they were relatively small at the end of this period. The accumulation of NOx gases is typically responsible for climate change and greenhouse effects.

*Methane*

The methane (CH4) pre-industrial concentration is calculated to have been 0.7 ppm. The amount today is more than twice as high, at around 1.8 ppm. Global emissions between 1970 and 1990 are estimated to have risen by 20%, but the amount in the air has remained steady ever since. "Global warming," "climate change" and the "greenhouse effect" are common words that describe the danger to human and natural environments from the continued emission of fossil fuel heat-trapping or "greenhouse" gases. These emissions, at an unprecedented pace, alter the composition of the atmosphere.

### *3.2. Land degradation and deforestation*

For more than 90% of the population in Developing countries especially sub-Saharan Africa and Asia, the only energy used for cooking, heating and lighting is obtained from biomass, in which 99% is derived from fuel wood, charcoal, crop residue and leaves, fuel wood occupying the leading position (Smith et.al. 2000).

To needs of exponentially increasing population is met at the expense of forest and its clearance. This directly contributes to deforestation. Both climate change and growth are central to the relationship between forests and resources. In developing countries, almost the entire population relies on charcoal or wood for household fuel, the key cause of deforestation and agricultural expansion. Every year, millions of hectares of tropical forests are lost because of the need for subsistence oil. The effect of deforestation is soil erosion, which is the reduction of the land's service capability.

Deforestation has been an issue for decades, leading to massive loss of species and biodiversity. Billions of people must face the problem of domestic energy needs that pushes them to deforestation, adding to the problems of drought and desertification.

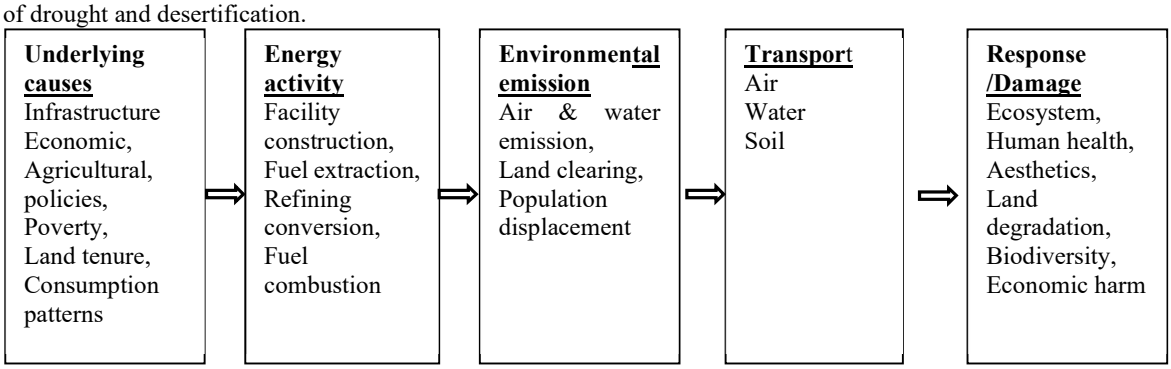


Figure 2 The relationship between energy use and environmental impact (Lazarus and Hippel 1995).

### *3.3. Pollution*

Pollution is the introduction of contaminants into the natural environment. Things as simple as light, sound and temperature can be considered pollutants when introduced artificially into land, soil and water. Pollution can be various types. Some of them are discussed as follows.

#### 3.3.1. Air pollution

The generation and use of energy lead to the acidification of water bodies and soil, emissions of tropospheric ozone precursors and emissions of (primary) particles. Energy-related emissions from transport and energy production contribute substantially to all emissions, with the transport sector being especially dominant in terms of ozone precursors (due to NOX emissions).

The ecosystem is also impaired by air pollution. Ozone can damage vegetation, adversely affecting the growth of plants and trees. These effects can limit plants' ability to absorb CO2 from the atmosphere and impact whole ecosystems indirectly. Visibility is decrease by particles in the atmosphere that disperse and absorb light (Godish 2004).

Indoor air pollution is another concern. A major challenge to the health of the world's poor is household energy and indoor air pollution. In general, households depending on biomass and coal use the fuel indoors in open

 

fires or in poorly working stoves, and typically with insufficient smoke venting. Biomass fuel and coal smoke contains a significant number of health-hazardous contaminants, including small particles, carbon monoxide, nitrogen dioxide, formaldehyde, sulphur dioxide (primarily coal), and carcinogens such as benzo pyrene and benzene.

The cumulative effects tend to be important for acute respiratory infections in children and chronic lung disease in adults, and the overall public health influence of indoor air pollution is significant in developing countries.

3.3.2. Pollution from oil spills

Oil contamination caused by coastal refineries, offshore facilities and maritime transport has placed tremendous strain on the marine environment. The consistency spilled oil can cause surface contamination and smother marine biota. Moreover its chemical components may have immediate toxic effects and long-term implications. Oil discharges from offshore facilities and coastal refineries have declined since 1990, despite increases in the production of oil and the aging of many large oil fields. This development is largely attributed to the increased use of technology for cleaning and separation (EEA 2008).

## 4. Energy and climate change

Non-renewable sources currently supply roughly 90 percent of the world's energy demand. Energy shortages are inevitable as world demand rises, unless we step up conservation efforts and rely more heavily on renewable energy sources. All practices involving energy extraction, conversion and transport have either direct or indirect adverse effects from an environmental point of view. The degradation of natural resources and ecosystems, contamination of soil and water, (hazardous) landfilling of waste and air pollution are clear examples. Air contaminants such as carbon oxides, sulphur dioxide, nitrogen oxides and respirable dust are produced by the burning of fossil fuels for energy, all of which have negative effects. For instance, one contributor to global warming and climate change is $CO_2$ emissions caused by human activities.

Climate change is a long-term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years (IPCC 2001).

Some naturally occurring gases such as carbon dioxide ($CO_2$) and water vapor, induce a greenhouse effect to trap heat in the atmosphere. $CO_2$ is introduced to the atmosphere by the combustion of fossil fuels, including oil, coal and natural gas. In the last 650,000 years, the a record $CO_2$ concentration was recorded. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change states that the majority of the global average temperature increase observed since the mid-20th century is very likely due to the observed increase in the concentration of anthropogenic greenhouse gases."

Over the past two hundred and fifty years, concentrations of greenhouse gases and in particular, carbon dioxide have increased, primarily due to the burning of fossil fuels for energy production. The $CO_2$ concentration in the atmosphere has risen from about 270 ppm to about 370 ppm since the Industrial Revolution in the 18th century. Owing to cattle processing, rice cultivation, and the release from landfills, methane concentrations have also increased. Nearly one-third of the emissions of human-induced nitrous oxide derive from industrial processes and from vehicle emissions.

There is a remarkable observable rise in the temperature of the earth's atmosphere, oceans, and land masses due to such concentrations of green house gases. This is caused by greenhouse gas emissions arising from the burning of fossil fuels. In doing so, the trace geochemical cycles are influenced by global climate processes.

## 5. Conclusion

Energy is the lifeblood of the global economy and development has traditionally been related to the universal availability of affordable energy; without a sharp rise in the use of commercial energy and/or a change to more productive energy sources that provide better quality energy services, no country in contemporary days has reduced poverty significantly.

Access to energy for lighting is linked to economic and social development as it enables home study in the evenings, increases security, enables use of information and communications technologies (ICTs) and allows commercial activity to occur at night, the productive use of energy is essential for poverty reduction.

Access to energy for lighting is related to economic and social development as it allows evening studies at home and schools, increases security, allows the use of information and communication technology (ICTs) and allows commercial activity to take place at night, and the efficient use of energy is important for reducing poverty.

No source of energy is free from environmental and monetary costs. These costs can make it prohibitively expensive or environmentally unacceptable for some energy supplies.

Poor ignition and efficiency of fossil fuels, specifically coal and conventional biomass systems, lead to high emissions and exposures of contaminants, resulting in high concentrations of GHGs in the environment, triggering climate change by disturbing the three pillars of sustainable growth.

The development of energy needs to be incorporated into sustainable development, where sustained

 

enhancement of people's general well-being and the broadening of their social choices are key elements.

The transition to economic development has largely been the result of a move to industrialization and a knowledge-based economy away from an agrarian economy. In exchange, such systemic shifts in an economy alter its energy use habits and levels and modify the types of fuels and energy technologies it uses. Thus, economic and social growth appears to go hand-in-hand with the transformation of the energy market.

As a nation grows wealthier, its dependency on the conventional use of biomass, mostly non-commercial and used in inefficient stoves, tends to decline while electricity use and its per-capita energy use rise.

By the introduction of efficient and less costly technologies that are capable of utilizing more abundant, safer and cheaper sources of energy, the challenges of long-term energy protection and environmental sustainability can be addressed.

The challenge for achieving sustainable development is to select energy media and end-use technologies that are best suited to community needs, most affordable and least environmentally damaging.

The challenge for achieving sustainable development is to choose energy media and end-use technologies that are ideally tailored to the needs of the population, most accessible and least detrimental to the environment. The link between energy and climate change is that climate change engages the energy sector particularly closely because energy is central both to the problem and its resolution.

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