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# The Role of Hydropower in Sustainable Development

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**Abstract:** The increasing energy demand caused by an incessantly raising world population and improving standards of living can be satisfied by the two aforementioned energy categories. The presently predominant category consists of the finite natural resources coal, petroleum, fossil gas and radioactive materials. The older but longer term category is made up of the renewable, i.e. sustainable natural energy sources delivered by the sun like solar energy in various forms, wind, hydropower, tidal and wave power, biomass and geothermal energy. Increasing globalization, the mounting pressures of population growth, 95% of which will occur in urban areas, and demographic change, coupled with global environmental issues affecting, water, air, forests, or biodiversity make the need for coordinated international action even more compelling[1]. Energy production is a global issue, and in a world where populations are increasing and economies are industrializing, the idea that global energy usage can remain flat through conservation is ridiculous. Today, the world population has reached 6 billion and is increasing by 80 million per year. A stabilisation is expected at around 8 to 11 billion. In 2001, the world electricity demand is about 160.5 Quadrillion British thermal unit (BTU), about 20 % of it renewable energy carriers and 80% non renewable energy. A central problem is the fact that 1.6 billion people are currently without access to a commercial energy and supply their needs mainly through forestry and technically primitive biomass utilisation. Moreover, there is an unbroken trend of world urbanisation with related consequences for the environment and energy supply in the overcrowded areas. Countries with huge populations such as China and India, along with most of Latin America and the rest of Asia, are industrializing with astonishing speed, yet their total energy consumption right now is only at the beginning of a rapid increase. If the per capita energy consumption in the developing world were to reach only 50% of that consumed by the citizens of industrialized nations, and if everyone in the prosperous industrialized nations were to conserve themselves down to that same level, energy production worldwide would have to double. The prevailing energy issue worldwide is how will global energy production more than double in the next twenty years in a way that is clean and sustainable. Because even with highly efficient energy usage and conservation worldwide, that's what it's going to take for all the countries of the world to stay on the course of increasing prosperity. Can "non-hydro renewables" provide this much energy? Maybe, but it would take a transformation in the world energy infrastructure of unimaginable speed and scope. Environmentalists can hope that such will happen, but they will need to back up hope with technological innovation, solid business plans, and arguments that rely on reason along with passion, if hopes are to become reality. The world is undoubtedly warming. This warming is largely the result of emissions of carbon dioxide and other greenhouse gases from human activities including industrial processes, fossil fuel combustion, and changes in land use, such as deforestation.

**Key words:** Hydropower, Sustainable Development, Renewable energy

## 1. INTRODUCTION

World net electricity consumption is expected nearly double to over the next decades, according to the International Energy Outlook 2004 reference case forecast. Total demand for electricity is projected to increase on average by 2.3% per year, from 13,290 billion kilowatthours in 2001 to 23,072 billion kilowatthours in 2025 (Figure 1).

[1] The Role of Hydropower in Sustainable Development; IHA, White Paper, February 2003.

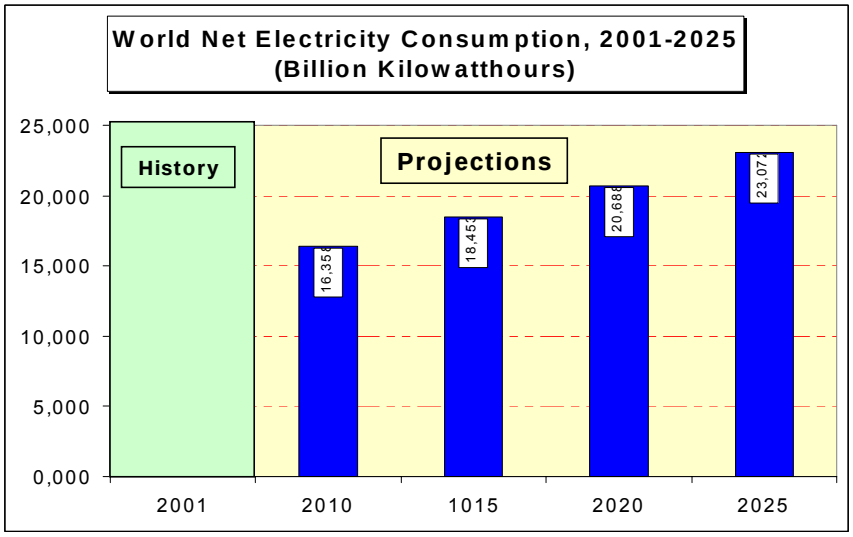


*Figure 1. World Net Electricity Consuption, 2001- 2025*

Hydropower supplies nearly one –fifth of the world's electricity, second in importance only to fossil fuel generated electricity (coal, oil, and gas). Classified as a clean, renewable energy source, hydropower reduces the net production of greenhouse gases by displacing other forms of power generation. In contrast to most other renewable sources of electricity, hydropower can supply a significant portion of the world's electricity needs.

The origin of the modern emphasis given in both domestic and international environmental law to the principle of sustainable development is the Report of the World Commission on Environment and Development (the "Brundtland Report"). While this principle has been adopted with enthusiasm in later reports and international conventions in a variety of different environmental contexts, the one area where little attention has been given until recently is energy.

This omission is surprising in light of the importance attached by chapter 7 of the Brundland Report to energy issues. The report considered energy to be a major feature of sustainability, and identified the key elements as follows:

- sufficient growth of energy supplies to meet the needs of humanity (including an allowance for development in non-developed countries);
- energy efficiency and conservation measures;
- public health, recognising the safety risks posed by energy use and production; and
- protection of the biosphere and elimination of local pollution problems.

Electric power generation should be categorized in two parts. One is for base load and the other is for peak load. The generating sources for the base load should be environmentally friendly, economical and capable of mass generation considering the enormous quantity of energy now mankind is consuming. Meanwhile, the generation for the peak load should be a flexible one in manoeuvrability and be able to provide the flexible power in a sufficient amount to cope with the big load fluctuation.

As most of the environmental impact today is coming from power generation, we have to seek for environmentally friendly and economical generating sources to disperse the gloom. From this viewpoint, hydropower is the most favorite generating sources. Geothermal, solar and wind power are the next. Especially in future solar and hydrogen energy are the most favorite generating sources.

Sustainable development is not a new idea. Many cultures over the course of human history have recognized the need for harmony between the environment, society and economy. What is new is an articulation of these ideas in the context of a global industrial and information society.

Energy is crucial to all aspects of development from powering manufacturing and modernisation of agriculture to providing electricity to run schools and health facilities, yet the impact of its

production, distribution and use grows more severe with every decade. Although new alternative and renewable as well as cleaner and more efficient technologies are being developed and implemented every year, the strain caused by the rise in energy demand and global consumption outweigh the benefits brought by these improvements. Furthermore, the growing number of people without access to very basic energy supply predicates a rapid growth in demand in the coming years. The challenge lies in finding a way to reconcile the necessity and demand for energy supply with its impact on the natural resource base in order to ensure a sustainable path of development.

Progress on developing the concepts of sustainable development has been rapid since the 1980s. In 1992 leaders at the Earth Summit built upon the framework of Brundtland Report to create agreements and conventions on critical issues such as climate change, desertification and deforestation. Throughout the rest of the 1990s, regional and sectoral sustainability plans have been developed.

Sustainable development... promotes efficient use of resources, environmental harmony, and a just and equitable social order, all at the same time, and quickly, without letting a small class of people capture all the wealth and then devising policies to help it trickle down to the long-marginalized minority.

## 2. HISTORY AND FUTURE OF HYDROPOWER

The term ‘Hydro’ is Latin for water, so hydroelectric power is made using the flow of water in a river. Hydroelectric power plants capture the energy released by water falling through a vertical distance, and transform this energy into useful electricity. In general, falling water is channeled through a turbine, which converts the water's energy into mechanical power. The rotation of the water turbines is transferred to a generator, which produces electricity. The amount of electricity that can be generated at a hydroelectric plant is dependant upon two factors. These factors are (1) the vertical distance through which the water falls, called the "head", and (2) the flow rate, measured as volume per unit time. The electricity produced is proportional to the product of the head and the rate of flow.

The first recorded use of water power (hydropower) was a clock, built around 250 BC. Since that time, humans have used falling water to provide power for grain and saw mills, as well as a host of other applications. Hydro has had a long and important historical role in providing mechanical energy, which was used in the every day's human activity. Specifically watermills were used in Mesopotamia as early as 3000 BC and since have harnessed the energy of water almost anywhere on the planet that boasts a river or stream. Anything approximating the strength of a horse that did not need to be fed or get tired was immensely valuable. The first use of moving water to produce electricity was a waterwheel at Appleton on the Fox river in Wisconsin in 1882. Hydropower continued to play a major role in the expansion of electrical service early in 20th century in the world.

Developments and improvements in electricity transmission and distribution methods led to a shift in the aims of hydroelectricity production in the early 20th century. High voltage transmission lines were developed and began supplying extensive distribution grids from large-scale hydroelectric plants.

Hydropower plants were much more reliable and efficient than the fossil fuel fired plants. Hydropower has always been an important part of the world's electricity supply, providing reliable, cost effective electricity, and will continue to do so in the future. The important role that hydropower plays, and will continue to play throughout the 21$^{st}$ Century, in world electricity supply. Hydropower, which uses the energy of flowing water to produce electricity, is the largest and least expensive source of renewable energy produced in the world today.

### *2.1. Global Hydropower Potential and Trends*

The world's theoretical hydropower potential 40,470 TWh/year total technically feasible hydro potential is about 14,322 TWh/year, of which just over 8,000 TWh/year is currently considered to be economically feasible for development (Table 1 and Figure 2).

Hydropower is only renewable energy technology which is presently commercially viable on a large scale. It has four major advantages. It is renewable, it produces negligible amounts of greenhouse gases. It is the least costly way of storing large amounts of electricity, and it can easily adjust the amount of electricity produced to the amount demanded by consumers. Worldwide, hydropower accounts for about 17% of global generating capacity, and about 20% of the energy produced each year. In many countries, hydroelectric power is the dominant source of electric power. In 2001 Norway derived 99 percent of its power from hydroelectric plants. The same year, hydroelectric power provided 100 percent of the electricity used in the Democratic Republic of the Congo (DRC, formerly Zaire) and 83 percent of the electricity used in Brazil.

Canada, the largest producer of hydroelectric power in the world, generated 327.9 billion kilowatt-hours (kWh) in 2001. This figure constituted 58 percent of the nation's electric power. Hydroelectric-power generation in the United States increased from about 16 billion kWh in 1920 to 255.6 billion kWh in 2002. Although the United States runs a close second to Canada in the total amount of hydroelectric power produced, only 7 percent of the electric power used in the United States was generated by hydroelectric power plants in 2002.

*Table 1. World Hydropower Potential*

| | **HEP Potential Theoretical (TWh/a)** | **Feasible HEP Potential Technical (TWh/a)** | **Feasible HEP Potential Economical (TWh/a)** |
|---|---|---|---|
| Africa | 4,000 | 1,750 | 1,000 |
| Asia (incl.Russia,Turkey) | 19,300 | 6,700 | 3,600 |
| Australia | 600 | 270 | 105 |
| Europe (excl.Russia,Turkey) | 3,220 | 1,225 | 775 |
| North & Central America | 6,330 | 1,657 | 1,000 |
| South America | 7,020 | 2,720 | 1,600 |
| **World** | **40,470** | **14,322** | **8,080** |

### *2.2. Enviorenmantal Impact of Hydropower*

Two major environmental issues, global climate change and local or regional air pollution, could affect energy use throughout the world in the coming decades. Current and future policies and regulations designed to limit energy related emissions of airborne pollutants, are likely to effect the composition and growth of global energy use. Future policy actions to limit anthropogenic (human caused) carbon dioxide emissions as a means of reducing the potential impacts of climate change could also have significant energy implications.

Technical, economic and environmental advantages of hydropower are shown with some of the challenges currently facing hydropower development. Hydroelectric power plants emit very few greenhouse gases in comparison with other (fossil fuel fired power plants) large scale energy options and thus helps slowing down global warming. In this respect, hydropower is better than burning coal, oil or natural gas to produce electricity, as it does not contribute to global warming or acid rain. Hydropower reduces atmospheric pollution and the resulting acidification of rain, soil and aquatic ecosystems (Figure 5).

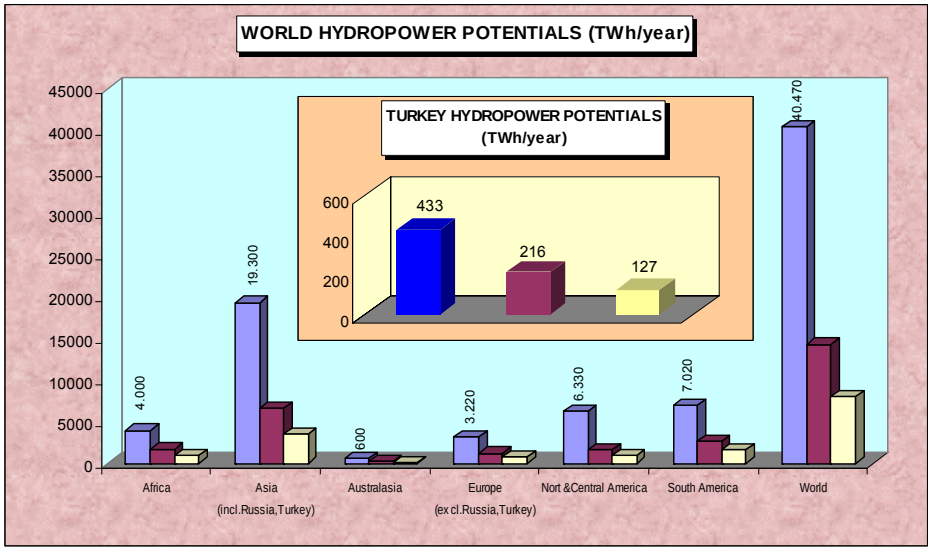


*Figure 2. World Hydropower Potential*

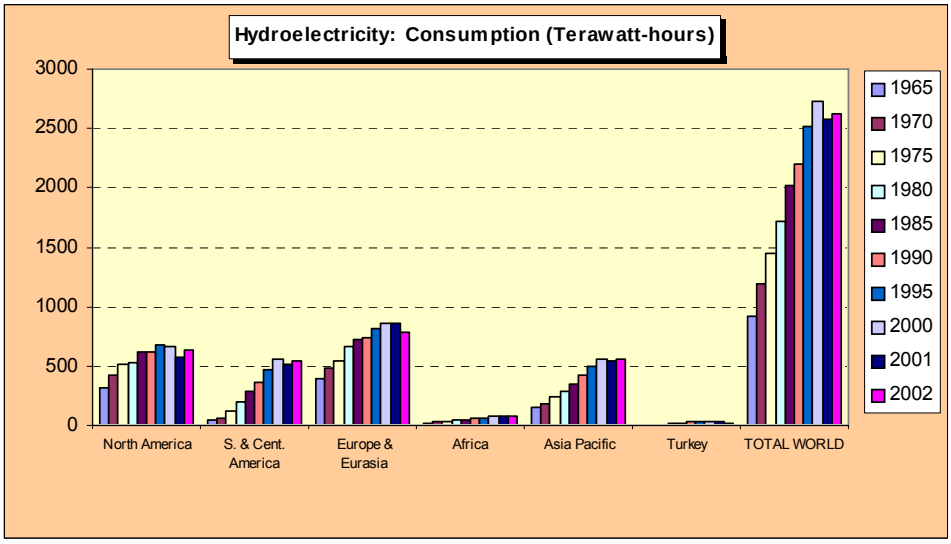


*Figure 3. World Hydroelectricity Consumption*

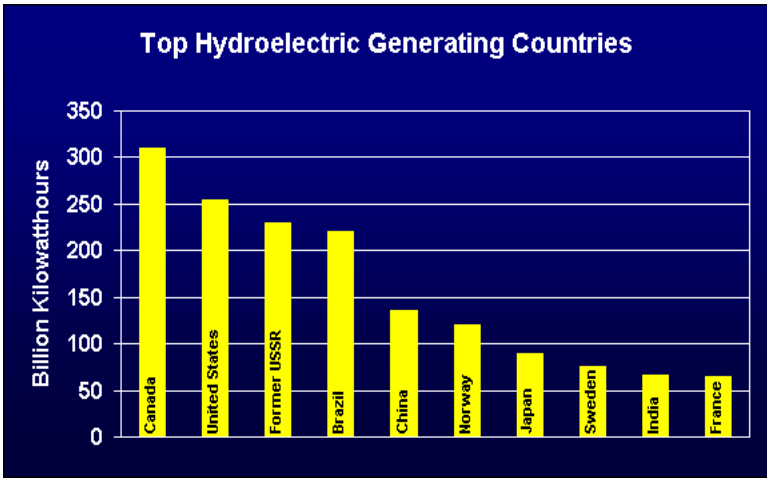


*Figure 4. Top Hydroelectric Generating Countries*

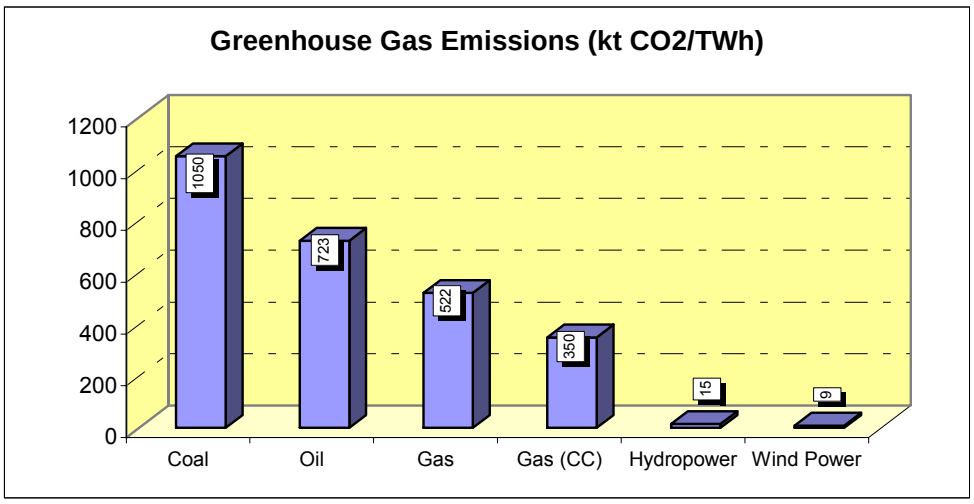


*Figure 5. Greenhouse Gas Emissions*

## 3. SUSTAINABLE DEVELOPMENT AND ENERGY

Sustainability is integral to all aspects of our business. We strive to balance economic, environmental and social objectives and integrate them into our daily business decisions to create value for all our stakeholders. In a sustainable development perspective, we must address the quality and sustainability of our use of natural resources and ecosystems, threats of global change, quality of life in our cities, and the impact of the production and use of the energy which is essential to our economies and to our way of life, and also centrally important in environmental problems, notably climate change. Making use of the knowledge and technologies developed by this programme will make it possible to meet a wide range of social and economic needs so reconciling economic development with environmental sustainability. The results will support policies formulated at Community level or deriving from international commitments.

Sustainable development means different things to different people, but the most frequently quoted definition is from the report Our Common Future (also known as the Brundtland Report): "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Sustainable development requires a balance between the nature and mankind; through this balance, it programmes for the life and development of both present and future generations without depleting natural resources. Sustainable development as a fundamental component of social responsibility, sound business practice and natural resource management. Sustainable development requires the integration of three components - economic development, environmental caution (ecology) and social justice - as interdependent, mutually reinforcing pillars.

The term ‘sustainable energy’ refers to energy provided and used in ways that support sustainable development in all its economic, social, and environmental dimensions. It does not mean simply an expanded supply of energy, but a progressive shift to energy resources and technologies that support human well-being and ecological stability over the long term[2].

The concept of sustainability is based on the premise that people and their communities are made up of social, economic, and environmental systems that are in constant interaction and that must be kept in harmony or balance if the community is to continue to function to the benefit of its inhabitants - now and in the future.

[2] World Energy Assessment; UNDP, UNDESA, World Energy Council; 2000.

## 4. THE ROLE OF HYDROPOWER IN SUSTAINABLE DEVELOPMENT

The critical roles played by energy and water in sustainable development have been recognized the world over and the fundamental goals of providing adequate access to energy and water were a main focus of the World Summit on Sustainable Development. With a large population and a growing economy, world's hunger for power is immense and this hunger has not been satisfied with the available sources of power.

Hydropower is a renewable source of energy, which gives off no polluting gases. Hydropower is considered an efficient, cost-effective, and clean energy source for generating electricity. Hydropower plants return the water to the system unchanged in quantity and quality.

Hydropower can be adaptive and flexible. Depending on the storage capacity involved, a major advantage of hydropower is that generation can be scheduled. Run of – river schemes can be implemented to provide continuouse "base load" generation. Therefore, hydropower can substaintially improve efficiency in a mixed power system, reducing emissions from fossil – fuel plants, and backing up intermittent sources such as wind power. After more than a century of experience, hydropower's strengths and weaknesses are equally well understood. We can summarizes its main advantages.

Hydropower demonstrates outstanding performance in the service it provides within the electricity supply system:

- *High reliability*: Hydropower is proven, well-understood technology base on more than a century of experience. Its schemes have the lowest operating costs and longest plan lives.
- *High efficiency*: Hydropower plants provide the most efficient energy conversion process. Modern plants can convert more than 95% of moving water's energy into electricity, while the best fossil fuel plants are only 60% efficient.
- *High flexibility*: Hydropower plants in contrast may, depending on their design, provide electricity for base or for peak demand, or both. This flexibility in energy supply is one of the specific technical advantages of hydropower, diesel and natural gas.

## 5. CONCLUSION

There is a need to develop new, more sustainable environmental planning and policy approaches that integrate social and ecological concerns in hydropower projects worldwide. These social ecological approaches would formulate and carry out long term rehabilitation efforts with rural societies to restore damaged aquatic environments from hydropower projects. Hydropower is not just a means of combating GHG emissions; water storage also supports adaptation to climate change. Water and energy are essential for the alleviation of poverty. Climate change makes this more pressing and for many countries hydropower is a vital part of the answer. Due to increased demands for reliable supplies of electric power, irrigation, and drinking water, the number of new hydropower reservoirs is increasing dramatically in the world.

Renewable energy is a key element of solutions to sustainable development. Renewable energy contributes holistically to our combined goals of economic growth, social development, energy security, and environmental protection, promising a brighter, safer, and cleaner future for this and coming generations. Some initial progress is being made. However, putting renewable energy solutions in to practice on national scale, in a world that has organized its institutional, industrial, financial, and governments systems principally around the supply and use of fossil fuels, will be very challenging.

"Limit climate change and increase the use of clean energy" is the EU strategy for sustainable development. The development of new and renewable energy sources is the key change. Doubling their share in the energy supply quota from 6 to 12% and increasing electricity production based on these energy sources from 14 to 22% is an objective for 2010.

On a global scale, power supply is the most capital – intensive sector of all. Every industry and every aspect of social progress is heavily dependent on energy. With a large population and a

growing economy, Turkey's hunger for power is immense and this hunger has not been satisfied with the available sources of power. At the same time there are significant avenues for development of hydropower on existing structures, modernizing of existing hydropower plants to improve efficiency and development of small, mini and micro hydropower plants to provide energy to rural, remote and under serviced areas. With the development/renovation/rehabilitation of these new and existing hydropower projects, significant additional clean and renewable energy capacity can be achieved.

Hydropower is the primary contributor of renewable energy in Turkey. Hydropower generation is not a contributor to atmospheric emissions, which are a growing problem on both national and global levels. So far in Turkey, for the purpose of hydroelectric energy generation, 674 hydroelectric power plants have been developed at the various levels.

At the same time there are significant avenues for development of hydropower on existing structures, modernizing of existing hydropower plants to improve efficiency and development of small, mini and micro hydropower plants to provide energy to rural, remote and under serviced areas. With the development/renovation/rehabilitation of these new and existing hydropower projects, significant additional clean and renewable energy capacity can be achieved. For hydropower developers, private or government to promote solutions for optimal water management practices is not practical as they have a vested interest i.e., the improvement of their own energy generation profiles.

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