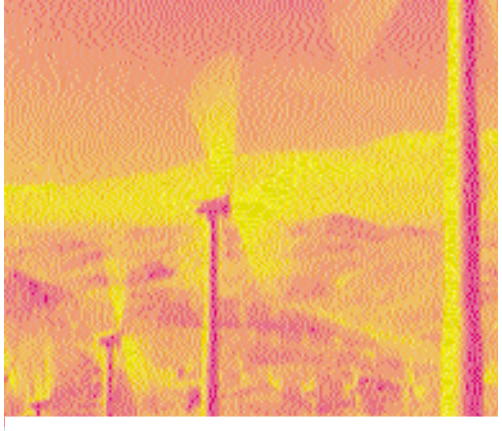
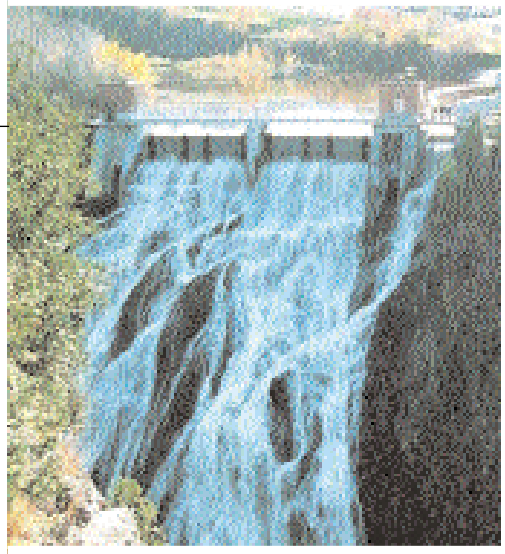
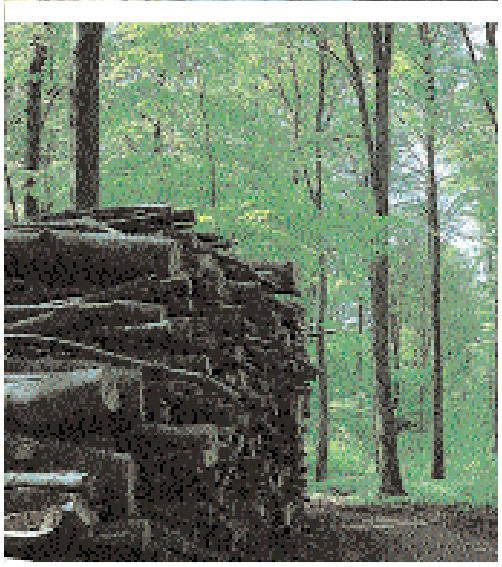
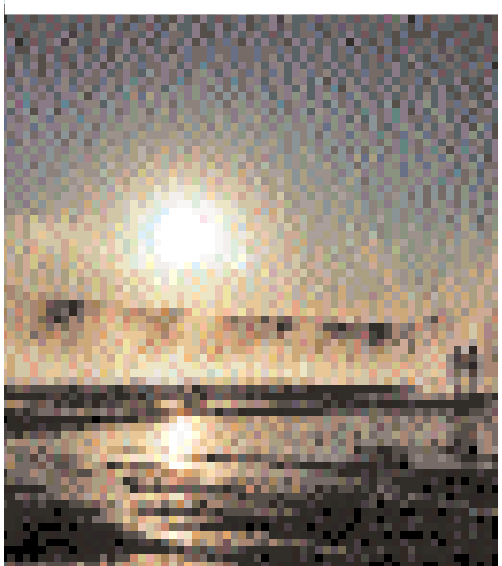
Natural Selection

Evolving Choices for Renewable Energy Technology and Policy









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Klaus Töpfer, Executive Director, UNEP

Before you read this booklet . . .

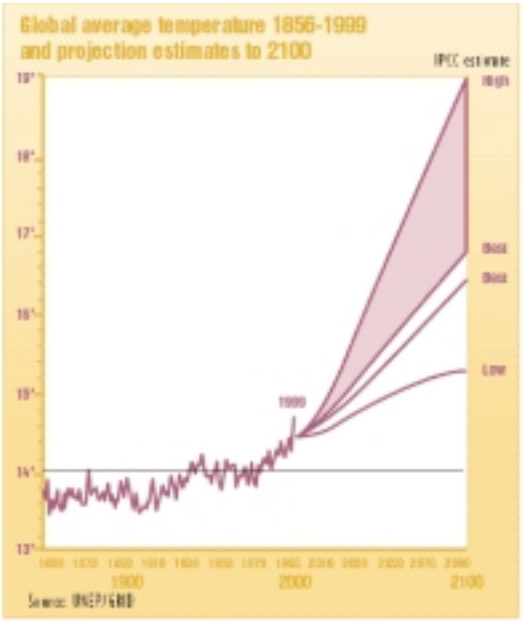
. . . consider that the 21st century presents the nations of the world with a simple, yet profound truth: the future is a matter of human *choice*. Embedded in this truth is the fact that every choice we make today will have consequences well into the future.

We therefore need to make wise technology choices, not only for ourselves, but for generations yet to come. Energy lies at the heart of the world's economic development. Sound energy choices are therefore fundamental if we want to achieve sustainable development. The task will be not be easy, as history is littered with examples of well-intentioned decisions resulting in serious and unforeseen consequences.

The discovery of a large hole in the ozone layer over Antarctica in 1975, for example, stunned the world's scientist and engineers. When chlorofluorocarbons (CFCs) began to be used widely in the 1960s as propellants in aerosol cans and in refrigeration, no one believed the non-toxic, non-flammable "wonder gases" were also highly efficient ozone destroyers, and could cause serious environmental harm. When computer programmers in the 1980s deliberately used two digits to represent a specific year instead of four to save money, they had no idea that the resulting Year 2000 bug (Y2K) would end up costing the world's governments and companies an estimated $500 billion[1] to eliminate. Similarly, we now understand that the use of fossil fuels has serious environmental consequences. Fossil fuels provide three-quarters of the energy needed to drive a $35 trillion world economy—a situation that is rapidly degrading the earth's natural systems. Slowly, we are realising that without healthy natural *ecologies*, we will not have healthy human *economies*.

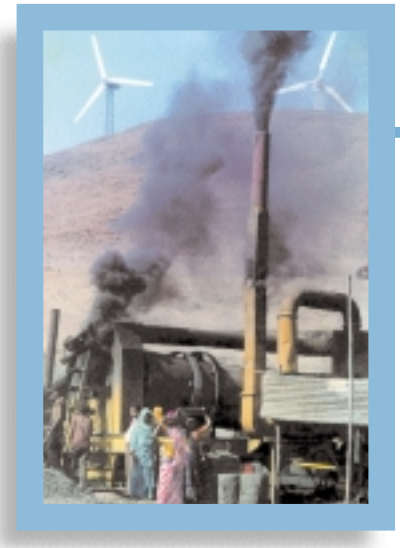
Our natural ecologies, however, are in a state of crisis. According to the United Nations Environment Programme (UNEP) GEO 2000 report, the time for a rational, well-planned transition to sustainable systems is quickly disappearing. Full-scale emergencies now exist in the use of water and land resources, forest destruction has gone too far to prevent irreversible damage in many areas, and urban air pollution is reaching crisis dimensions in many of the megacities of the developing world. The use of energy—or the demand for energy—is intimately tied to all of these emergencies.

For example, much of the air pollution that kills an estimated 500,000 people each year comes from burning fossil fuels in power stations, industrial furnaces, and motor vehicles, which produces small particles that can be deeply inhaled into the lungs. Air pollution also causes an estimated four to five million new cases of chronic bronchitis, as well as millions of cases of other serious illnesses.[2] The economic burden of this pollution is estimated at 0.5 to 2.5 percent of world GNP, some $150–750 billion per year.



These facts alone are reason enough to find new sources of energy and change the way it is used. However, the world's increasing appetite for fossil fuels is creating an even more compelling reason to accelerate the switch to clean forms of energy, namely global climate change.

Climate scientists almost unanimously agree that the accumulation of carbon dioxide and other heat-trapping greenhouse gases, mainly from the combustion of fossil fuels, will change the earth's climate. Scientists cannot yet make specific predictions about how the climate will change on a *regional* or *local* level, but they do agree that there is enough certainty of adverse climate change on a *global* level to recommend serious cuts in the emission of six main greenhouse gases.[3]



(Photo: Topham Picturepoint)

According to the best available science, sometime near the middle of this century the concentration of carbon dioxide in the atmosphere will double from that of the pre-industrial era to a level not seen for 400,000 years. As a result of this doubling, scientists estimate that some elements of global climate change are now inevitable. This is cause enough for concern, but scientists also fear that if the complex atmospheric system is "pushed" too quickly, and carbon dioxide levels *triple*, the results may be catastrophic. Nations with low-lying land exposed to the ocean are particularly at risk, as a warming earth would result in the thermal expansion of water and melting polar ice over land areas,[4] causing ocean levels to rise.

Within this context, the nations of the world face an unprecedented challenge: ensuring that economic development continues and expands, while at the same time dramatically reducing the environmental impact of that development. This challenge, however, also presents an unparalleled opportunity to create new economies and societies. In the next two decades alone, an estimated $9–15 trillion will be invested in new power sector projects. If a majority of this investment is directed towards clean energy technologies, the nations of the world will enjoy a global economy that is more secure, more robust, and much cleaner than that of the 20th century.

This is particularly relevant to developing countries, who now have an excellent opportunity to bypass the polluting energy path of developed countries. As the information in this booklet demonstrates, a sustainable energy path using renewable energy technology can create not only clean energy, but environmental security and regional development as well. Decision-makers who believe the use of large power stations is the best energy solution will be surprised to learn that the average size for a new power generation unit in the United States has declined by a factor of ten in less than two decades.

There are no technical, financial, or economic reasons why the nations of the world cannot enjoy the benefits of both a high level of energy service and a better environment. Clearly the combined effects of environmental damage and depleted non-renewable resources will ultimately shift human economies to sustainable energy systems. How soon that shift occurs, however, ultimately depends on what actions are taken now.

Natural Selection: Evolving Choices for Renewable Energy Technology and Policy has been designed to help you, the policy or decision-maker, create that shift sooner. In Part 1, you will find a brief, but thorough, overview of major renewable energy technologies followed, in Part 2, by a discussion of the policy frameworks that will further their deployment. This is intended to create a firm foundation of knowledge on which you can base action. Following Part 2, there is a brief discussion of scenarios that can lead us to a sustainable energy future.

Please read the booklet carefully, and share its content with colleagues. Use the information to ensure that the next energy decision you make is both well-informed and another step on the path to sustainable development.

Klaus Töpfer
Executive Director
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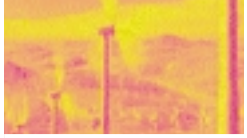

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"There is nothing so powerful as an idea whose time has come"

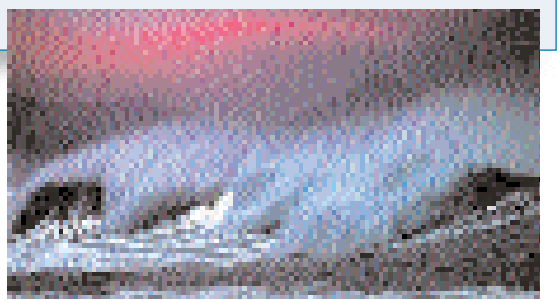
— Albert Einstein

Renewable energy is abundant, clean, and inexhaustible. It is also the most cost-effective energy source for a variety of applications, meeting between 15 and 20 percent of total world energy demand and 24 percent of the world's total electricity supply.[5] Renewable energy in the form of traditional biomass fuels, such as wood and crop residues, represents about 14 percent of the world's total energy consumption—a larger share than coal (12 percent).

Defining Renewable Energy

Sources of renewable energy exist in the form of direct and indirect solar radiation, the heat of the earth (geothermal energy), and the gravitational effects of the moon that creates the tides. Direct solar radiation striking the earth also drives the global weather system and photosynthesis. This, in turn, creates the wind and waves, as well as biomass (plant and animal matter). The energy in falling water may also be considered a renewable energy source but only if the local environmental impacts are sustainable. Generally, new large-scale hydropower schemes are not considered a source of renewable energy due to their substantial environmental impacts.

Renewable energy can be converted to many other energy forms. Electricity can be generated from solar, wind, biomass, geothermal, hydropower, and ocean resources. Heat can be generated from solar thermal and geothermal sources, while biofuels such as ethanol and methane can be obtained from combinations of renewable sources.



(Photo: Topham Picturepoint\UNEP \ Schinogrotzki)

However, the contribution of newer renewable energy technologies (RETs) is increasing rapidly, in spite of new competition from deregulated energy markets. From a small base in the 1970s, biomass, geothermal, solar, small-scale hydropower, and wind technologies have grown proportionally faster than any other electricity supply technology, and now supply about two percent of total global energy demand.

The wind energy industry, for example, has grown in just two decades from a producer of small machines for remote power applications, to a modern, multi-billion-dollar industry supplying bulk, grid-connected power. At the beginning of the 21st century, 14,000 megawatts (MW) of wind turbines generate clean electricity in more than 30 countries. The evolution of the wind energy industry has far exceeded even the most optimistic 1990 European Union prediction that 5,000 MW would be installed by the year 2000. Consequently, the cost of wind-generated electricity has dropped seven-fold, which makes windpower competitive with most fossil fuel technologies.

Global Generating Capacity of Non-Hydro RETs

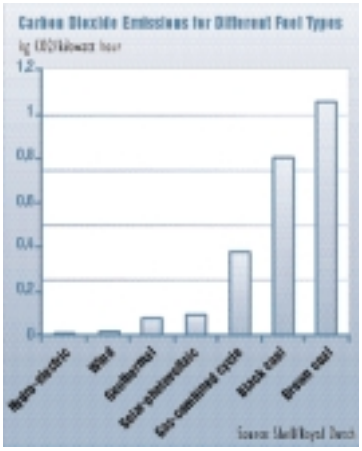
Technology	Installed Capacity (MW)
Biomass	35,000
Geothermal	9,000
PV	1,200
Solar Thermal	350
Wind	14,000
Total	59,550

figures are for year 2000 and approximate. Source: UNEP

The modern wind energy industry evolved rapidly due to a combination of government support, sufficient research and development, and policies that created a market for wind-generated electricity. This successful model provides valuable experience for the development of other RETs (see Part 2: Frameworks for Success).

Advantages and Limitations of RETs

Renewable energy technologies are first and foremost the cleanest options for producing energy and eliminating greenhouse gas emissions. But there are many other advantages. These include energy, economic, and environmental security.



Energy Security

RETs can diversify the energy supply, thereby promoting energy security and price stability. For some nations, RETs can reduce dependence on imported fuels, an issue that is particularly important for developing

countries. RETs can also promote energy security by decentralising energy supplies with smaller, modular, and rapidly-deployable energy projects that are particularly suited to the electrification of rural communities in developing countries.

Economic Security

RETs are often the most economical choice because of their *scale*. Their modular nature means they can be built (and paid for) as the demand for energy grows, and embedded within an existing network, if there is one. By contrast, large, centralised energy systems take much longer to build and are normally designed to supply a future demand that may not eventuate. The vulnerability of central power plants and transmission lines to power interruptions is also important. In the United States, for example, power interuptions cost as much as $80 billion annually.[6]

For developing countries, the energy security provided by RETs makes them attractive in rural areas, while simultaneously offering a clean "leap" over fossil fuels. The modular and distributed nature of RETs can also reduce the need for upgrading electricity distribution systems, or for expanding distribution or transmission capacity.

RETs can also provide regional and local job opportunities, particularly in rural areas. This can contribute to the stability of local communities, which then slows urbanisation—a particular problem for many already overcrowded cities in developing countries. In addition, if energy is locally produced, money is invested in the local community and not exported, although RET products and services can be exported. All of these impacts can create an increase in local tax revenues, which can then create a more diversified tax base.[7]

In terms of electricity generation, RETs are more employment intensive than fossil fuel or nuclear

Installation of wind turbines can provide significant new employment, as well as clean energy. (Photo: Nordex)

options. The employment potential of RETs can be clearly seen in the wind energy industry. According to a survey by Danish wind energy manufacturers, 17 worker-years are created for every megawatt of wind energy manufactured, and five worker-years for every megawatt installed.[8] In the year 2000, the wind ener-

Limitations of RETs

The major limitation of RETs lies in the intermittent and site-specific nature of the energy source. Solar cells, for example, generate electricity only when light is available, and wind generators operate only when there is sufficient wind. However, even though such resources are intermittent, they are often highly predictable.