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cal upsets of all kinds, impoverishment and the regression of ecosystems. And we can count ourselves lucky if this is done as it has been done traditionally in Europe and other regions with a long history of exploitation of the natural environment: here, agricultural, livestock farming, forests and cities and other types of facilities have been distributed in a more or less balanced, equitable way over the territory. The resulting patchwork conserves a certain diversity within the simplification of nature and, furthermore, prevents catastrophes such as plagues, fires, the accumulation of waste, etc. However, modern agriculture and livestock farming are not moving towards the distribution of the landscape into a patchwork, or mosaic: the work of machines, the distribution of pesticides, animal feed, etc. requires homogeneous cultivations and enormous expanses stretching monotonously over entire territories and threatening to leave no areas even relatively virgin and whose vital role in the ecology I cannot expand on here.

This panorama of dependence of what we could call the civilisation of a few agricultural and animal species, of ever-increasing energy consumption, of the ever-greater resistance of our competitor species to the chemical products we use, the ever-more ecological fragility of humanised ecosystems, has to be complemented by a parallel situation: diminishing fertile lands, soil loss due to erosion and desertification, the pollution of waters, increase in food demand due to the enormously fast rate of population growth and so on. And, closing the circle, the short- or mid-term exhaustion of traditional energy resources, basically fossil fuels (which is not to imply that there is not a use for them).

Food for thought

To conclude, then, humanised ecosystems function through the consumption of an enormous amount of energy (Figure 4). Due to the environmental and economic costs of generating this energy, and to the thermodynamic losses resulting, as well as the selection this energy flux makes of natural communities, this has drastic consequences on the level of the ecosystems, all of which tend to impoverish them. We should now go back and have a look at Table 1, at the comparison between energy consumption in developed and developing nations. I leave it to the reader to carry out the basic calculation of the energy consumption and environmental impact which would be involved if the approximately four thousand million people who, in round figures, live in the first group of countries (which have been called the South) were to reach the average energy consumption of the approximately one thousand million human beings living in the developed countries (the North). I mean, simply (returning to the beginning of this article) if each and every one of the inhabitants of Rwanda, for example, were to have access to information about the meteorite bombardment of Jupiter,

(If this way of speaking offends anyone's feelings, we can simply change -if they were to have access- to -when they have access-, passing from a conditional way of speaking to a future idea). But that, perhaps, could form the subject for another article.

Energy: from common good to resource/merchandise

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Energy has changed from being considered a common good to being treated according to the laws of the market. However, a method of treating energy which takes into account neither the cost of energy sources nor the effects of the pollution caused by certain fuels has led us to adopt an unsustainable energy system. The author analyses this energy system and makes new proposals.

The same thing has happened to energy as has occurred in many other fields of human activity and facets of everyday life. Energy sources which were originally a -common good- have ceased to be so, and have become -energy resources-.

This can be seen through analysis of the process which has led us to consider energy sources as a -resource-, but above all if we go back to the very origins of the word -resource- itself, particularly in its plural form.

It is clear that in the earliest times humanity learnt how to live, and for many thousands of years has lived, without the need for any type of -resource-. Of course, men and women had at their disposal food to eat, water to drink, heat, knowledge and materials to use to make clothes and shelter. The natural environment supplied goods which allowed people to satisfy their needs.

Humanity had never had -resources- until the concept was invented in modern times. In order to illustrate this point, let us see how the word -resource- was defined at the beginning of industrialisation. The -Oxford English Dictionary- provides an idea of what was understood by the word -resource- in the 17th century: -resource: all that which the Earth receives from our hand and which it returns to us with more or less growth. So, when the word -resource- appears, it still expresses the sense of -common good-, as the term is still employed to describe the gifts/presents exchanged between humanity and the Earth, that is, common goods.

Growing industrialism changed all this radically, so that the word -resource- became associated with the concept of -wealth of nations-. In his -Natural History Commentary (1870)-, for example, Yeats makes this changing definition clear: -When we speak of the natural resources of a nation, we mean the minerals in its mines, the stones of its quarries, the timber in its woods, etc-. This is perhaps the first time in the history of humanity that the word -resource- is used in the sense in which it has become universally understood since the emergence of industrialised society. Now, a century later, most dictionaries define -resource- as -the collective wealth of a country or its means of producing wealth-, or as -anything which

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can be converted into money». Transforming the natural world and converting it into money has become the obsession of our time.

The transformation of mutual gifts-presents exchanged between humanity and the Earth—common goods—into lifeless merchandise, renaming them «resources», is much more than a mere change in language usage. The common goods of the Earth have become resources as part of a process of depriving Nature of her rights, as the idea of nature possessing rights limiting or restricting the way in which people use these goods in fact prevents its exploitation in the industrial sense of the term.

That is how things stood, and as any type of gift-present implies reciprocity between the giver and the receiver, it also implies mutual respect and shared obligations. All kinds of gift-present imply a donor who has to be recognised and given gratitude by the receiver. Such questions of conscience and courtesy disappear when the common goods of the Earth are considered as «resources». «Resources» only exist as a source of potential wealth and power.

In this way, the word «resource» has been used to strip the Earth of her rights! And more and more parts of the world are taking on a new status: they are dismembered and separated from their local context and are renamed «resources».

Thus, over more than one hundred years, has the word «resource» been employed to observe or contemplate the world as «useful input for industrial production». The same was true for «energy resources»: we observed a wood and what we saw were trees cut to make firewood; we looked at a mountain and what we saw were open mines; we contemplated rivers and saw valleys flooded by dams; sedimentary basins were oil fields being worked at maximum capacity, etc. The consequence of converting energy sources «common goods» into «resources» is that the dominant political and social systems have given energy an economic value: extracting and burning fossil fuels, extracting, concentrating and fissioning uranium, flooding fertile valleys and woods to make dams, etc, all to create material wealth without taking into account that what we were doing was destroying natural systems and cultural systems going back thousands of years, that is to say, without taking into account the cost of the ecological and social problems associated with raw energy sources, particularly fossil fuels and nuclear resources (throughout the entire cycle) nor taking into account the *intergenerational assignment* of energy sources which can be called non-renewable—at least if we use the human scale for measuring time, as they may be renewable according to the geological time scale.

Energy in human societies

Throughout the history of humanity, energy has been used for various functions: to provide food and comfort, to transport people, materials and informa-

tion, to obtain materials, to replace human muscular force and mental force, and so on. It has also been used to constructive and destructive ends.

The first energy sources tapped by humanity were the free energies, which were available to all. These are the energy sources which have their origin in the sun. Through photosynthetic reaction, solar radiation made possible, and indeed still does, the synthesis of organic matter. Not only this, but without it, our planet, the Earth, would be completely uninhabitable, as its temperature would be close to absolute zero (-273°C).

The advent of industrialism and industrialisation brought with it the widespread use of the fossil energy sources (coal, oil, natural gas, etc) which had accumulated in the subsoil of the Earth over millions of years, as well as nuclear energy. Neither fossil energy sources nor nuclear energy are free, nor are they available to all.

The use of each energy source has had a different impact on nature, on natural systems and on society itself. The massive use of wood has brought about processes of deforestation and soil erosion. Entire cultures have disappeared due to their abusive use of wood. The construction of dams in order to harness hydraulic energy has entailed the flooding of large areas of fertile farmland very often inhabited by non-industrial cultures which have existed (and some of them continue to exist) in harmony with natural systems. The extraction of coal and uranium renders large extensions of land unusable due to the large quantity of *sterile* matter produced by both. The use of fossil fuels in huge quantities causes pollution of the atmosphere, water, the soil and living beings. Another consequence is to modify local and/or global climate, producing acid rain and atmospheric warming. Generating electrical energy from nuclear fuels causes radioactive poisoning of natural systems, due to both the normal and accidental emissions associated with it and the waste produced. The fact that what at first glance appeared to be the existence of «abundant» and «cheap» energy sources was one of the factors making possible the birth of the process of industrialisation. The apparent abundance and low cost of energy sources made it possible to alter *production* relations, automatising production processes and decreasing the control of the workers over the production process. It also made possible the emergence of differences in the trade relations between nations and between social groups living in the same country.

All in all, it gave rise to a situation in which, instead of maximising the energy use of different sources, we tended towards maximum consumption, rapidly exploiting the energy resources accumulated in the subsoil, doing nothing to promote a better use of energy sources of solar origin. In fact, this has led to the creation of a *rising-cost economy* (it is necessary to invert more and more energy and capital in order to obtain a new energy unit and the most readily-available and, therefore, cheapest stocks are the first to

become exhausted). It has also meant burning useful materials for other ends and the generation of high social and ecological costs (which the dominant economic system has shown itself incapable of including).

As systems emerged involving the domination of certain sectors of society over others, this process of replacing free energy sources available to all by other energy sources which were neither free nor available to all has been a constant throughout the history of humanity. After the birth of industrialism, the process accelerated greatly.

Lewis Mumford's monumental work of critical analysis on the birth and evolution of the machine age and its social implications contains numerous examples of how wind and water, despite being subject to the caprices of the climate, were energy sources difficult to monopolise (from the 13th century onwards, many attempts were made to prohibit small windmills to the benefit of the local lord's mill). These were free energy sources, with low construction cost and practically zero maintenance cost, as the materials used for construction were long-lasting and the energy supply inexhaustible. Moreover, far from degrading the earth (as did mining), windmills helped to enrich it and to maintain a stable agriculture. The energy produced by the coal-fired steam engine, on the other hand, was expensive (high investment costs and expensive coal), caused pollution, degraded the earth (mining activities) and brought about the destabilisation of rural communities. It also tended towards monopolisation and concentration into large industrial facilities. The introduction of the steam engine heralds a change in perceptions with far-reaching consequences, as «large» begins to be associated with «better». This is an idea which dominated the scene until well into the 1980s.

In order to ensure a «cheap», «abundant» energy supply, the economic, political, military, etc, powers gradually developed a vast system of strategies for control and domination. In this way, energy sources, formerly free, clean and available to all, ceased to be common and, therefore, free goods which made possible all those activities which allowed the autonomous subsistence of people and communities.

And so energy sources became a «resource» which allows and makes possible the «economic» production of all those «artefacts» (goods, utensils, articles, etc) which satisfy the «needs» on which the current, industrialist form of life is based.

Thus, energy sources became merchandise and, as such, a source of profit, power, ecological imbalances and much more, making planning necessary for the use and availability of the «resource» (energy supply and demand) through the emergence of an elite of experts, technicians, bureaucrats, functionaries and so on, justifying and defending the «resources».

In this way, energy sources became a source of contamination, pollution and destruction, as the degra-

duction of energy materials ceased to be based on the only renewable energy flux received, the sun and associated sources, and the recycling of material cycles ceased to be maintained.

The unsustainability of the dominant energy system

It was during the 1970s that one-fifth of humanity realised that the energy sources on which their lifestyle was based were ephemeral. Even today, the World Energy Council admits that oil reserves will not last more than another 40 years, natural gas reserves a little longer and coal reserves just over a hundred years.

As we entered the 1980s, to the non-renewable nature of energy sources made clear during the previous decade was joined the use of the adjective -dirty- before the massively used energy sources, firstly when the devastating effects of so-called -acid rain- became known and later when increasing concentrations of atmospheric CO₂ and the radioactive poisoning of our natural systems were demonstrated.

All this makes it unthinkable that the energy model we have inherited can be sustainable in the long term, much less if it is adopted on a global level. If CO₂ emissions increasing worldwide, they will have doubled by the mid-21st century. The world economy would be unsustainable even if everybody used energy as efficiently as does the Japanese economy, which produces \$10,839 of GDP per tonne of carbon emitted, with the equivalent of 2.35 tonnes of carbon per capita.

Let us see this by carrying out a small calculation. Total carbon emissions in the world are around 6,000 million tonnes each year (about 20,000 million tonnes of CO₂). As Gross Global Product (directly linked to the use of fossil fuels) is 18.5 billion dollars, efficiency is \$3,083 per tonne of carbon (around one third of the efficiency of the Japanese economy). If all the 5,500 million inhabitants of the Earth produced carbon emissions at the same level as the inhabitants of Japan, the result would be that carbon emissions on a global scale would more than double to 13,000 million tonnes, when the recommendations of the IPCC (Inter-Governmental Panel on Climatic Change) are aimed at reducing global emissions by between 60-80% in order to prevent the destabilisation of the climate (which could only be from 2,400 to 1,200 million tonnes of carbon).

What, then, would constitute a sustainable energy model? If we apply to the field of energy the criteria applied by H. Daly (-Steady State Economics-, Island Press, Washington, 1991) and D.H. Meadows, D.L. Meadows and J. Randers (-Beyond the Limits-, Earthscan, London, 1992) to characterise a **sustainable society**, we could say that a sustainable society in energy terms would be one in which:

- The rate of use of natural energy sources does not exceed replenishment rates.
- The rate of use of non-renewable energy sources

does not exceed the rate at which systems are developed for the use of substitutory renewable sources.

- The rate of the emission of pollution does not exceed the capacity of natural systems to absorb or neutralise it.

This means that in order to move towards sustainable societies in terms of energy we have to abandon the present dominant energy system (based on non-renewable, dirty energy sources) bringing into being a new energy system based on renewable, clean, energy sources, as stated in the first edition of the now renamed work -State of the World-, published by the Worldwatch Institute in 1984. That is to say, that the solar age must be born, as many pioneers have been telling us since the early-1970s and as UNESCO itself proposes in its Declaration of the Solar Decade (1995-2005). And we must re-establish climatic stability by reducing emissions of the greenhouse gases, such as CO₂ and CH₄.

In fact, though, we should never speak of energy as separate from matter for, as José Manuel Naredo points out, -they are two sides of the same physical reality-. Naredo further states that -reasonable energy management has to be approached together with materials management. However, the habit of focussing on things taken separately means that we insist on identifying the "energy problem" with the commercial supply of a handful of products which we use now as sources of heat, light, ... or mechanical force. In this way, we practise a double oversimplification: firstly, we leave any consideration of materials out of our calculations; and, secondly, only a number of its most highly concentrated and monetisable manifestations are considered as energy. Once this conceptual reduction is complete, the so-called "renewable energies" are relegated, by definition (as being insufficiently concentrated and/or difficult to monetise) to a merely token status in energy balances and human societies are condemned to take part in the Promethean struggle into which they have been flung by the industrial revolution, leading them into ever-more unsustainable situations. An approach to energy which serves to orient the management of present societies towards more sustainable bases will require breaking with the oversimplifications mentioned above and the widening of the object of study to include all manifestations of energy and the materials obligatorily associated with them.

Other energy paths

We have to go back to the 1970s for the emergence of numerous critical proposals for alternatives to the dominant energy models. Perhaps the most innovative of these is that published by Amory Lovins in -Soft Energy Paths-, criticising the official so-called -Hard Energy Path-. Time has demonstrated that Lovins' predictions were much closer to reality than the expectations of the official energy planners.

This opened the door to a multitude of proposals on

the part of independent scientists and technicians linked to what we now know as NGOs. Table 1 provides an exhaustive list of these proposals. Almost all recommended the abandonment of non-renewable energies and their replacement by renewable sources. Another group of alternative proposals referred to concrete plans to close nuclear power stations, demonstrating their feasibility (Table 2), whilst the last group of reports (Table 3) makes specific proposals regarding the path towards energy sustainability, abandoning the current, unsustainable energy model which is based on non-renewable energy sources, uses highly inefficient transformation technologies and is ecologically pollutant. These independent sectors did not always limit themselves to making proposals but also often demonstrated in practice that the defence of energy efficiency and of renewable energies could become a reality right away.

The pioneering Amory Lovins is now research director at the prestigious Rocky Mountain Institute in Colorado (USA) a research centre whose team of some 30 scientists investigate energy, water, agriculture and local economies. Located in the heart of the Rocky Mountains, the centre uses only renewable energies and equipment with high energy efficiency, operating completely without recourse to fossil fuels. Today, Lovins and his team act as consultants to a multitude of energy companies and bodies all over the world, particularly those interested in contributing to the necessary transition to a world without fossil or nuclear fuels.

Robert Todd, coordinator in 1976 of -An Alternative Energy Strategy for the UK-, was also one of the founders of what is now known as the Centre for Alternative Technology in Wales where, in 1974, on an ecologically degraded site (a disused quarry) a group of volunteers began the task of demonstrating that it is possible to live and work with low-impact technologies (the entire centre operates on renewable energies only, with recycling and ecological agricultural methods). The importance of the educational work undertaken is demonstrated by the hundreds of courses which they have given to thousands of people every year. Moreover, the centre receives some 100,000 visitors every year.

Are the -new energies- really new?

In no way can clean, renewable energy sources, which have their origin in the sun, be considered as -new energy sources-.

In fact, since its very origins, humanity has utilised all kinds of plants and animals for food and used wood to cook and for warmth.

In what we now know as Europe, beginning in the Middle Ages, use of the force of water and wind began, spreading to attain considerable importance. Mills, used to grind grain or to press olives, to make paper pulp, to cut up wood, to pump water, to drive

wet zones, etc, were common all over Europe. In the mid-19th century there were in the Low Countries some 9,000 windmills, whilst in England there were 10,000 and by the end of the 19th century there were over 18,000 in Germany. Nevertheless, all these technological innovations, the work of eminent engineers since the mid-18th century, were not enough to prevent the steam engine (first used to grind grain in England in 1781), capable of operating 24 hours a day, from encroaching on the windmill's territory, despite the fact that since the beginning of the 19th century this had become the first automatised factory in the entire history of technology.

The invention of the hydraulic turbine by Founeyron in 1820, and the discovery of the phenomena which were to lead to the use of electricity as an energy source paved the way for the many hydraulic facilities lining the rivers to be transformed into hydroelectric power stations. The first hydroelectric power station in the world entered service in 1878, whilst only four years later the El Moli facility in Girona, using hydropower to supply the city's public lighting service, was opened.

The windmill met the same fate. In 1888, in his Cleveland home workshop, Charles F. Brush constructed the first aerogenerator for the generation of electricity. This was a mill with 177 blades each 17 m in diameter, mounted on an 18-metre high tower, coupled to a 12 kW dynamo producing enough electricity to feed 350 incandescent light bulbs, two arc lights and three engines (the firms of Brush Instruments, Edison and Thomson-Houston were merged to create General Electric). In Europe, Professor Paul la Cour, with the assistance of the Danish government, constructed a four-blade aerogenerator in Askov in 1892. The electricity it generated was used to dissociate through electrolysis a watery solution of sodium hydroxide, and the oxygen and hydrogen obtained were stored so that, at the end of the 19th century, the school in Askov was lit by Drummond lamps, which created a white light produced by the flame caused by the combustion of a mixture of oxygen and hydrogen in a zircon cylinder. Later, a system using incandescent bulbs and lead accumulators was adopted, and the lighting system operated perfectly for over 20 years.

By 1902, both Askov and its school had lighting thanks to la Cour's mill. Since in those days very few villages had lighting, those wanting to install such a system used to go to Askov to ask advice of la Cour who, according to the locals, 'could turn the rain and the wind into light and energy'. This popular demand led to the foundation, in 1903, of the Dansk Vind Elektricitets-Selskab (Danish Association for the Production of Electricity using Wind), which was very active both in the field of education and engineering, offering courses and designing windmills to generate electricity at a power of between 5 and 25 kW.

Since then, it has been common knowledge that the wind can be used for the production of mechanical

and electrical energy. It is estimated that by the 1930s there were 200 MW of wind power functioning in Denmark. The First World War showed the Danes the vulnerability of oil supplies, so that since then Denmark has given great support to the use of a local renewable energy source: the wind.

At the beginning of the 20th century, there were more than six million small *aeroengines* used for pumping water in the United States of America. These simple artefacts, even today widely used, were invented in 1850 by Daniel Halliday. Also during the first third of the 20th century, thousands of small aerogenerators with three blades were used to generate electricity in many rural regions all over the world. In the USA, Jacobs Wind Electric manufactured, installed and exported aerogenerators throughout the world. These were machines of up to 4.5 meters in diameter which produced from 400 to 500 kWh/month, ideal for rural dwellings. These aerogenerators could operate in the most adverse climatic conditions (during his Antarctic expeditions, Admiral Richard E. Byrd used a Jacobs aerogenerator for electricity supply. When, in 1955, the founder of the Jacobs company decided to recover the machine, it was found to be in good condition after having functioned for 22 years in the most adverse of weather conditions). Jacobs Wind Electric closed down in 1957, due to the generalisation of rural electrification programmes connecting isolated rural communities to the electricity grid.

Nor is the direct use of solar energy a new discovery. More than 2,500 years ago, the Ancient Greeks began to design houses oriented to the south, with a good number of openings, so that the sun could enter during the winter months, but whose eaves would prevent this in summer. Many other cultures also did the same. The case of the Anasazi Indians (known as 'Pueblos' by the Western invader) is well-known. This people constructed true dwellings, which we today would call bioclimatic, in the 11th and 12th centuries. And by the late-19th century, the first flat solar collector had already been invented and placed on the market. The Climax model, developed in Baltimore, heated 2,500 litres and more. In 1900, there were more than 1,500 Climax systems in California. They were even sold coupled to cheap cookers.

In 1860, a Frenchman, A. Mouchot, began to study the use of solar energy to drive a steam engine, building the first solar engine (a conical concentrator with a boiler extending the length of the cone axis) in 1874. This invention was demonstrated at the 1878 Universal Exhibition in Paris. Two years later, one of Mouchot's assistants exhibited in the Tuilleries Gardens a solar engine driving a printing press, which printed 500 copies of the 'Journal Soleil'. The photovoltaic effect was also discovered some time ago, in 1839 by Edmund Becquerel, and the first photovoltaic cells were constructed, using selenium, 50 years later.

Nonetheless, of all the clean, renewable sources,

wind power was probably the first energy source, a fact which further underlines to what extent a technology can be shelved despite the existence of sufficient knowledge and ability to make of it a sustainable social use. Let us take a look at its history: in 1931 a 30 m diameter three-blade aerogenerator began to function in Balaklava (Crimea), producing 100 kW. It was connected to the electricity distribution network and generated over 200,000 kWh/year. However, the Nazi invasion ended this Soviet attempt to produce electricity using the wind. Shortly after this, though, the first attempt to develop a large wind system for electricity generation took place. This experiment was carried out in 1941 by P. C. Putman, who designed an aerogenerator with two blades of 53 m in diameter and 1.25 MW power. The opinion of Dr V. Bush, dean of the MIT School of Engineering is quite clear: 'This machine has demonstrated that, in the not-too-distant future, houses will be lighted and factories operated using the electricity produced by eolic conversion systems' (1946). It is during the second third of this century that systems harnessing wind power can be said to have reached maturity. This is born out by the eolic projects carried out in this period, some of the most outstanding of them including: in Denmark, Gedser's aerogenerator, a 24 m diameter, 200 kW machine which operated without interruption from 1957 to 1967, generating a total of 2,242,000 kWh (a similar aerogenerator entered service in the early-1970s, financed by the Danish and US governments); in Great Britain, the North Scotland Hydroelectric Board's 100 kW aerogenerator, installed in 1952 on Costa Hill in the Orkney Isles; in France, the BEST-Romani aerogenerator, 20 m in diameter, 800 kW, installed in Nogent-le-Roi, operating from 1958 to 1963; and, in Germany, the Hütter-Allgaier aerogenerators, with power ranging from 10 to 100 kW (1957-1968).

It required the occurrence of the first energy crisis to revive interest in the harnessing of renewable energy sources. But what were the reasons behind the marginalisation of clean, renewable energy sources in covering the energy needs of the industrialised world, in spite of the fact that the progress made in the field showed clearly the significant contribution these could make?

Before identifying a number of factors which can help to answer this crucial question, I will reproduce a number of quotations in support of my case. On 10 July 1953 the following was published in 'Engineering': 'Wind energy now shows possibilities for commercial application', and 'The time has come to apply various forms of wind energy'. Moreover, in a long article on wind energy published in the magazine 'La Technique Moderne' (March-April 1949), G. Lacroix wrote: 'Regarding aeroengines, it is not a question of inventing, but of constructing and beginning to operate. Even the president of the so-called National Commission for Special Energies wrote in the 'Revista de Ciencia Aplicada' in 1961 that, 'There

Renewable energies: the possibilities of the wind and the sun

now exist prototypes of wind power facilities whose construction in series would allow us to begin the industrial exploitation of wind energy.

Assuredly, a series of factors have prevented clean, renewable energy sources, such as eolic energy, from competing on the market in equal conditions with dirty, non-renewable energy sources. What is more than evident today is the question of the hidden costs of energy production from fossil and nuclear fuels. Since the price of energy thus produced does not include some of its real costs (particularly its ecological and social costs) we find ourselves in a paradoxical situation in which it appears to be more expensive to produce electricity by using wind or solar power than with fossil or nuclear fuel. But what is even more paradoxical is that, even though we know that generating energy from atomic fission is very expensive (a conclusion reached from study of the nuclear programmes of many countries) nuclear energy, what Amory Lovins calls «cutting butter with a chainsaw», has continued to be developed. Many of the answers to these questions can be found in a key work in the energy field, published as far back as 1952 under the title of «Energy Sources: The Wealth of the World». Its authors are two technical experts, one at Gulf and the other at Westinghouse. Of all the answers they provide, I will just quote one highly significant passage here. It goes as follows: «It is highly likely that nuclear power stations may not have the chance of proving that they are economically competitive. Nevertheless, due to military interest in nuclear energy and the necessary government control of it, it could well be that the operation of nuclear plant is linked to the production and processing of nuclear fuel for military purposes, so that the cost of the nuclear part of the power station would not represent its real cost. Despite the fact that the cost of nuclear energy seems too high to be competitive, it is certain that nuclear power stations will be constructed».

This could be one of the various reasons behind the fact that many countries abandoned wind (and solar) power programmes during the 1950s and 1960s and we had to wait until the 1970s, but above all the 1980s, with the proliferation of small independent producers, to see how an energy source, marginalised and denied facilities for its development, can demonstrate that producing electricity using wind power is cheaper than generating it at conventional power stations, even without taking into account the social and ecological costs associated with the dirty energy sources ●

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In 1990, solar and eolic power accounted for less than 0.1% of total world energy supplies. To bring about a significant increase in the use of these energy sources involves solving certain theoretical problems, but also depends on measures brought to bear by governments.

The contribution of all renewable energies to world energy supplies in 1990 was 18%, the equivalent of 1,559 Mtoe. The most important of these energies is traditional biomass, accounting for 60% of this figure, widely used in Asia and Africa. Next are large hydraulic power facilities, supplying 30% of the figure. The remaining renewable energies, what we could call «new» renewable energies, made up just 2% of total world energy consumption.

Among these «new» renewable energies are solar, wind, geothermal, modern biomass, tidal and small hydraulic power. The contribution of each to total energy consumption is rather insignificant: in 1990, solar energy accounted for 0.08% and wind power for 0.01%.

The provisions presented by the World Energy Council at its meeting in Montreal in 1989 consisted of two 30-year projections based on two scenarios, the first continuing present policies and the second taking into account the application of more «ecological» policies («ecologically driven scenario»). These projections suppose, in the first case (continuing the same policies as at present) that the renewable energies will double their share (from 2% to 4%) and in the second (more «ecological» policies) that they will increase their share six-fold (from 2% to 12%).

In both cases, the share of solar and wind power in the entire world in the year 2020 is expected to increase by more than the average, as the figures below show:

	Solar	Eolic	New renewables
Present policies	0.82%	0.64%	4.0%
«Ecological» policies	5.20%	1.94%	12.1%

These figures are reached as a result of the estimations made by geographic area. The distribution of these percentages within the areas varies according to the evolution of various parameters, amongst which some of the most important are population

growth, per capita energy consumption, total primary energy consumption and the distribution of energy sources utilised. The evolution of these parameters is different for each of the renewable energy sources in each geographical region, with institutional action and the evolution of projects also varies from region to region.

The obstacles preventing the expansion of renewable energies in the world are numerous and complex. It is possible to make a broad description of the situation for each energy source, but we can point out five factors at the global level which comprise a summary of all these factors and which affect all renewable energies: definition of the resources available, level of technological development, economic and institutional policies, degree of education and information available to the public and international technical and financial co-operation.

In the European Union, efforts are being made through the European Parliament and each of the governments of the member states to make firm commitments to reaching a high degree of penetration of the part of the renewable energies into European energy production over the coming years. Outstanding initiatives in this field include the recent «Declaration of Madrid», with the «Action Plan for Renewable Energy Sources in Europe», approved by the European Conference which took place in Madrid this year under the sponsorship of the European Commission and Parliament, among others, which states that «By the year 2010, renewable energy sources can and, with the co-operation of all those involved, should substitute 15% of conventional primary energy consumption in the European Union and to which end proposes an Action Plan which «establishes concrete lines of action and proposes specific measures for overcoming the barriers to increasing, supporting the widespread use and development of renewable energy sources in Europe, making possible the substitution of 15% of conventional primary energy consumption on the part of these energy sources».

This initiative of the European Union is not an isolated gesture, but complements a series of actions which it has carried out in the last 15 years in the fields of research, development and diffusion which will be increased notably before the year 2000.

We shall now concentrate on the two energy sources mentioned earlier: solar and eolic, as, according to estimates, these are the ones whose application will grow most over the next 30 years.

WIND POWER

The global potential for the use of the wind to produce energy is enormous. Estimates indicate that approximately 27% (29,000 km²) of the earth's surface is swept by winds at speeds of over 5.1 m/s, capable of being harnessed and which, if utilised, would generate 240,000 GW of electrical energy. How-