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The Case For Renewable Energies

Thematic Background Paper

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This is one of 12 Thematic Background Papers (TBP) that have been prepared as thematic background for the International Conference for Renewable Energies, Bonn 2004 (renewables 2004). A list of all papers can be found at the end of this document.

Internationally recognised experts have prepared all TBPs. Many people have commented on earlier versions of this document. However, the responsibility for the content remains with the authors.

Each TBP focusses on a different aspect of renewable energy and presents policy implications and recommendations. The purpose of the TBP is twofold, first to provide a substantive basis for discussions on the Conference Issue Paper (CIP) and, second, to provide some empirical facts and background information for the interested public. In building on the existing wealth of political debate and academic discourse, they point to different options and open questions on how to solve the most important problems in the field of renewable energies.

All TBP are published in the conference documents as inputs to the preparation process. They can also be found on the conference website at www.renewables2004.de.

Executive Summary

Renewable energy is inexhaustible and abundant. Ultimately it was the origin of fossil fuels which became the basis on which the Industrial Revolution was built. These sources of energy however will not last forever and have proven to be one of the main sources of our environmental problems. It is clear therefore that in due time renewable energies will dominate the world´s energy system, due to their inherent advantages such as mitigation of climate change, generation of employment and reduction of poverty, as well as increased energy security and supply.

About the Author

José Goldemberg earned his Ph.D. in Physical Science from the University de São Paulo of which he was Rector. He has served as President of the Energy Company of the State of São Paulo (CESP), Minister for Science and Technology and Minister of Education of the Federal Government of Brazil. Presently he is Secretary for the Environment of the State of São Paulo.

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1. Introduction

All energy used by man originates in one of the following sources: (a) *radiant energy* emitted by the sun (solar energy); (b) *geothermal energy* from the interior of earth; (c) *tidal energy* originating in the gravitational pull from the moon; (d) *nuclear energy*.

The dominant is solar energy, thousands of times larger than all the others and inexhaustible as long as the sun shines (approximately 4.5 billion years). Table 1 compares the energy available on earth with present energy consumption and fossil fuel reserves.

Table 1 . Energy available on Earth

	x10^{12} watts
Solar	174 000
Geothermal	32
Tidal	3
Present world energy consumption*	12.7
Photosynthesis	40
Winds, waves convection and currents	370
Fossil fuel reserves (mainly coal)	≈ 2000

Source: Hubbert [1971]. World's average primary energy consumption (2001) is 2.1 kW per capita.

Lasting for a long time is not the only criteria to judge an energy source. The way it is converted into forms that meet our needs, the environment and health issues – at the local, regional and global level – the problem of guaranteeing energy security, the overriding social issues such as the connection between energy and poverty, employment generation and gender have also to be addressed.

We will show in this paper that the present energy system, based essentially on the use of fossil fuels (not renewable), cannot handle these problems very well and that increasing the share of renewable energies is one of the best ways of addressing them. We will specifically address the following aspects: (1) the contribution of renewable energy to *mitigating climate change*; (2) *innovation, local markets and employment generation*; (3) *diversification of energy supply*, *energy security* and *prevention of conflicts* about natural energy resources; (4) *poverty reduction* through improved energy access and gender aspects; (5) *health related impacts* (local air pollution, indoor air pollution) and (6) positive *spill-over effects* to other sector and further benefits. In the concluding section some recommendations will be made.

2. Renewable Energy – Some Characteristics

Solar energy manifests itself as low temperature solar heat, high temperature solar heat, wind electricity and photovoltaics. Low temperature solar heat is produced by the absorption of sunlight by darkened surfaces that convert it into heat that can be used for warming water or other fluids. High temperature solar heat can be obtained by focusing sunlight and heating fluids to high temperature that can be used to generate electricity. Wind electricity is produced by winds created by turbulence caused by the warming of the atmosphere by solar heating. Photovoltaics is the direct conversion of the ultraviolet component of sunlight into electricity in appropriate surfaces. These forms of energy are all renewable by definition.

Geothermal energy manifests itself in the form of hot water or vapor and can be used for heat or electricity production in some specific regions. It is a renewable energy source. Tidal energy can be used to generate electricity in some coastal areas and is also a renewable source of energy.

Hydropower is indirectly linked to sunlight which evaporates water of the oceans which precipitates in the form of rain in the continents forming rivers. Dams are built on rivers forming reservoirs, which guarantee a steady supply of water for electricity generation. A large dam is a dam with a height of 15 meters or more from the foundation. Small dams are smaller than that or have no storage reservoir. Usually they produce less than 10 Megawatts of electricity. Large hydropower plants flooding large areas might displace people and have undesirable ecological or social impacts, so they are considered to be non- renewable resource by some. Small hydropower plants are usually not affected by such problems.

A small part of the solar energy reaching the Earth is converted by photosynthesis into biomass (organic matter). Part of such matter was buried in the distant past (hundreds of millions of years) by sediments and earthquakes and transformed by bacterial action in coal, oil and gas which constitute present fossil fuels resources (which are not renewable). Biomass is usually used as a renewable energy except when leading to deforestation.

Box 1 - Biomass

Biomass can be used in two ways:

Traditional or non-commercial biomass is unprocessed biomass-based fuels, such as crop residues, fuelwood and animal dung used frequently with very low efficiencies for cooking and heating in many developing countries. Although traditional energy sources can be used renewably they frequently are leading to deforestation. This is why programs to develop and disseminate improved biomass stoves in many African countries, China and India are so important.
Modern biomass is the biomass produced in a sustainable way and used for electricity generation, heat production and transportation (liquid fuels). It includes wood/forest residues from reforestation and/or sustainable management, energy crops, rural (animal and agricultural) and urban residues (including solid waste and liquid effluents), excluding the traditional uses of fuelwood in unefficient and pollutant conversion systems. Most of the biomass used in OECD countries falls in this category.

The most important energy source in many developing countries is only renewable if realistically replaced. Much biomass use in developing countries either domestic small scale use or large scale for industrial purposes, is leading to deforestation. Moreover, biomass use for cooking and heating in developing countries is a major cause of serious indoor pollution, particularly to women, small children and the elderly. On the other hand, in OECD countries most biomass used is "modern biomass", from wood plantations, wood, urban or rural residues.

3. The Advantages of Renewables

3.1 The contribution of renewable energy to mitigate climate change

The present energy system is heavily dependent on the use of fossil fuels. Worldwide coal, oil and gas account for 80 percent of primary energy consumption. Fossil fuel combustion is the prime source of carbon dioxide (CO_2) emissions which are growing at the rate of 0.5% per year. According to the Intergovernmental Panel on Climate Change [IPCC, 2003], present levels have reached 340 ppmv up from 270 ppmv at the dawn of the industrial revolution two centuries ago.

Emissions of anthropogenic greenhouse gases, mostly from the production and use of energy, are altering the atmosphere in ways that are affecting the climate. As stated in the Third Assessment Report of the IPCC, there is new and stronger evidence that most of the warming observed over the last fifty years is attributable to human activities and that significant climate change would result if 21st century energy needs were met without a major reduction in the carbon emissions of the global energy system during this century. Current CO_2 emission trends, if not controlled, will lead to more than a doubling of atmospheric concentrations before year 2050, relative to pre-industrial levels. Changes have already been observed in climate patterns that correspond to scientific projections based on increasing concentrations of greenhouse gases.

This is a serious challenge to sustainable development and the main strategies to prevent it are: (a) more efficient use of energy, especially at the point of end use in buildings, transportation, and production processes; (b) increased reliance on renewable energy

sources; (c) accelerated development and deployment of new and advanced energy technologies, including next-generation fossil fuel technologies that produce near-zero harmful emissions. The relative importance of these options and the order they become relevant depends on the stage of development of the region as well as availability of natural resources and technology. There are however important differences in the energy systems of OECD and developing countries as indicated in Table 2.

Table 2. Characteristics of energy systems (2000)

	Fossil Fuels (%)	Renewable energy (%)	Nuclear (%)	Growth rate, all sources (%/yr, 1971-2000)
OECD	82.7	6.2	11.0	1.6
Developing countries	71.7	27.6	0.7	3.9

Source: IEA [2002]

In the OECD countries which have reached a very high level of development, gains in energy efficiency have been the main strategy followed. In developing countries where renewables (mainly biomass) are already very important (27.6%) – albeit used in inefficient ways – modernization of the way they are used seems the better strategy to follow. In these countries energy consumption is growing 2.5 times more rapidly than in OECD countries so there is ample space for innovation as the energy system grows. In all cases the increased use of renewables, which are carbon free, will contribute to reduction in CO_2 emissions and thus mitigate climate change.

3.2 Innovations, local market and employment generation

The rapidly growing renewable energy industries and service sectors in many countries show clear evidence that the systematic promotion of such new technologies offers great opportunities for innovation, for the development of energy markets with locally or regionally oriented value chains and thereby, for the creation of new jobs with very different qualification requirements. While the development and deployment of new state-of-the art renewable energy technologies, such as wind or photovoltaic energy, require highly skilled, knowledge intensive work-forces in industrialized countries, developing countries can, for instance, benefit economically from an increased use of improved biomass-based energy generation, both in terms of better availability of energy for productive use and through the provision of energy services as such. Examples are the widespread use of improved wood and charcoal cooking stoves in Kenya and other African countries as well as the production of ethanol – an excellent substitute of gasoline in otto-cycle – from sugarcane in Brazil.

Generally speaking, renewable energies are important for local employment and income generation which results from manufacturing, project development, servicing and in the case of biomass, rural jobs for the biomass production.

Usually renewable energy devices are decentralized, modular in size and have low operating costs in addition of involving short construction times which give much greater flexibility in energy planning and investment. The Table 3 provides an idea of the number of jobs per unit of energy generated from different sources.

Table 3. Direct jobs in energy production.

Sector	Jobs. year /MTOE (fuel production)	Jobs - year / Terawatt-hour (fuel production + power generation)
Petroleum[1]	396	260
Offshore oil[1]	450	265
Natural gas[1]	428	250
Coal[1]	925	370
Nuclear[2]	100	75
Wood energy[3]		733 – 1067
Hydro[4]		250
Minihydro[5]		120
Wind		918 (5) – 2,400 (6)
Photovoltaics		29,580 (7) - 107,000 (5)
Bioenergy (from sugarcane)[8]		3,711-5,392

Sources: (1) Grassi [1996]; (2) Electric Power International [1995] *apud* Grassi [1996][1]; (3) Grassi [1996][2]; (4) Carvalho and Szwarcz [2001]; (5) Perez [2001]; (6) IEA [2002b][3]; (7) REPP [2001][4], IEA [2002b][5]; (8) ÚNICA [2003][6].

[1] , 500 people was the staff level for operation of a 1350 MW nuclear power plant in the U.S., producing 9.45 TWh/yr (or 2.138 Mtoe/yr) at efficiency of 38%

[2] electric generation based on herbaceous crops (5.5 direct jobs/ MWe) and on forestry crops (8 direct jobs/ Mwe), utilization 7,500 h/yr

[3] world installed capacity for wind 17,300 MW, utilization 2,000 h/yr and 4.8 jobs/MW

[4] including 12 different activities to construct, transport, install and service 1 MW of PV (not included economies of scale between 2 kW and 1 MW), world installed PV capacity is 800 MW

[5] utilization of 1,200 h/yr; 35.5 jobs/MW (included 15 different activities to manufacture, transport, install and service 1 MW of wind power)

[6] ethanol industry provides 33 direct jobs/ million liter in Brazil, where ethanol production in the 1992-2001 period ranged between 10.6-15.4 billion liters/yr (LHV of ethanol 6,500 kcal/kg and density 0.8kg/l); energy production comprised 7 Mtoe of ethanol fuel, plus 9.6 TWh/yr of cogeneration (installed capacity 2,000 MW, utilization of 4,800 hours/yr)

These numbers were obtained from a variety of sources and include jobs involved in operating the generating stations as well as the jobs involved in producing and maintaining the equipment. Photovoltaic energy is usually generated (and used) in small modules of 100 watts and the generation of 1 TWh would require typically 10 million modules to be installed and maintained. This is the reason for the creation of a large number of jobs. Ethanol production involves large plantations of sugarcane, which explains the number of generated jobs.

The main beneficiaries of the adoption of renewable sources of energy will be the developing countries, where biomass, and particularly fuelwood, are used widely with very inefficient and wasteful technologies for cooking and heating. In such countries the modernization of the use of biomass could bring – among others – great benefits, including a reduction in deforestation.

3.3 Diversification of energy supply, energy security and prevention of conflicts about natural resources

The cost of maintaining energy security in today's industrialized countries comes at high, but usually hidden, costs that find expression in military and security spending. The volatile world market prices for conventional energy sources, in particular oil, pose great risks for large parts of the world's economic and political stability, with sometimes dramatic effects on energy-importing developing countries. In this context, renewable energies can help to diversify energy supply and to increase energy security. It should increase the economic benefits that result from transformations in energy trading patterns. Additionally, in the mid-and long-term perspective renewable energies prolong the availability of most fossil fuels for the satisfaction of both energy needs and numerous other non-energy needs.

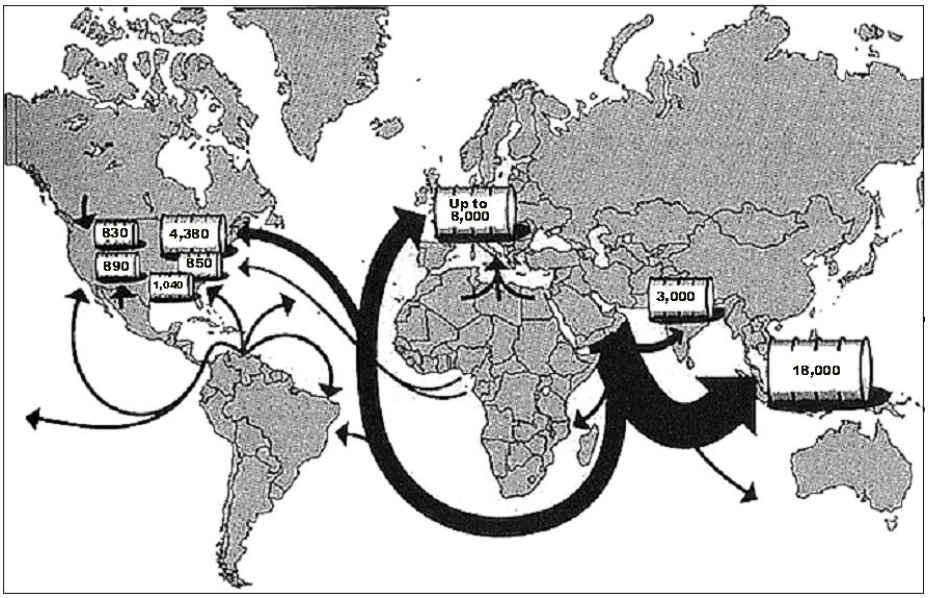
The potential for conflict, sabotage, disruption of production and trade of fossil fuels and fissionable materials cannot be dismissed. As far as electricity supply is concerned this is dramatized by recent "blackouts" in the Eastern United States, the United Kingdom and Italy, probably due to accidents, which are difficult to eliminate in highly centralized production and distribution systems. As far as oil is concerned, potential threats lead to sudden transient price increases (price spikes) that cause economic problems in many countries, and disrupt global economic growth.

The present energy system of industrialised countries is heavily dependent on fossil fuels, which are geographically concentrated in a few regions of the world. Dependence on imported fuels leaves many countries vulnerable to disruption in supply, which might pose physical hardships and an economic burden for others; the weight of fossil fuels imports on their balance of payments is unbearable in some countries (Box 2).

To reduce such dependence is a high priority in many countries, particularly in oil importing developing countries which frequently spend a large fraction of the foreign currency earnings in oil imports. Just to give an example oil imports consume one half of all export earnings in Barbados and this situation is widespread among oil poor countries. To increase the share of indigenous renewably energy in their system is an important step in solving this problem.

Box 2 - Flow of Gulf Oil Supplies (2010)

Almost two-thirds of the world's oil resources are in the Middle East, mostly in the Gulf region (the Islamic Republic of Iran, Iraq, Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates). Although these six countries now account for only 27 percent of global crude oil supplies, they are expected to double their share to 53 percent in 2010 [UNEP, WEC and UNDESA, 2000]. All OECD countries are expected to increase their dependence on oil imports over the next few years. Their imports, 56 percent of their energy requirements in 1996, are expected to rise to 76 percent in 2020. Asia-Pacific countries crude oil imports are expected to increase to 72 percent of their requirements in 2005 (up from 56 percent in 1993). The Middle East is expected to account for 92 percent of the region's imports. The Gulf region is expected to supply 18 million barrels a day to Asia-Pacific countries in 2010.



3.4 Poverty reduction through improved energy access and gender aspects

The enhanced use of renewables is closely linked to poverty reduction and elimination, since energy services can: (a) improve access to pumped drinking water – clean water and cooked food to reduce hunger (95% of food needs cooking); (b) reduce the time spent by women and children on basic survival activities (gathering firewood, fetching water, cooking, etc.) and; (c) provide lighting that permits home study, increases security and enables the use of educational media and communication in school and reduce deforestation.

More than two billion people cannot access affordable energy services, based on the efficient use of gaseous and liquid fuels, and electricity and are dependent on gathering fuelwood, fetching water, cooking, etc. This constrains their opportunities for economic development and improved living standards. Women, the elderly and children suffer disproportionately because of their relative

dependence on traditional fuels and exposure to emissions from cooking which is the main cause of respiratory diseases. Access to electricity through transmission distribution lines is unlikely to be possible in many parts of the world for a long time, so access to modern decentralised small-scale energy technologies particularly renewables are an important element to successful poverty alleviation. The revenues from exported biofuels are another important element to alleviate poverty in developing countries.

3.5 Health related impacts

The main pollutants emitted in the combustion of fossil fuels are sulphur and nitrogen oxides, carbon monoxide and suspended particulate matter. Ozone is formed in the troposphere from interaction among hydrocarbon, nitrogen oxides and sunlight. The environmental impacts of a host of energy-linked emissions — including suspended fine particles and precursors of ozone and acid deposition — contribute to local and regional air pollution and ecosystem degradation. Human health is threatened by high levels of pollution from fossil fuel combustion. At the local level energy-related emissions from fossil fuel combustion, including in the transport sector, are major contributors to urban air pollution, which is thought to be responsible for about hundreds of thousands deaths annually around the world. At the regional level precursors of acid deposition from fuel combustion can be precipitated thousands of kilometres from their point of origin – often crossing national boundaries. The resulting acidification is causing significant damage to natural systems, crops, and human-made structures, and can, over time, alter the composition and function of entire ecosystems. Table 4 shows some of the consequences of the use of fossil fuels. Needless to say renewables contribute far less to these emissions.

Table 4. Environmental and Health Problems

Insult	Human Disruption Index	Share of the human disruption caused by fossil fuel burning (%)
Oil added to oceans	10	44
Sulphur emissions to atmosphere	2.7	85
Nitrous oxide flow to atmosphere	0.5	12
Particulate emission to atmosphere	0.12	35
Carbon dioxide flow to atmosphere	0.05	75

Sources: UNEP, WEC and UNDESA [2003] [7].

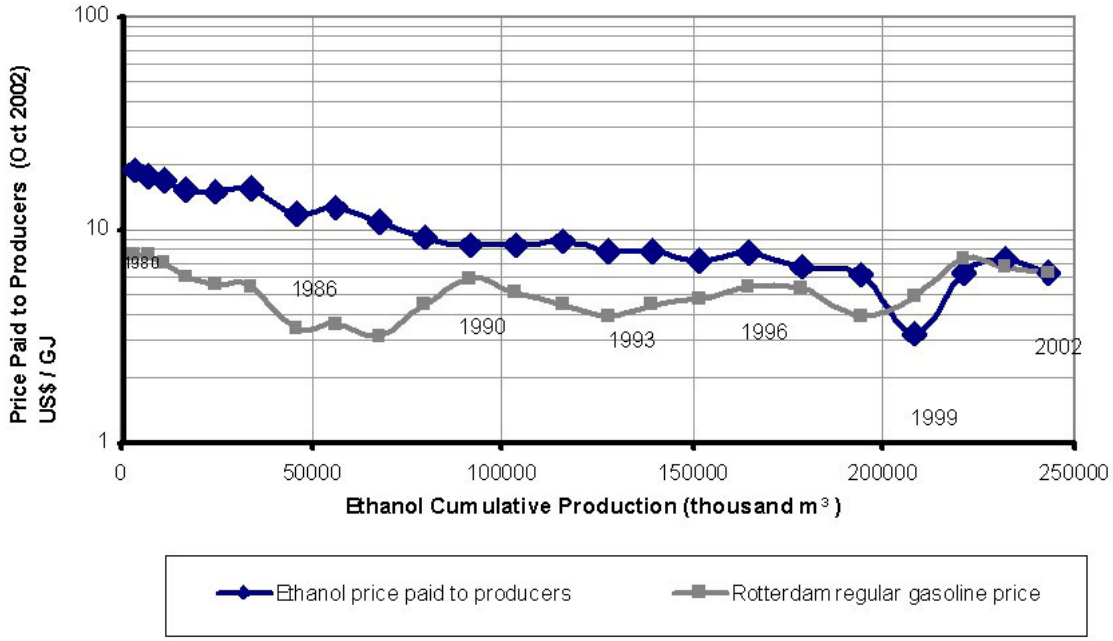
[7] The human disruption index is the ratio of human generated flow to the natural (baseline) flow.

3.6 Positive spill-over effects to other sectors and further benefits

One of the problems with renewables is the fact that some of them are intermittent. This is indeed the case for PV, which requires sunshine, which tends to be erratic in some locations. However geothermal, small hydro and specially biomass do not suffer from such shortcomings. In the case of PV which is eminently suited for decentralized use in rural remote areas that cannot be reached by the electricity grid, the use of automobile batteries for storage has proved to be a sensible and practical solution supplying electricity for lighting in the evenings when it is most needed, and the same applies to other uses such as radio, TV communications and refrigeration. In the case of wind, the problem of intermittency can be solved by feeding the electricity generated in large grids, as it is done in Denmark, Germany and the United Kingdom. Another solution is to use electricity to compress air which can be stored and generate electricity when needed.

One of the most striking successes of renewables, and its spin-offs, is the ethanol program in Brazil, where it is produced from sugarcane and has replaced one half of the gasoline that would otherwise be consumed in the country (using roughly 4 million hectares of land). In this case, most of the energy needed for the processing of the raw material to the final product comes from the bagasse (sugarcane residue after crushing process), requiring very little "external" sources of supply in the form of fossil fuels (in agricultural part of sugarcane production). This is the reason why the energy balance for ethanol production in Brazil is 10:1 and the production of ethanol from corn in the United States has an energy balance of approximately 1.5:1. The technological progress in this area, both in the agricultural and industrial sectors is striking and in Brazil, as well as economies of scale, led to the impressive reduction of costs in ethanol production, which is presently competitive with gasoline in Rotterdam (Figure 1). This has led to intensive research to produce liquid fuels from celulosi materials, which is very promising since the resource base of biomass is so widespread all over the world. Developed countries have a significant role to play introducing biofuels in their energy systems, either directly or blended with gasoline or diesel.

Figure 1. Compared prices of gasoline in Rotterdam and ethanol in Brazil



Source: Goldemberg, Coelho and Lucon [2003]

4. Conclusions

The full potential and advantages of renewables are hindered at present because the costs of fossil fuels do not reflect their full cost. They are subsidized in several parts of the world and the "externalities" associated with them, such as additional health and environmental costs are not considered. Removing subsidies from fossil fuels would make renewables competitive in many areas. Generally speaking the use of renewables might benefit from bilateral and regional cooperation. After the Johannesburg World Summit for Sustainabale Development (WSSD), a number of programs to that effect were presented to the United Nations Secretariat to promote sustainable energy programs in developing countries, 23 of these with energy as a central focus and 16 with a considerable impact on energy. These partnerships included most prominently the DESA-led Clean Fuels and Transport Initiative, the UNDP/World Bank-led Global Village Energy Partnership (GVEP), the UNDP/LPG Association led LPG Challenge, the EdF/ACCESS led AREA: Alliance for Rural Energy in Africa, the EU Partnership on Energy for Poverty Eradication and Sustainable Development, and the UNEP-led Global Network on Energy for Sustainable Development (GNESD). Particularly important among them is the Johannesburg Coalition for Renewable Energy (JREC) to which more than 80 countries have adhered. The enhanced use of renewables with its reliance on decentralized production, employment generation and reduction of environmental impacts is a general characteristics of most of these programs.

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