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ON

ENERGY, DEVELOPMENT, AND THE ENVIRONMENT



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INTRODUCTION

Three years ago, when we first started our UNIS/UN Student Conferences, we felt that the most urgent problem in the world was Equity and that all people should be assured food, shelter, health care, education, and employment. We felt then, as we do now, that study and understanding of a problem can be the beginning of a commitment to finding the particular personal actions that can make a dent in the problem. In this belief, we start our fourth UNIS/UN Student Conference on "Energy, Development, and the Environment."

THE NEW INTERNATIONAL ECONOMIC ORDER

The 1980s mark the Third Development Decade. By the 1960s most former colonial countries had achieved their independence. But because for many years their economies had been run for the benefit of the mother country, they needed to catch up to the industrialized world. A new era was to dawn when all nations would take their places as equals in the global community.

As the second development decade of the 1970s got under way, statistics emerged showing that the gap between the rich and poor nations was far from narrowing; it was widening. How was this possible? Aid was pouring into the "developing" countries. Why was this assistance not having the effect of raising people's standard of living and bringing them the economic basis for self-respect that liberation had promised? Some answers began to come in by mid-decade. A nightmarish twist had occurred in the structure of aid so that the "haves" could continue to have, at the expense of the "have-nots." Some of the factors contributing to this situation were:

1. Humanitarian health measures had caused a rise in population.
2. The priorities and methods of development were set by western, industrialized countries.
3. Raising cash crops, increasing large scale farming, and industrializing for export disrupted food production and caused a massive influx into the cities.
4. Much of the aid from rich countries came with strings attached, political and economic. The pattern of investment created a new form of exploitation.

More wealth was taken out of the countries than was developed in them. There were few jobs for the urban poor; not enough land was available for the small farmer; and not enough money was put into the health and education of children so that the pattern of poverty would not be endlessly repeated.

In 1974 and 1975, two special sessions of the United Nations General Assembly called for a New International Economic Order. A new structure of aid was spelled out. It was not perfect by any means, but it was a beginning. Nations were to be helped to become more independent; not aid but self-reliance was the aim. Developing countries should get fair prices for their raw materials and share in world trade to the extent of producing a minimum of 25 per cent of all the manufactured goods on the world market. More aid should be given them by the United Nations, and in addition the rich countries should contribute 0.7 per cent of their Gross National Product (GNP). Only Sweden and the Netherlands reached that 0.7 per cent goal. As recession struck and the developed countries had difficulties balancing their budgets at home, they became reluctant to increase their external aid.

THE THIRD DEVELOPMENT DECADE

This summer the United Nations will hold another special session, this time on a New International Development Strategy for the 1980s. It is a different world from the 1970s, and perhaps the single most important factor contributing to the change is the energy crisis. The growth in the economies of the developed countries after the Second World War was built on cheap oil. Easily accessible light crude oil is running out. The oil producing countries must gain what profit they can from their nonrenewable resources. They must slow down production both to make the oil last as long as possible and to absorb the enormous income by developing their own economies.

The high price of oil has slowed development both in the industrialized "North" and in the developing "South." The "massive transfer of resources" from the rich nations to the poor, repeatedly called for by United Nations conferences, has not taken place. When calls for generosity and "enlightened self-interest" are shrugged off as unrealistic, what development strategies can the United Nations suggest that will work in the increasingly tight economic situation?

Mr. K.K.S.Dadzie, Director General for Development and International Economic Co-operation, has suggested a three pronged attack. First, ways must be found to stop the recession producing the downward spiral of supply and demand. If industrialized countries stop importing goods, or raise tariffs to protect their industries and employment, then developing countries cannot earn enough through their exports either to finance development or to pay their debts.

The second prong is to spur development in both the rich and the poor countries and create an interchange of mutual benefit. The industrialized countries should be encouraged to turn to high technology production at home and massive investment in industry, transportation and other services in the developing countries. This investment should enable the developing countries to produce goods requiring a lower level of technology for sale in the developed countries. Everyone would benefit. The consumer in the wealthy "North" would be able to buy cheaper goods, and the developing countries would earn enough to buy the high technology products.

The final prong to this strategy is long term planning, both to establish the machinery for this exchange and to tackle the problem of energy production and use. Energy is important at every stage to power the various development projects. The details of the New International Development Strategy (NIDS), which can revive the hopes of a New International Economic Order (NIEO), are to be worked out this summer. The appeal to the international community is based on the conviction the economic crisis is world wide and that the parts cannot prosper indefinitely separate from the whole. Nations cannot devise individual survival plans. Mankind can only survive within a global strategy for survival.

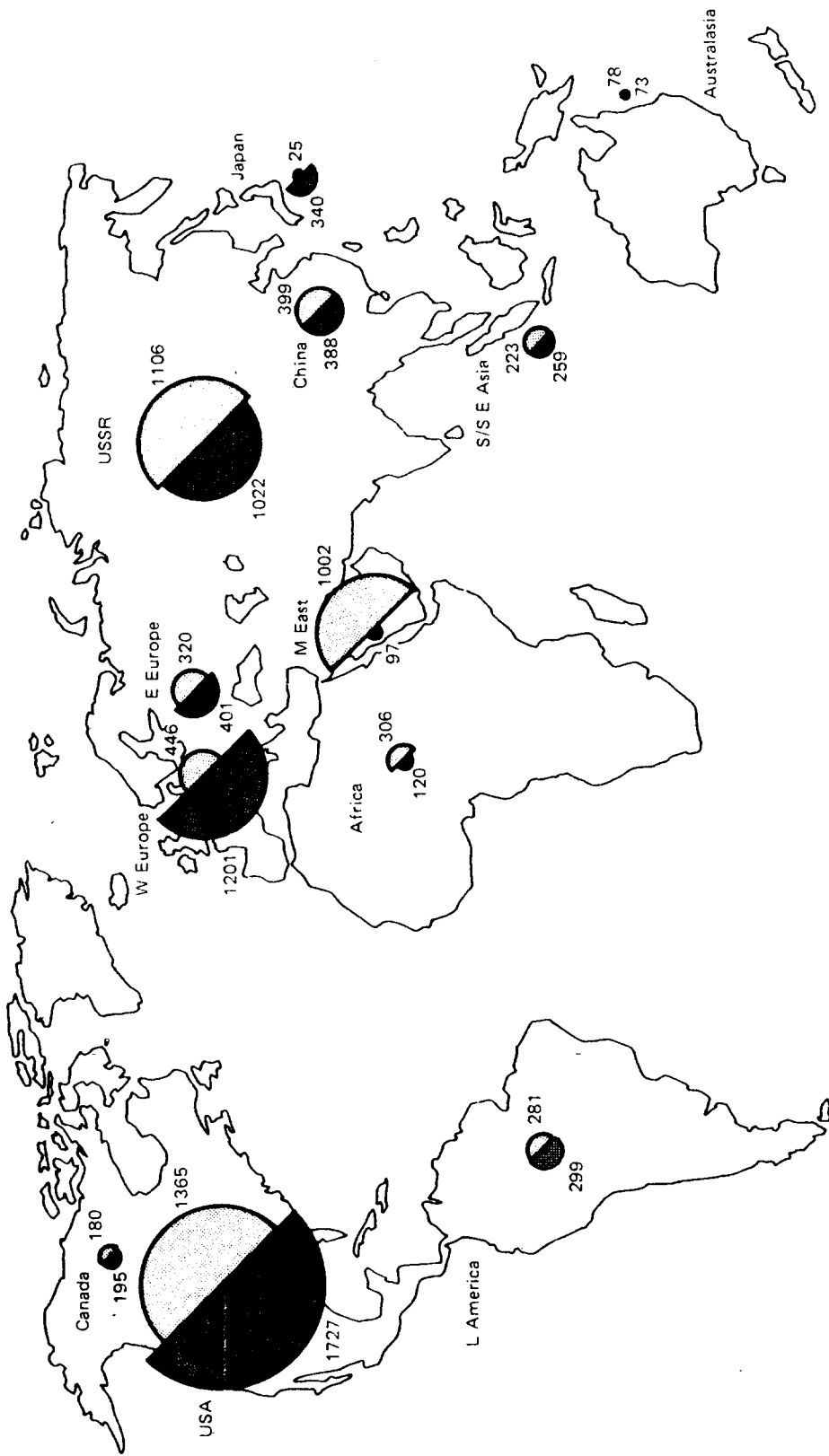
DEVELOPMENT STRATEGIES WITHIN COUNTRIES

There are many different roads to development. Considerable disagreement exists as to which is the best approach in any particular situation. A basic question troubling both rich and poor countries concerns the nature of development. Do we measure development by the amount of material possessions or by the quality of life? Do we enjoy the beauties of nature, the stimulation of cultural activities, the company of friends more with wealth, or is materialism as much an obstacle to happiness as a cause of it? When a cross section of Sweden's population was asked if they would be prepared to sacrifice some of their high standard of living so others could raise theirs, the answer was an emphatic "No." And Sweden is a country with a fine record of international generosity.

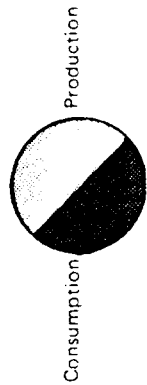
Industrialized countries have exported that concept of the desirability of material development. As resources are limited, such concepts have resulted in the creation of wealthy elites and poverty stricken majorities within the poor countries. However, if development strategies shift their priorities and fulfill the demand for adequate food, housing, health, education, and employment, more could be achieved with less. Some countries have already changed their focus. Measured by the standards of its Gross Domestic Product (GDP) Sri Lanka is a low income country. But on a Physical Quality of Life Index, which measures life expectancy and literacy rates, it has a high rating.

Another question concerns the value of industrialization as opposed to rural development. Which should take precedence, industry, the cities, the "modern" sector -- including the elites -- or the villages and the "traditional" sector? This question is closely connected with problems of decision making and control. Do centralized governments devise and impose plans, or do communities become more self-reliant? Does wealth "trickle down" from the top, or "bubble up" from the people? Should a development strategy ensure that trickles and bubbles meet somewhere in the middle?

Map 2: World Energy Production and Consumption
(million tonnes oil equivalent)



World total production 5730 mtoe
World total consumption 6123 mtoe



Sources: UN World Energy Supplies 1971-1975
BP Statistical Review of the World Oil Industry 1975

ENERGY AND DEVELOPMENT

Every country needs energy. The industries, utilities, and transportation in developed countries consume the major portion of the world's energy. But the developing countries cannot build their industries, irrigate their fields, cook, heat their homes, power their busses and trains without energy. The more energy used by developed countries, the less is available and the higher the price of the remaining world sources. The key words in a world energy strategy are efficiency and equity. Efficiency implies both conservation and appropriate technology. A wind powered generator is more appropriate and cheaper for a remote village with steady winds than electricity brought to that village over high voltage power lines from a distant nuclear reactor.

The developing world is unlikely to use as much energy as the industrialized countries in the near future, but it will require a fair share of technology and capital to develop what it does need. If the major share of investment and research goes to hard technology projects in the industrialized countries, what will be left for the others?

Even if the developing countries get their fair share of investment capital and technology transfers, how will these resources be applied within countries? Industries, concentrated in the cities, will need electricity, generated by either nuclear reactors, coal, or synthetic fuels. Yet villages may be better served by renewable sources of energy. The improvement in the overall quality of life depends on cheap and dependable sources of energy.

ALTERNATE, NEW AND RENEWABLE SOURCES OF ENERGY

It was not worthwhile investing in processes that would create the equivalent of one barrel of oil for over \$20 when the price of light crude was well under that sum. It is now well over that price which has made the cost of producing alternate sources of energy competitive. New and better technology may reduce the price of alternate energies further. A group of developing countries, led by Kenya, have urged the United Nations to make available - in a world forum - the latest research on new sources of energy. These alternate energies could free the world from dependence on oil and save these fossil fuels for their most appropriate end use: transportation and petrochemicals.

According to Dr. Joseph Barnea of UNITAR (United Nations Institute for Training and Research), at least forty-six alternate energy sources, discounting the nuclear option, are known. There is no shortage of oil: only easily accessible light crude oil is scarce. Oil is to be found in new sites, deeper in the earth, in tar sands and in shale. There are fourteen different forms of natural gas. There is coal. The technology exists to recover these resources and to deal with the environmental damage that might be caused. The purpose of a recent UNITAR conference in Montreal on Long Term Energy Sources was to review various energy technologies and to judge which seemed to be the most promising for further investment of time and money. Solar energy was explored, and its long range potential for providing cheap

electricity was examined. The conference was most optimistic. It suggested that there need be no "Limits to Growth," as was feared by a group of scientists known as the Club of Rome, in the early 1970s when it had become apparent that the world was consuming its nonrenewable sources at an alarming rate. New technologies are making us look at energy in totally new ways and finding sources where we had previously thought none existed.

It is important that the United Nations make available to developing countries the technology for these new energies. The Conference on New and Renewable Resources, to be held in Nairobi in August, 1981, plans to do just that. There is some controversy within developing countries as to just what alternate energies are suitable for their own economies. The countries within that group have developed at different rates in the last twenty years, and a group of middle income countries has emerged with the capacity to compete in industrialization and trade with the developed world. They need large amounts of cheap electricity and consider nuclear energy the best alternative to oil for generating it. The poorer developing countries cannot afford to build nuclear reactors and have insisted that the nuclear option be excluded from discussions during this conference. The conference will focus on these forms of new and renewable sources of energy: solar, geothermal, wind power, tidal power, wave power, the thermal gradient of the sea, biomass conversion, wood, charcoal, peat, energy from draught animals, oil shale, tar sand, hydro-power.

In his address to the Second Committee of the General Assembly last November, Mr. M.H.Gherab, Secretary-General of this conference, explained both the purpose and the problems of organizing it. A series of miniconferences and demonstration projects will inform both developed and developing countries of alternative options for energy sources and use. Some countries feel that a return to wood, animal, and wind power is primitive and bound to perpetuate the pattern of inferior development in the poorer countries. The conference Secretariat is aware of the tensions between centralized, hard technology energy production advocates and supporters of decentralized systems that better serve the villages. Some countries have already experimented with new energy technologies, but have not yet shared that knowledge with others. The conference will strive to make knowledge of these alternatives available to all countries, especially developing ones. But it cannot control the transfer of the technologies from those who have them to those who need them, nor advise national governments as to which energy source would be most appropriate for them.

TECHNOLOGY AND DEVELOPMENT

Technology is a term that refers to methods and machines for achieving goals. It can be complex or simple, require sophisticated training or plain common sense. It can be "capital intensive" and require large investments in materials, training and organization, or it can be "labor intensive," and employ many individuals in accomplishing given tasks. The terms "hard" and "soft", or "centralized" and "decentralized" are often associated with these extremes.

Most research into new technologies is done in the developed world -- more than 95 per cent, in fact. This creates two problems for the developing countries. First, most of the research arises from the needs of industrialized, urban societies. Second, the innovations are considered "property," are patented, and can only be bought or used for a fee. Technology is an integral part of development. Less developed countries need methods to solve their problems, as well as money. The problem is aggravated when methods are not only inappropriate, but have price tags on them.

Two recent conferences have addressed themselves to these problems: the United Nations Conference on Technical Co-operation in Developing Countries in Buenos Aires in August, 1978, and the United Nations Conference on Science and Technology for Development in Vienna in August, 1979. TCDC, as it has come to be called, is almost a doctrine. It proposes that countries turn to each other for help and share their common experience in solving the problems of underdevelopment. The flow of information should be horizontal, within the group, rather than vertical, i.e., from the rich down to the poor. It is too early to judge how successful the doctrine will be. The middle income developing countries may become as reluctant to share their income producing inventions as industrialized countries.

The key word at Buenos Aires was "cooperation." In Vienna it was "transfer." In Vienna the rich countries were asked to be more generous with their technology. They gave away very little. Technology has become the last bastion of wealth. The report of the conference, the Vienna Programme of Action, sounds optimistic, but it calls for no more than voluntary action and pledges to a common research fund of \$250 million, a tiny fraction of the billions spent annually on "R and D" (Research and development) in the developed world. The report also suggests more research in the "North" on problems affecting the "South", more opportunities for training of nationals who will serve their country of origin, more control of transnational corporations in their use and monopoly of technology in the host countries. There is little guarantee that any of these plans will be implemented. Without the transfer of technology that is both appropriate and affordable, the developing countries cannot solve their energy problems.

ENERGY

Five main aspects of energy concern us:

1. The science of energy. How can energy be conserved and how can it be used most efficiently by minimizing loss in its transformation?
2. The economics of energy. All non renewable resources are by definition finite in supply. How can we minimize the demand for these resources and control the rising cost?
3. The environmental impact of energy. Is it worth using a particular type of energy if it destroys the air, water, land, etc.?
4. The ethics of energy. How can we justify using too much energy and wasting it when others go without?

5. The politics of energy. How do our means of producing energy affect democracies, civil liberties, etc.?

There are two types of energy: renewable and non renewable. The non renewable sources of energy include the fossil fuels: coal, petroleum, natural gas, oil shale, tar sands, uranium. The renewable sources include: sun, water, wind, plants, animals, and recyclable wastes. The renewable sources are comparable to a fixed monthly income. They will always be generated and you can count on them. The non renewable sources of energy are comparable to a capital fund; once you have used it you cannot get it back. It is only within the last 200 years that we have used non renewable sources, and we are fast using them up. Energy is the ability to do work. Power is the rate of speed at which work is done or energy is used up.

Power is measured in watts.

Energy is measured in Joules, kilocalories, British thermal units (BTUs), ergs, eVs, etc. (see Glossary)

One of the most important problems in the use of energy is matching the fuel source with the task it has to perform. In a given situation, what is the most efficient way to use energy?

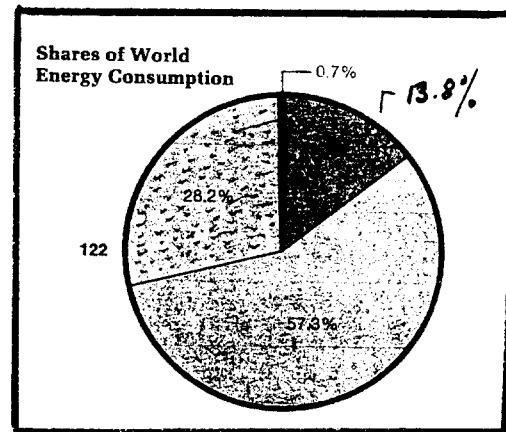
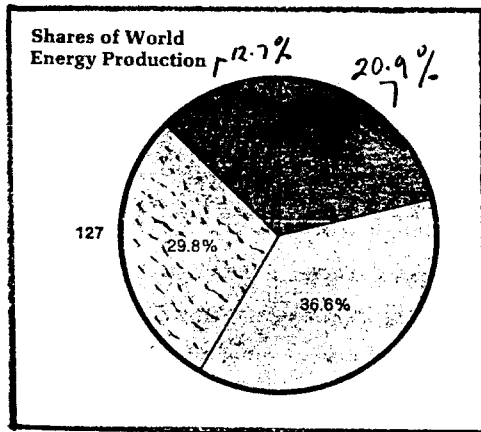
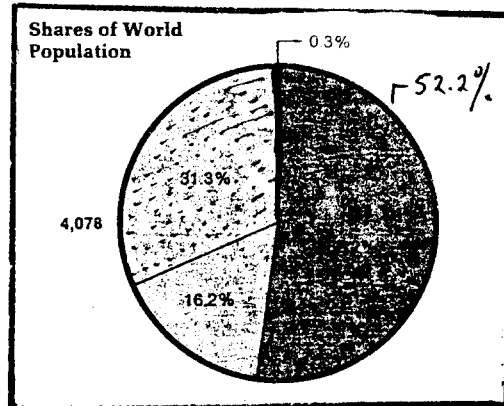
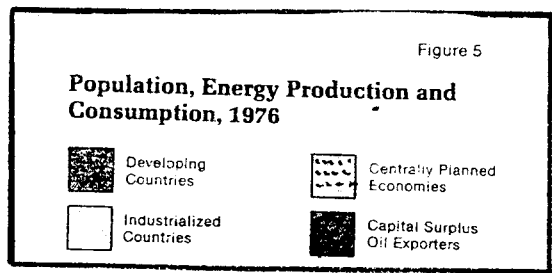
The first and second laws of Thermodynamics explain the transformation of energy. All matter has energy and as it changes it gives off heat as well as doing work. Some forms of energy are more easily harnessed to do work than others, so it is important that they are used efficiently. An energy source that produces tremendous heat, like a nuclear reactor to power an electric generating plant, is an inappropriate use of energy if that electricity heats homes. Home heating is a low temperature task which can as easily be performed by "soft" technologies like solar power. That electricity should be used for purposes for which there is no better alternative.

Fit the source of energy to the task it must perform. We do not need to settle for less energy; we just have to use it more efficiently.

ALTERNATE ENERGIES

This Working Paper concerns energy. The era of cheap energy from fossil fuels is gone. It will take some time to develop energy sources that are as reliable, versatile and perhaps once again as cheap as oil was. Some scientists speak of nuclear fusion, others of a mix of several alternatives. But an era of plentiful energy will not dawn for another thirty to fifty years. In the meantime, we must deal with a transition period during which we must develop several types of energy as a bridge toward a technological millenium.

How does a country choose which energy source is most appropriate for its needs? The nature of these energies must first be understood. We could not cover them all, nor any in the scientific detail of experts. In describing these various energies we have asked certain questions; How do they work? What do they cost? What is their most appropriate end use? What is their effect on the environment? Are they capital intensive, and so requiring some "centralized" control by corporations or governments, or labor intensive, and therefore capable of being decentralized?



1/ Reproduced by permission World Bank - Development Report 1979

TRADITIONAL AND MODERN ENERGY CONSUMPTION IN SOME DEVELOPING COUNTRIES, in kcal/day/capita

| Country | Traditional energies | | | | | Modern energies | Percentage of total nonfood energy consumption filled by traditional energies |
|------------|----------------------|-----------|------------------|-------|-------|-----------------|---|
| | Food | Fuel wood | Crop by-products | Dung | Total | | |
| Bangladesh | 1,900 | 200 | 1,900 | 1,100 | 3,200 | 500 | 86 |
| Nigeria | 2,100 | 7,000 | 600 | — | 7,600 | 1,700 | 82 |
| Indonesia | 2,000 | 6,500 | 200 | — | 6,700 | 3,400 | 66 |
| India | 2,000 | 2,400 | 500 | 1,000 | 3,900 | 4,200 | 48 |
| Brazil | 2,500 | 5,800 | 1,100 | — | 6,900 | 12,800 | 35 |
| Turkey | 2,800 | 2,600 | 1,300 | 2,000 | 5,900 | 12,100 | 33 |
| China | 2,100 | 1,100 | 2,000 | — | 3,100 | 8,300 | 27 |

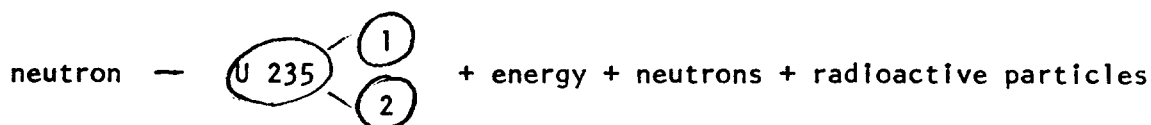
NUCLEAR ENERGY: FISSION

"Coal is wonderful stuff, but uranium is even better."

... Hans Albrecht Bethe

Introduction:

Nuclear fission is the act of splitting atoms in order to release energy. The energy release is made possible through a conversion of mass to energy ($E=mc^2$). The mass of the starting atom is greater than the sum of the masses of the resulting atoms. The mass that is lost is converted to energy. Only certain atoms can be used for fission, and for an atom to be split with an accompanying release of energy, it must be one with a large mass, and thus it has radioactive properties.



The fission of atoms to release energy is accomplished in a nuclear reactor. There are different types of reactors, but they all operate on the same principle. The fuel for the reactor is usually Uranium (U 235) which is enriched from the 0.7 per cent found in nature to about 2-3 per cent. This fissionable material is in the form of pellets and is fitted into tubes, called fuel rods, made of a material that is highly resistant to radiation damage --- zirconium alloy. A coolant, water or gas, circulates around the fuel rods. Neutrons are used to begin the fission process. These neutrons are slowed down by collision with a moderator (water or graphite in most cases) because "slow" or "thermal" neutrons split atoms more readily than do unmoderated neutrons. When an atom is split into two smaller atoms, a number of neutrons are released. Some of these neutrons collide with the moderator, become slow and split more atoms, resulting in what is known as a chain reaction. The energy or heat released through this process converts water into steam, which powers turbines, as in any conventional electric generator.

Reactor Safety:

The fuel used in a nuclear reactor is radioactive, which can make nuclear fission very dangerous. Nuclear power plants must therefore be equipped with various features designed to prevent accidents, and to contain radioactivity in the event an accident does occur. The construction of nuclear reactors in the United States is governed by federal and state laws and two agencies: the Nuclear Regulatory Commission (NRC), and the International Atomic Energy Agency (IAEA), which performs the same task all over the world. All mishaps, however insignificant, must be reported so that this information can be used to prevent accidents in other plants.

There is no danger of a plant exploding like an atomic bomb, because the nuclear fuel is not bomb grade material. The concentration of fissionable material in the fuel rods is too low.

The ultimate danger in a nuclear power plant is a core meltdown, the "China Syndrome." A meltdown can be caused by an interruption of the cooling cycle. The intense heat generated in the reactor causes the fuel to break apart or melt down. If unchecked, such an accident could cause the release of radioactive particles into the atmosphere and eventually lead to a complete meltdown: the reactor core would melt through the steel floor of the reactor building and through the earth, causing widespread contamination. It has not happened yet, so there is much controversy about the exact consequences of such an occurrence.

A serious accident at a nuclear plant would almost always be traced to a malfunctioning of the cooling system. An interruption in the cooling cycle could make a nuclear plant susceptible to a disastrous accident. To reduce the probability of such an occurrence a nuclear plant is built with many safety features such as control rods, which absorb neutrons and stop the fission reaction: emergency core cooling systems, to take over in the event that the normal cooling system breaks down: and automatic shutdown of the plant itself. But there is still the possibility of human error, as the accident at Three Mile Island showed.

At about 4 a.m., on Wednesday, March 28, 1979, one of the pumps that circulates water to the reactor at Three Mile Island broke down. The heat accumulated in the moderator did not dissipate, so there was an increase in pressure in the system. This caused an automatic relief valve to open, and the pressure in the system was reduced. The valve should then have closed, but it did not, and the water level began to drop. The emergency cooling system was automatically activated to pump water back into the moderator, and the water level began to return to normal. At this point the operators of the plant made a serious mistake. When they saw the water level rising, they thought that the relief valve had closed. They shut off the emergency cooling system to prevent an overflow of the reactor. But the relief valve was still open, and more water escaped through it, overflowing the drain tank of the containment building. This water was more radioactive than was normal, because the core had heated up and the fuel rods had cracked, releasing some fission fragments. The radioactive steam from this water entered the environment through the building ventilation system, and from there escaped into the atmosphere. At this point the operators realized their mistake and shut off the system. But the story of Three Mile Island continued. Inside the reactor, the core had become partially uncovered and had heated up to about four thousand degrees Fahrenheit. The water separated into hydrogen and oxygen because of the tremendously high temperature. The hydrogen collected at the top of the reactor, forming a hydrogen bubble. The danger was that the oxygen and hydrogen could recombine, causing a violent explosion that could conceivably rip the containment building open and release all the radioactivity inside. Everyone expected a catastrophe. What actually happened was that the oxygen combined with the zirconium, producing zirconium oxide.

The accident at the Three Mile Island plant showed how the safety features of a plant can fail. It also showed how critical a human decision can be, even when all the safety features work.

One of the more constructive results of the accident at Three Mile Island is the publication of the Kemeny Report, which stressed several measures that should be undertaken to eliminate at least the human error. The report recommended that signals on the control board be simplified to avoid confusion or misreading; that greater computerizing of processes be instituted to enable technicians to decide the effects of alternative emergency measures; and that the training of operators be improved.

Although the Kemeny Report could be seen as reassuring, there are still too many unknowns in reactor safety. One was recently illustrated when the Ramapo fault shifted, causing tremors under the Indian Point Nuclear Plant, 35 miles outside New York City.

Nuclear Fission as an Almost Renewable Source:

Uranium is a non renewable fossil fuel. The fuel becomes exhausted so that it will no longer sustain a chain reaction. The rods must then be disposed of and replaced. But uranium is costly and will eventually run out. There are several ways in which it can be made "renewable."

When a fuel rod is "spent" it is removed from the reactor. But a substantial amount of fissionable material is still present in the rod. Reprocessing involves separating the fissionable from the non-fissionable material in the rods, and recycling them. Plutonium is one of the elements separated, and instead of being part of an intensely hot fuel rod, it is now in a form that can be transported and used for different purposes. Plutonium, and the actinides that are also separated, are the most toxic substances known to man. A tiny particle inhaled can cause cancer and death within two weeks. A twenty pound lump can blow up a city.

President Carter has refused to approve the building of reprocessing plants in the United States or to allow aid for the building of such plants in other countries. Such plants are the first step to the creation of plutonium, and the manufacture of bomb grade materials. England, France, Russia are going ahead, both with reprocessing and the building of "breeder" reactors that would produce more plutonium than they would use. France, England, West Germany, Belgium, the Netherlands, and Italy have joined together to build the largest breeder reactor in the world, the Super-Phénix, outside Lyons, in France. Whatever dangers the accident at Three Mile Island might have posed, a similar accident at a breeder reactor would be 10-100 times more devastating.

A reactor does exist which so far has proved to be both safer and more efficient. The Canadian Deuterium Uranium (CANDU) reactor uses "heavy water" as a moderator, making it possible to use large quantities of lower grade uranium. Although the initial cost of the "heavy water" is high, several countries are building CANDU reactors, seemingly with much satisfaction in their operation.

The Disposal of Nuclear Wastes:

In the United States, a third of the fuel rods in a reactor are removed annually. The rods must be disposed of safely as there are radioactive fission fragments in them. The present practice is to place the rods in a pool of water forty feet deep. The rods cool, and some of the short lived isotopes disappear. But the problem of the long lived isotopes remains. Strontium and Cesium must be stored for about 600 years. Plutonium has a half life of 24,000 years. A breeder reactor, or a reprocessing plant would use up most, but not all, of the wastes.

The proposed method of storage is to fuse the fuel rods with glass or ceramic and then encase them in steel cylinders. The whole would then be stored two thousand feet underground. An ideal storage place is a salt bed. The radioactivity could not contaminate underground water because there would be no salt bed where there is water, since salt melts in water. The salt beds are geologically stable. The salt would fuse and form a solid casing around the rods if put under any heat pressure. No such sites have yet been developed as no community is anxious to be host to radioactive fuel rods. The spent nuclear rods are at the moment accumulating in storage areas in present nuclear plant complexes.

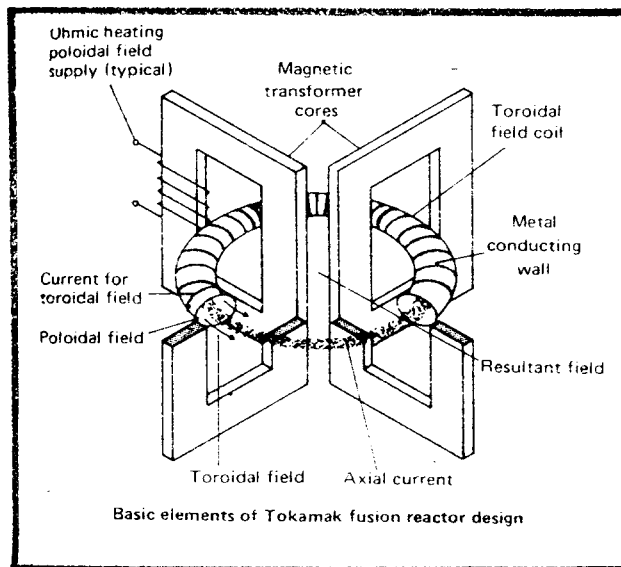
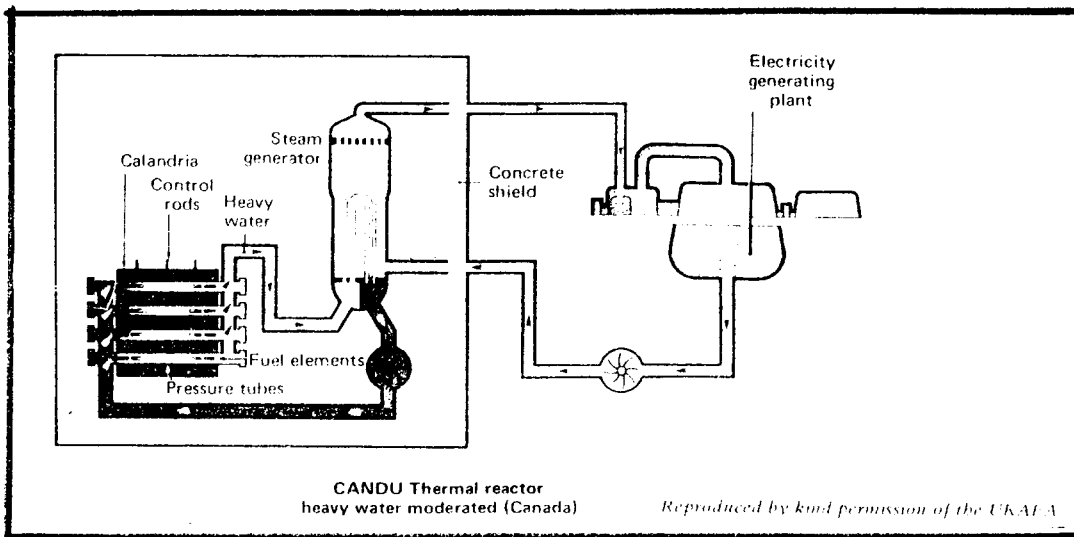
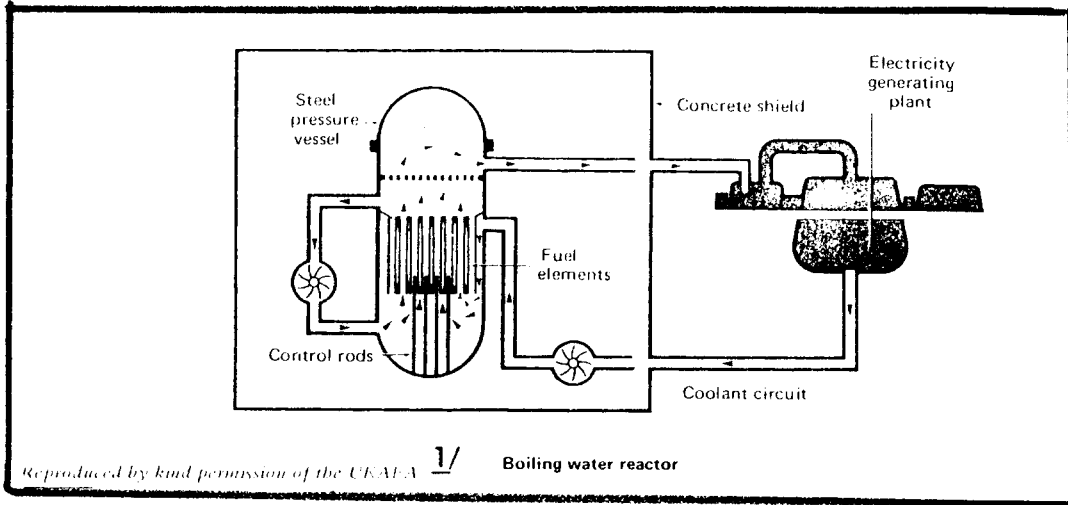
The Advantages and Disadvantages of Nuclear Energy:

The supporters of nuclear energy are aware of its dangers, but believe that technology can overcome most of them. They argue that the problems of accidents and waste disposal are more easily contained than those caused by pollution and burning of conventional fuels. A kilowatt of electricity produced by a nuclear powered generator is still the cheapest source of energy for an industrialized society that needs massive amounts of energy. Four hundred gigowatt (one thousand kilowatt) nuclear powered reactors would supply the world with all the electrical energy it is using now. Further economic development is inconceivable without the existence of such an energy source.

The anti-nuclear argument challenges this confidence on several counts. There is first of all outrage at the inherent danger of nuclear energy and at the power of those who control it. Protest groups all over the world have forced governments to look more closely at the construction of nuclear powered plants. New safety devices have raised the price of the electricity generated. Companies are no longer sure they can retrieve their investments and make a profit within the thirty year lifespan of a reactor. Nuclear generated electricity is no longer the cheapest source of energy, once it has been made safe and the construction of reactors has slowed in the United States.

Many developing countries view nuclear energy as an attractive option. To possess a nuclear reactor is a sign of national prestige. It is also the first stage in producing a bomb. It is enormously capital intensive -- in the building of the reactor as well as in constructing the electrical grid to carry the power where it is needed -- but middle income developing countries see nuclear energy as the path to becoming fully industrialized. Little seems to be said about its dangers. The Tarapur Atomic Power Station (TAPS) near Bombay, the first nuclear

NUCLEAR REACTORS



reactor to be built in the Third World, is so contaminated in certain areas that workers can only rush in for a few seconds to make minor adjustments. The government is reluctant to shut it down as there is no alternative electrical generating system for the city of Bombay.

There is also the political danger of nuclear proliferation. Not only will more nations have the bomb, but the theft of plutonium from breeder plants could put whole cities at the mercy of terrorists. Stealing plutonium is suicidal, but death for a cause on the part of fanatics is not unknown in history. The police methods that would have to be used to search for stolen plutonium would severely test the democratic system.

Thus, the true price of nuclear power can only be assessed when, to the economic costs are added the costs of potential or probable radiation pollution, long-term storage of nuclear wastes, the proliferation of nuclear weapons, and the loss of democratic institutions. When the full costs of nuclear energy are compared to the full costs of alternate energy systems it then becomes possible to reach conclusions about the relative merits of the many energy systems available to mankind.

NUCLEAR ENERGY:FUSION

Nuclear fusion is a potential hard energy source. It operates on the same principles as the sun--and the hydrogen bomb--under controlled conditions. Pairs of lightweight atomic nuclei are fused together to form a single nucleus having less mass than the sum of the original two. The lost mass has actually been turned into energy in the form of heat. Aside from its method of heat production, a fusion plant operates along the same lines as a fossil fuel burning plant. It uses heat to make steam that runs an electrical generator.

The atoms which are currently being considered for fusion are various forms (isotopes) of Hydrogen: Deuterium (containing one proton and one neutron) and Tritium (containing one proton and two neutrons). Because of the extremely high temperatures that fusion involves, the atoms undergo numerous collisions, thus stripping them of their electrons. When the fuel is in this state it is known as a plasma, a gaseous mixture in which its components are electrically charged and at high pressure.

The fusing of Deuterium and Tritium nuclei was chosen because it requires a relatively small amount of energy. The reaction results in the recombining of the fused nuclei to form a Helium nucleus (containing two protons and two neutrons) as well as releasing a neutron. The energy released by this reaction is in the form of velocity of the neutron, and to a lesser degree, of the Helium.

The development of fusion to the point where it can "break even", that it would create as much energy as it would consume, has not yet been reached. For fusion to take place at a rate that will permit break-even between the energy expended and the energy created, the Deuterium-Tritium reaction must occur at a temperature of at least 100,000,000 C. It is especially difficult to contain the plasma long enough for this reaction to occur because of the plasma's tendency towards instability and because of the loss of the necessary high temperatures.

Magnetic confinement attempts to overcome the problem of containment by keeping the plasma in the center of the reaction chamber with a magnetic field. This is possible because of the electric charge of the plasma. In this form of confinement the plasma will not come into contact with anything else and therefore will not tend to cool as rapidly, or melt the reaction chamber.

The shape found to be most suitable for a magnetic confinement chamber is that of a large "inner tube" which contains the plasma and is surrounded by magnets. This design, known as a TOKAMAK, is a Soviet invention. The largest reactor of this type is the TFTR (TOKAMAK Fusion Test Reactor) currently being built at Princeton University. The Princeton reactor is scheduled to be completed by 1981, and it is hoped that it will demonstrate break-even capability. TOKAMAK research is being conducted elsewhere in the United States and in other countries as well as in the Soviet Union. Other fusion technologies are being studied that use laser and particle beams.

However, it is some years before Nuclear Fusion will be developed to the point where it can be used commercially to generate electricity. Some estimates say it will take fifty years, and even then it may turn out to be too complicated and expensive for commercial use.

Fusion is not an energy source for developing countries in the near future. It is not yet available to the developed world, and it the most complex power source ever invented. Tritium is radioactive and will present a problem at the beginning, but there are more advanced fusion reactions, which involve no radioactivity, that can be employed in second or third generation reactors. Great amounts of technological as well as financial assistance must be made available to developing countries to enable them to produce energy by fusion.

Yet, if these various problems can be solved, fusion could possibly provide an almost limitless supply of safe, clean energy, as Deuterium can be retrieved directly from water.

COAL

Coal, often termed "underground sunshine," is in abundant supply and can be found in many parts of the world. It is difficult to measure the exact amount of world coal reserves. Some coal sources are more accessible than others. Some coal is of

higher quality. Anthracite is the aristocrat of coals, and it is in the least plentiful supply and more difficult to mine. Bitumen and lignite are softer coals, more polluting and used for different tasks.

The mining and use of coal poses many hazards. Mining is possibly the hardest form of labor in the world, and it causes a high incidence of black lung among miners. Strip mining and air pollution are environmental hazards. The emissions from burning coal are carcinogenic. Some of these particles combine with others in the air, causing rain to turn acid--in some cases as acidic as a lemon. Acid rain is affecting the forests, lakes and wild life in Europe and North America, often in areas far removed from industrial smokestacks. The carbon dioxide reaching the atmosphere is heating it, causing the "greenhouse effect." Some studies--though not all--indicate that a rise in the temperature of the atmosphere of 2-3 degrees centigrade might melt the polar icecaps and cause the sea level to rise.

These environmental hazards are formidable and caused a drastic decline in coal burning after the second world war. However, the present energy crisis has spurred a return to coal. New technologies may overcome some of the environmental problems. Burning coal by the fluidized bed process eliminates sulphur and other particles, a system much used in England. More complex technologies look to the liquefaction and gasification of coal. During the second world war Germany developed the Fischer-Tropsch process of making petroleum from coal, a costly process but one worth re-considering now.

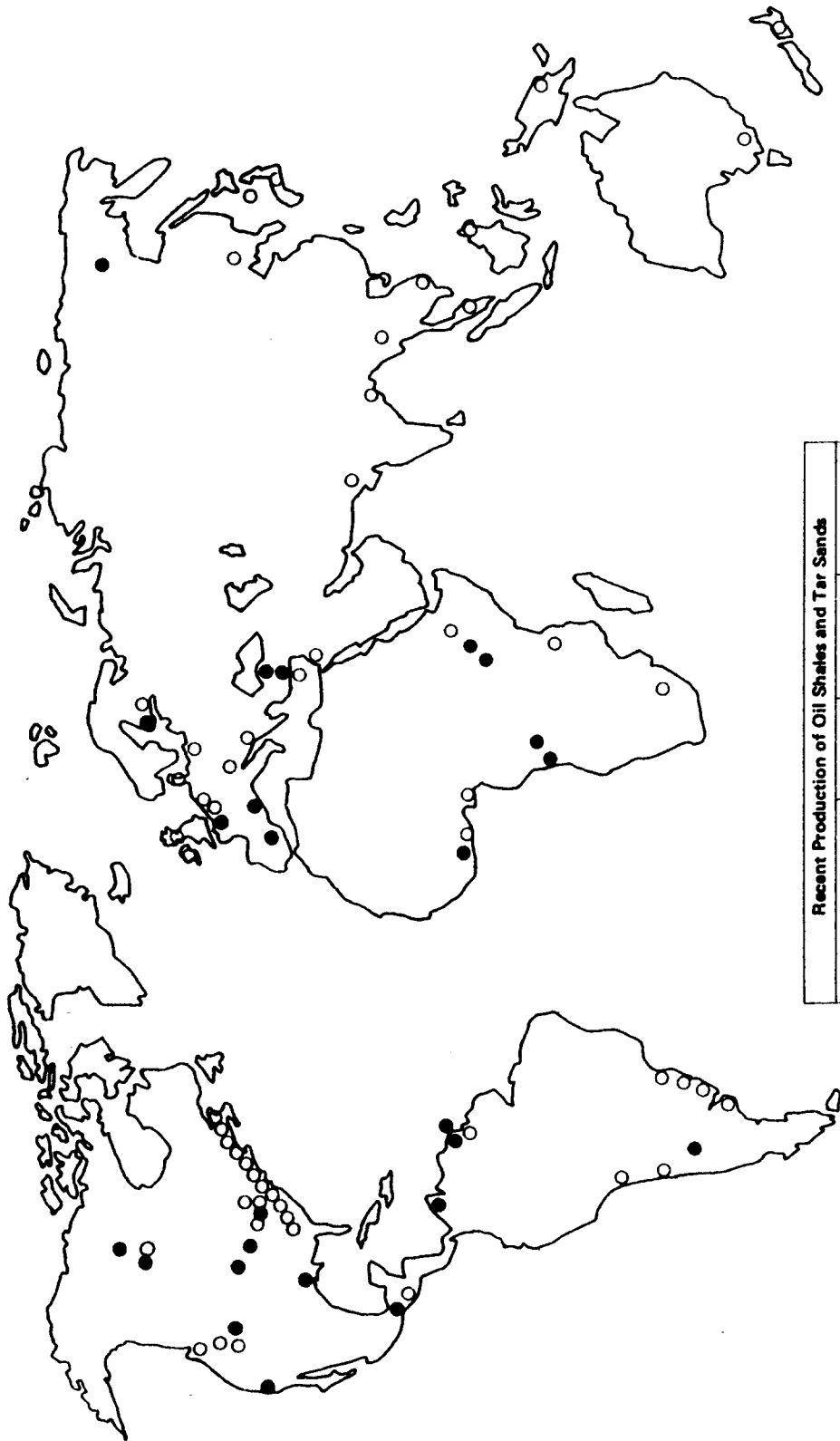
The ideal way of utilizing the large deposits of coal in the USSR, the United States, Europe, China, India and parts of Africa is to draw out oil and gas "in situ," without bringing it above ground. These are all capital intensive technologies, but the fuel is there and will be for several hundred years.

SYNFUELS

Petroleum and its by-products are the most important sources of energy available today for development. Petroleum distillates are necessary for thousands of products from plastics to candles. As the world's current supply of "light crude" runs out, alternate sources must be found to produce the energy and products the world needs.

Heavy Crude Oil exists in large quantities throughout the world, much of it in developing countries in Africa. It has not been extracted as yet because it is "thicker," i.e., more viscous, than light crude oil, and more difficult to pump up and through pipelines. It must be treated with steam to make it "flow." The technology for these processes exists, and heavy crude oil can be produced by present methods used for extracting light crude. The obstacles to this production is economic. Some countries that have heavy crude deposits do not have the pumps, the pipes (the infrastructure) or the capital for producing and transporting the oil. Others, like Venezuela, which has the richest heavy crude oil deposits in the world, are reserving them for later use.

Map 13: World Deposits of Oil Shales and Tar Sands



● Oil Shales
○ Tar Sands

| Country/Area | Year | Resource | Production (kilotonnes) |
|---------------------|------|-----------|-------------------------|
| Austria | 1974 | Oil shale | 1.47 |
| Trinidad & Tobago | 1975 | Tar sand | 80.7 |
| Brazil | 1974 | Oil shale | 8.0 |
| Athabasca (Alberta) | 1974 | Tar sand | 2490.0 |

Source: Survey of Energy Resources: 1976

The other sources for producing petroleum are the synthetic fuels, or "synfuels," which can be divided into three groups: oil shale, tar sands, and coal (see "Coal"). The goal of the synfuel project is the extraction of the petroleum (usually in the form of heavy crude) from the material, and the refining of the heavy crude so that it can replace light crude in most situations.

Tar Sands are a form of sandstones which contain heavy oil that must be extracted by new methods, like steam injection. The extracted material resembles heavy crude oil except that it is more viscous. There is an approximate density which defines where heavy crude ends and tar sands begin. Tar sands hold much promise for the future because they are easier to process than oil shale. But 90 percent of the world's usable tar sands are in Canada and Venezuela. Real promise of more than minimal production in developing countries is slight. Although there are enormous deposits of these sands in the Americas alone--over 440 billion barrels of recoverable crude in comparison to the 370 billion barrels reserves of the Middle Eastern countries--the extraction and processing problems are enormous.

There are two ways of obtaining tar sand: strip mining and "in situ" mining. In strip mining, the land, or overburden, is removed to reach the oil sand deposits which are then mined and transported to the processing plant. One of the greatest problems with this method is the harshness of the environment. Near the Arctic circle in Canada it was found that the 100 pound teeth of the excavators wear out in 4 to 8 hours of digging. The ground is so hard that in winter the teeth often glow red hot from friction. In situ mining holds greater promise but is now only in the experimental stage. Steam under great pressure is sent down through bore holes where the heat separates the tar from the sand. Once separated, the tar can then be pumped up. With this system mining costs and waste disposal problems are drastically reduced, but at this moment, the yield has been too small to be economical.

Oil Shale is the other important source of crude oil. Oil shale is fine, sedimentary rocks from crude petroleum can be extracted through heating to 500 degrees centigrade. Oil shale resources are enormous. Only 4 percent of this projected total resource roughly equals the entire world supply of light crude oil as projected in 1975. Oil shale deposits are distributed throughout the world, making them a significant alternate energy source for developing countries. There are two possible ways of extracting the oil: on the surface in a retort vessel or underground in situ. The first method, more technologically feasible at this time, consists of crushing the rock and placing it in a retort where it is heated. The in situ method consists of boring channels in the rock, burning the rock underground, and forcing the melted heavy oil to flow into channels from it is then extracted.

The mining of these synthetic fuels pose two main problems: cost and environmental damage; the latter further increases the cost as processes must be undertaken to minimize it. Waste disposal is the first environmental problem. Both tar sands and oil shale leave almost as much residue after they have been extracted as the original mass that was mined. Improved in situ mining technology would help to solve the problem. Stripmining techniques require that the land be reclaimed afterwards. Perhaps the most serious problem is the need for water. In processes involving steam extractions large amounts of water are needed, which will put a strain on

already limited water resources. In all mining waste can leach into streams and ground water, contaminating them.

The cost of production is great. However, as the price of light crude oil rises, the price of synthetic fuels may become competitive. There is some controversy as to whether that point will ever be reached, as estimates of the cost of production of synfuels are continuously rising, and will continue to do so until there are further technological breakthroughs. The capital investment and technological expertise required are staggering. The decision to undertake such investment can only be made within an energy policy that considers the advantages and disadvantages of alternatives also.

HYDROELECTRIC POWER

Electric power generated from falling water is called hydroelectric power. It is the only renewable hard energy source in widespread use today. Hydroelectric power plants rank with nuclear fission plants as being the most costly, the most capital intensive form, of electric generation. They involve building huge dams to store water, so as to ensure a year round supply of energy. The force of the water behind the dam, when released, turns turbines which generate electricity; the electricity is then sent through high power lines to industries and urban centers.

Hydroelectric power enjoys several distinct advantages over other hard energy sources. It does not pollute the atmosphere; it is renewable. It can be intergrated with irrigation and flood control projects, although in some areas flooding to create the needed storage area for water hardly compensates for the loss of prime farm land.

There are other problems. Some became apparent after the building of the Aswan high dam on the river Nile in Egypt. In 1970 it was completed in the hope of providing the greatest part of Egypts energy needs, as well as of irrigating farm lands and controlling the Nile floods. Instead, over-intensive use of water above the dam allowed the project to produce only about one quarter of its energy capacity. The large expanse of slow moving water behind the dam and in the irrigated channels increased the range of the parasitic disease schistosomiasis. Before the building of the dam the disease was present in about 5 percent of the population. After the dam was constructed the incidence of the disease increased to as high as 85 percent of the population in some areas. Schistosomiasis can leave its victims with permanently damaged livers, bladders, and intestines. The natural seasonal Nile floods has increased the salinity of the soil. Furthermore, the nitrates and phosphates that these floods brought are no longer naturally fertilizing the fields. Egypt now imports foreign fertilizer.

Despite such problems, many countries have plans to develop hydroelectric plants. The world now derives about 8 percent of its electricity from this source of power. The World Bank, which has been the leader in lending developing countries money to

build dams, does not envisage building any new major dams. The suitable sites for such construction are few. Where the land and water are right, no industries or cities exist nearby to make the construction of a complementary power grid worthwhile. Electricity is lost in transmission, thus adding to the cost of kilowatts that are finally used. Some thought has been given to regional plans for hydroelectric power, where it could be transmitted short distances across national borders to the nearest area of practical use.

Another possible means of producing hydroelectric power is artificially to construct high water-storage areas. A depression in the Egyptian desert may be used; or a canal to bring the waters of the Mediterranean to the lower level of the Dead Sea could be built.

Decentralized uses of this form of energy are called "micro-hydro." Small dams costing less and flooding less agricultural land can provide energy for villages. In some areas the speed of streams and rivers can be directly harnessed to move machinery for rural industry.

SOLAR ENERGY

Solar energy is a term that includes many forms of energy directly or indirectly dependent on the sun. The most direct way of using the sun is by using its heat. The sun's heat can be used simply by designing houses to absorb as much heat as possible in the winter. This is passive solar heat. Another way of heating homes is a system of panels on the roof through which water is circulated, providing space heating and hot water for washing. These systems are already used in many parts of the world and relieve the demand on electrical generating plants.

A more complex way of using the sun's heat is to gather its rays with moving mirrors that follow the sun during the day, to direct reflected rays to a water tower in order to create steam that can be used to generate electricity. Still another complex form of solar energy is the solar pond. Solar ponds are lined with black plastic and filled with salt. As the sun warms the water the heat created at the bottom can be harnessed to do work as energy. In some definitions, Biomass and wind energy, dependent on the sun for photosynthesis and weather patterns, are also forms of solar energy.

Photovoltaic cells, or solar cells, are discs usually made of silicon to be found in sand. The top half of the cell has a negative charge and the bottom half a positive charge (which is obtained by coating the surface with boron). They are twelve thousandth of an inch thick, and the largest cells are four inches in diameter. They are wired together to form panels of dozens or hundreds of cells whose life span is approximately twenty years.

Solar cells, unlike solar collectors, convert sunlight directly into electricity, instead of producing steam which generates electricity. Photons (sunlight) striking the cell are converted into electrons which are rejected by the negative half of the cell, and accepted by the positive half, thereby forming an electrical current. A four inch cell can provide slightly more than 1 peak watt at noon (see glossary).

Solar cells are more efficient in providing a decentralized source of electricity as no power is lost in transmission lines. For those who are thinking in terms of vast, centralized systems of energy, there is the possibility of solar satellites in space, beaming down electricity through microwaves. Many problems with solar energy remain to be solved before it can become cheap enough to compete with conventional fuels in electricity production. Nonetheless, except for large buildings, the average rooftop has enough area to provide all the power needed by the building, with enough excess energy to power an electric car.

BIOMASS

Biomass is the term used to describe plant and animal matter that can be converted into energy. It is renewable, non-polluting and has multiple uses. The technology to convert it into energy exists and is expanding.

Wood. Firewood is one of the oldest forms of fuel. As population has increased, more trees have been cut down than have been regrown. Deforestation is denuding the foothills of the Himalayas, causing soil erosion and floods. It is causing desertification in the Sahel region in Africa. The burning of wood for cooking is so deeply part of the tradition of these areas that it is more useful to create more efficient ways of using this energy source than to replace it with an alternative. Reforestation with fast growing trees and distribution of stoves that use half as much wood as open fires are two possible methods.

Methane is a high energy gas that can be mixed with natural gas, transported through existing pipe lines and used to power electric generators. It can also be used in rural areas to be used locally. Methane is produced through anaerobic bacterial action on plant and animal waste. Sewage, animal dung, agricultural wastes such as stalks, grasses, wood chips, sea weed and even water hyacinths, the scourge of rivers in equatorial regions, can all produce methane. The residue, after the gas has been withdrawn, can be used as fertilizer.

There are perhaps 2 million methane plants in China, and they are a hot selling item in India. In many ways, methane is the perfect fuel, but there are still some problems to be solved. Toxic materials, such as industrial wastes, get into the sewage to be converted into methane and are eventually spread over farmland as fertilizer. These contaminants get into the water and into plants. It is therefore necessary to separate the materials first. Methane can only form at warm temperatures. Methane plants in China and Korea have to shut down in cold weather and so cannot produce a steady supply of energy. A method of using some of the methane to warm up the plant could be devised.

The use of animal dung for methane plants has created some unforeseen problems. Previously, cows owned by the rich landlords would wander through the village generously donating their dung to all who would collect it for fuel and fertilizer. But now that there is money in dung, the cows are kept fenced in and their dung has become private property, to fuel the methane plants owned by the landlords. This is not the first time that a technological revolution to benefit all has only benefitted the rich. The Indian government is helping to finance community methane plants, and research in making them cheaper to build and more labor intensive.

Alcohol can be produced from plants high in carbo-hydrates--sugar cane, cassava (manioc, tapioca) corn and other cereals. The residue makes highly nutritious animal feed. The alcohol can be burned directly to create heat and energy, or mixed with gasoline to make gasohol. American cars run on a mixture of 10 percent alcohol to gasoline. Brazil is experimenting with the addition of 20 percent, and eventually hopes to produce a car that will run entirely on alcohol. Brazil is particularly interested in this energy source because its land/people ratio is so favorable that much agricultural land that would otherwise be needed to grow food can be converted to growing fuel instead. Brazil hopes to become energy independent with this technology. There are problems however. In some processes, energy is required to produce alcohol and this makes it less economical and less efficient. Not all countries can spare prime agricultural land for fuel crops. The use of cassava which grows on poor soil is promising, but it would be tragic if energy took precedence over food.

There are other, more exotic ways of using plants to produce energy. The Euphorbia bush that grows in the desert produces petroleum. Research on the energy uses for weeds and waste has barely begun.

WIND ENERGY

Wind energy is the conversion of the wind's kinetic energy into electricity by a wind turbine. Historically, wind energy has been used for small scale energy production--for pumping water or grinding corn--in rural areas in the United States as late as the 1930s and 1940 and in Holland and many other parts of the world for centuries. With the need to produce alternate sources of energy wind is once again coming into its own. Cities in Rhode Island and Puerto Rico are currently producing a large portion of their electricity from 200 kilowatt wind turbines. The turbines

which sit on a 200 foot tower have two blades whose measurement is as large as the wingspan of a Boeng 747. An even larger wind turbine is being built in California. The Hydro-Quebec company, which produces electricity from a network of dams in Canada, is considering adding electricity from wind to its network, and is building second generation vertical axis wind turbines (VAWT's) ranging in power from 0.6 to 10 megawatts.

Wind energy is limited by the sporadic nature of wind patterns, which necessitates energy storage systems. In addition, windmills can only be located in areas with constant winds at high velocities, often at a great distance from energy consumption areas. Work is currently being done on creating efficient energy storage systems for the wind electric generators. Batteries have been found to be relatively inefficient. Another approach to this problem is to use the wind power when it is available to pump water to higher level reservoirs from which it can be withdrawn to turn turbines when the wind gives out. This process is expensive and requires suitable sites. In some areas huge windmills can interfere with television transmission, although the blades can then be coated with a special paint, or made of glass fiber. There is even some fear that if a "windy" area is blanketed with windmills to use available energy, the force of the windmills all going round at the same time could disrupt local wind patterns.

However, wind power remains--because it provides a clean, safe form of renewable energy, and because the technology is simple, reliable, and relatively cheap--an attractive source of energy. Its greatest potential is in the development of small, local windmills that would supply electricity to rural areas.

GEOTHERMAL ENERGY

Geothermal energy comes directly from the earth's heat, either from the outer layers of the earth's crust, from volcanoes, from geysers or hot springs. The core of the Earth is basically made up of hot, molten rock called magma. The surface of the earth is a series of twelve interlocking plates that float on this magma. Where these plates rub against each other there is opportunity for the heat of the magma to escape in some form--most usefully for energy purposes as steam. This steam contains corrosive materials that would have to be removed before coming in contact with the materials of a turbine.

The main drawbacks to geothermal energy are that it is not known how much there is of it, where the main sources are, or how much it will cost to develop it. Moreover, it is not known just what harm might be done to the environment by tampering with geological formations. Geothermal energy can be captured in several ways. The simplest way is to to drill down far enough to obtain a sufficiently high temperature steam to heat homes in areas close to the source. This hot steam could also run generators, an economical way to generate electricity if not too much is lost in transmission between the source and the cities. Other methods of tapping this heat exist, some that involve deep drilling, but such techniques might seriously affect

the movement of the earth and cause earthquakes.

Rural communities, such as those in Indonesia, could best benefit from the simpler forms of geothermal energy, which provide a clean, safe and renewable source of energy.

CONSERVATION

Conservation, in housing, industry and transportation, is the developed world's simplest energy source. It is readily available, relatively inexpensive, doesn't release dangerous amounts of sulphur into the air, doesn't have geo-political implications and won't melt down and force you to leave your home. It takes the pressure off the world's energy resources and releases more to be shared with developing countries.

Domestic heating and transport uses two-thirds of all energy in the United States. Homes are like sieves; with better insulation more than half the amount of oil and electricity needed to heat them could be saved. The era of the gas guzzling car is over. Smaller cars and the development of railroads and mass transit would save large amounts of petroleum in an area where technology has not found an adequate replacement.

Industrial and commercial conservation has become profitable as the cost of energy has risen: heat, light and air conditioning are computerized, turned on and off as required; heat is circulated and re-used; industrial processes are more carefully monitored for waste. The original investment in energy saving devices is soon made up in savings on utility bills.

Cogeneration. Another form of conservation is the use of the heat that is lost in the generating of electricity--two-thirds in most plants. Some technology diverts this energy to nearby buildings for heat, or running machinery that requires low level heat. It is also possible to recycle the "used" steam back into the generator plant, saving the amount of fuel needed to heat it up from scratch.

Recycling of waste materials is another form of conservation. Metals, cloth and paper that can be re-used consume only part of the energy that it takes to make them from raw materials.

Garbage is a valuable commodity. When burned in new processes, the heat generated is sufficient to create steam that turns turbines. Several cities already use this process to generate electricity.

Conservation is primarily the job of industrialized countries, but the World Bank has pointed out that it is a problem of developing countries as well. Inefficient machinery and transportation causes much waste. The capital does not exist in developing countries to modernize existing plant and build new sources of energy, and yet both are necessary.

Conservation is also a state of mind, a respect and value for the environment, a wish to put as little strain on it as possible.

KENYA: AN EXAMPLE OF ENERGY STRATEGIES IN A DEVELOPING COUNTRY

Kenya's energy situation makes apparent the economic and politico-cultural influences that are unique to developing nations.

The early 1970s were pivotal for the global community, due to the dramatic rise in oil prices. However, Kenya, like other developing nations, was faced with more than just high oil prices; food production was also low. These and other factors altered development plans and programs.

Kenya recognized the inevitability of petroleum depletion as well as the impracticality of non renewable energy sources (especially for developing nations), and proposed that a conference be held to discuss the world energy situation. The resolution to hold the conference was passed in the General Assembly on December 28, 1978, and the conference will be held in Nairobi, Kenya, in August of 1981.

Developing nations are looking forward to this conference because it stresses the importance of international cooperation in the field of new and renewable energy.

Although developing nations need and want assistance, they also need and want freedom and independence. For example, foreign oil companies in Kenya hold a 49 per cent share of the oil profits, while the Kenyan government holds a 51 per cent share. The government believes that they should control the actions of the transnational corporations within the country. This attitude is a result of Africanization, a reaction to colonialism, and a way of guarding African sovereignty.

Developing nations also have the politico-cultural problem of educating the masses. Kenya hopes to repopularize the use of energy from firewood, charcoal, and biomass. However, due to colonial conditioning as well as technological advancement, many consider these energy sources "primitive." Nonetheless, Kenya wants to use its own free sun for solar power and free sand for photovoltaic cells, and plans to educate the masses as well as the policy makers of Kenya as to the advantages of these forms of energy. Also planned is the establishment of an International Energy Institute. Another source of energy in Kenya is hydroelectric power. Some is brought from Uganda, but most of it is generated in

Kenya. Geothermal energy use is also planned. Kenya has recovered from the food production crisis of the early 1970s and is now agriculturally independent. Animal power is very important in Kenya. Cross breeding is producing stronger work animals. Manure also is used for energy.

Conservation measures are part of life in Kenya. There are hardly any two car families. Although gas is not rationed, it costs \$2.25 per gallon and is used carefully. Many Kenyans walk or ride bicycles or motorcycles. There is an extensive bus system in Nairobi.

Developing nations depend on each other for help in order to grow. Kenya gets most of its oil from Saudi Arabia, which is considered a good and generous ally. There is a type of "Buy now, pay later" agreement. Kenya used to obtain oil from Iran but because of recent developments that supply has been stopped.

Kenya's government is clearly very concerned about energy. The Ministry of Energy was established recently. Kenya's Ministry of Natural Resources and Ministry of Power and Communications will be involved in the United Nations Conference in 1981. The Government is concerned about how energy development will affect Kenya's beautiful land and wildlife, and how Kenya's vast solar resources can be safely and effectively used for energy production.

MORE ALTERNATE ENERGY SOURCES

We have only described some of the many alternate energy sources. We have not discussed the small oil and gas wells which previously were not considered worth exploiting but now look more attractive. The World Bank is offering to aid developing countries in exploring these smaller resources. There is tidal power and the energy from ocean thermal energy conversion (OTEC); the latter uses the difference in temperature between surface and deep water to convert ammonia to steam which can turn turbines. There is animal draught power, a serious alternative in many countries. The possibilities are endless and intriguing. There is an enormous sense of fun and adventure in tinkering with what Denis Hayes calls the "fiddly" technologies. Rather than seeing them as primitive, they should arouse our ingenuity and give us once again a sense of optimism and self-reliance.

DEVELOPMENT AND THE ENVIRONMENT

In describing these various energies we have referred to their environmental impact. None are without their limitations, but some are very definitely more environmentally hazardous than others. Nuclear energy (fission) and the burning of fossil fuels, the hard technologies most favored for industrialization, are most dangerous. What priorities determine a country's choice of energy sources?

How should development or environment be weighted in a decision? If development is seen as industrialization, they are often in conflict with one another. The argument for industrialization goes something like this: underdevelopment means starvation for millions; environmental hazards like pollution do not affect people immediately, and by the time they do, we will have invented something to cope with them. Live now, pay (or maybe not pay) later.

Do we know all the alternatives? Is it possible to make the protection of the environment the first priority, and also work toward attaining a decent life for all? When the astronauts saw Earth from space they were moved by an enormous love for it. It is a fragile, closed system which has been resilient enough in the past, but may be getting to the point where it cannot absorb any more abuse. Increased amounts of carbon dioxide are being spewed into the air; the forests which used to absorb them are being cut down. There may be no present life without development. There will be no future life without safeguards for the environment.

There must be a balance. It would be tragic for developing countries to take up hard technologies for which they have so little capital and ignore the utilization of renewable sources of energy. Soft technologies have environmental and social advantages in the developed world also. Where massive amounts of electricity are needed and the only alternatives are generating plants run on nuclear or fossil fuel, we must use them. But if we favor their use before first investing in renewable and nonpolluting energies least destructive to the environment and most decentralized, then perhaps those energies will always remain stepchildren and never be used, thus limiting our choices in the future.

Who decides? Who makes the decisions of what energies to use, where to invest capital and technology? Is the basis of choice corporate or government profit, the health and wealth of populations, the safeguarding of our environmental life-support system, the need for decentralization and local control? Is equity achieved when people can participate in their own decisions, or when others make those decisions for them? How can we determine what we need? How can we influence circumstances?

GLOSSARY

Barrel: 31.5 U.S. Gallons, 36 Imperial Gallons.

BTU: British Thermal Unit; the amount of energy required to raise one pound of water one degree Fahrenheit.

Calorie: The amount of heat necessary to raise one gram of liquid to one degree Celsius.

Erg: Unit of energy 10^7 smaller than a Joule.

Fossil Fuels: Created millions of years ago by pressure on vegetation (coal, peat), marine life (petroleum, natural gas).

GDB: Gross Domestic Product - (GNP without exports).

GNP: Gross National Product- the total amount of goods and services produced in the economy in one year.

In Situ Recovery: of fuel on its site.

Joule: Unit of Energy.

Kilocalorie: 1,000 calories.

Kilowatt: 1,000 Watts.

Megawatt: Unit of power 1,000,000 watts; amount of power 10,000 100 watt lightbulbs produce.

Peak Watt: Equal to the amount of power produced in full sunlight at 77 degrees.

PQLI: Physical Quality of Life- measure of social welfare.

Watt: Unit of power - 1 watt=1 joule per second.
1,000 watts=3143 BTU's.

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