SOLAR ENERGY

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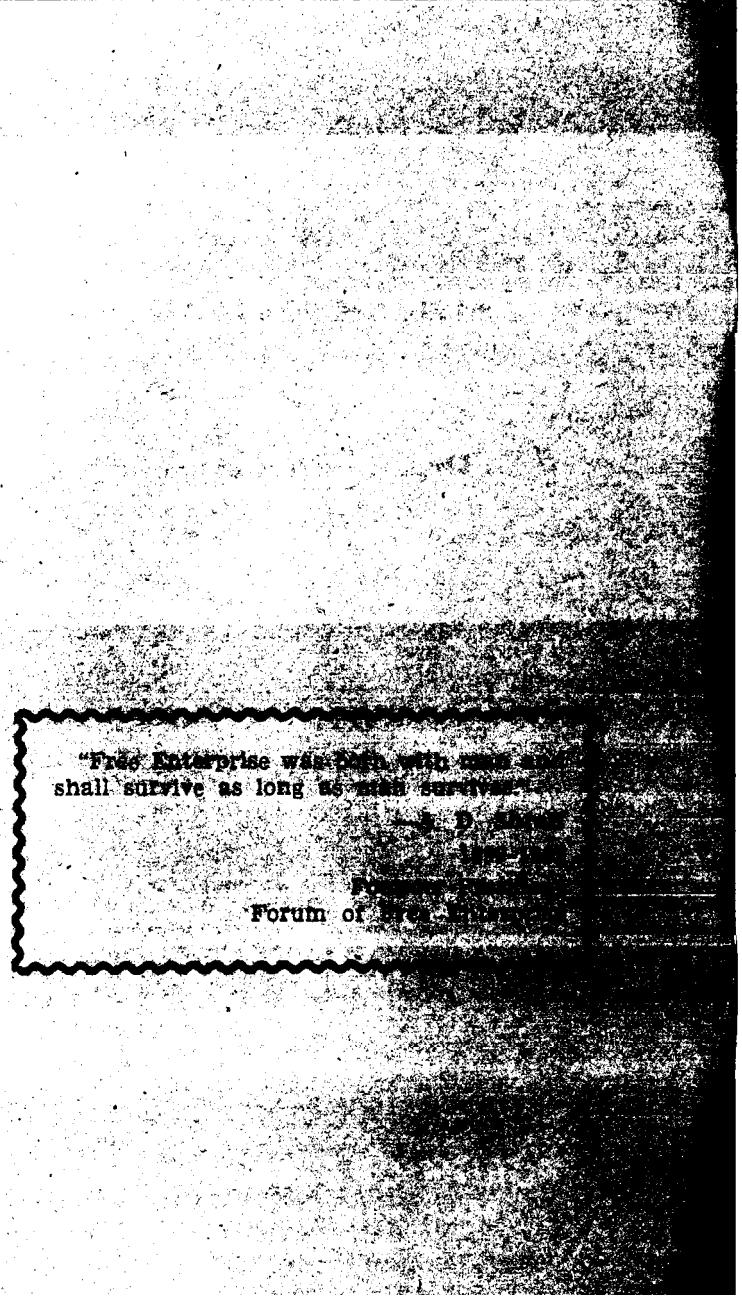

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This is an unique era in the history of the planet earth. Never before in the 4.6 billion-year history, the earth, with its total system of the life and materials, has been in a fundamental change as at present. The earth has seen many climatic and geological changes, but none so dramatic, fundamental and lasting as the ones generated by human intervention. Even the present technological civilization is intrinsically and in content different from all civilization during the last 2 million years of man's existence. Every change that has occurred has been due to one single fact, that is, the effective utilization of energy. Everything that occurs on the earth or for that matter anywhere in the universe depends on energy, directly or indirectly. Everything moves because of energy.

Whatever the origin of the earth, life would never have originated nor sustained itself for a moment without one source of energy, that is, the sun. Everything living depends on the sun. Besides supplying energy for sustenance, the equilibrium of the planetary environment is ensured by the radiation the earth receives from the sun. At the distance of 92.7 million miles the sun radiates the total energy of 180,000 trillion watts to the earth. Such prodigious amount of energy is created by nuclear fusion reactions, which is estimated to last at least for the next 5 billion years. Much before that, probably within the next 200 years, man will have found space and environment, if not better than the

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earth, at least, equally conducive in our galaxy or possibly beyond that.

The Energy Crisis:—The engine of industrial civilization is run by fossil fuel at present, which was stored in the bowels of the earth during the geological era. However, the conventional sources of energy--commercial or non-commercial—such as coal, oil, natural gas, nuclear, hydropower, lire-wood, cowdung and other wastes are non-renewable. The non-conventional energy sources include solar, tidal, geothermal, wind, etc., none of which is extensively used at present as a source of energy. The life-time of fossil fuel is finite and with the exponential utilization of oil sometimes during the middle ofl the next century most of oil reserves of the earth will be exhausted. In the case of India, the proven reserves will not last beyond 2010 A.D.

Energy Crisis in India:—For 90% of the 625 million Lndians, the energy crisis is a fact of life. It is seldom experienced by Americans who consume 100 times more energy **per capita** than an average farmer in India. In reality, with only 225 million people living in the United States, consuming **32%** of the world's energy, the energy crisis is practically unnoticed in the mechanical style in which the energy consumption in every walk of life has become the life-blood of society. In India, the significance of poverty and underdevelopment are reflected in the insignificant availability and consumption of energy for the masses of people. When the first report of the Club of Rome, "The Limits to Growth". observed that "We are soon to be engulfed by problems of unprecedented intensity and magnitude and it is not at all clear that we shall survive," it certainly did not refer to the burden imposed by India at its present level of energy consumption.

On the other hand, if India is to develop industrially and provide to her people minimum decent standards of living, the utilization. redistribution and discoveries of **new** sources of energy will demand priorities in the new agenda for economic planning.

Except for vast amounts of coal and limited oil reserves. the subcontinent of South Asia is one of the poorest regions of the world in energy supply. The largest source of energy available to India is coal with gross reserves of 80 billion tons which at the projected rate of consumption can last up to 2120 A.D. Unfortunately, prime coking coal is highly limited. At present, the annual consumption of coal is roughly 90 million tons per year. By the end of the century, the coal requirements will be to the order of 650 million tons. Roughly 35% of the coal is used for the production of electricity and the coal-fired power stations produce about 60% of all the electricity generated in India.

Even though India has a vast magnitude of coal deposits, the major difficulties in coal resource development lies in its transportation all over the country to various points of consumption from selected areas like Bihar and West Bengal where the deposits are located. Besides, heavy investments are required for washing the coal as well as the development of coal mines. Beyond this, one must consider the price of installing the pollution control equipment. It is estimated that each, 500 Mwe coal-fired plant produces 20,000 truck loads of ash. The improvement of coal mines to prevent accidents and control health hazards would also require large investments. Probably with further research in liquified gas, it might be possible to make coal a major source of energy supply in India.

The other neglected source of power with great possibilities is hydel-energy. The Government of India has estimated that the total hydro-electric potential available in India is to the order of 41,000 Mwe at the average capacity factor of 60%. Because of its many advantages hydro-energy needs to be more effectively developed but it will meet only limited demand of the growing energy consumption which is at the rate of 4.5% a year at present.

One of the most versatile and valuable forms of energy is oil which is called the black gold of the modem age. Until

recently India had a limited supply of oil. At present the annual consumption is 32 million tons of which only 40% is supplied by indigenous sources, for which India pays approximately 20 billion Rupees ($1.00-8.5 Rupees). By 1985 the demand for oil will reach 50 million tons while it is hoped that the country will produce approximately 28 million tons, 50% of which will be available from the new finds off Bombay. By the end of the century, the requirement for crude oil for approximately 935 million people will be to the order of 150 millon tons while the domestic capacity of production will not exceed 50 million tons a year. It is more likely that by that time or by 2005 most of the oil reserves in India will be exhausted imposing a terrifying crisis for India's development unless by that time alternative sources of energy will have been discovered.

It is out of this urgency that India must explore two attractive but conflicting alternatives to energy development. Overall, India is committed to nuclear energy development. Nuclear fuel offers new challenge. India's uranium resources are limited to 52,000 tons. But there is abundant thorium which is about 325,000 tons in reserve. Compared to the United States which has 60 nuclear reactors, India has only 3, generating 3.2 billion Kwh gross electricity. Considering the tremendous energy requirements of the country, nuclear power offers only meagre and limited relief. Moreover, nuclear power development is highly capital intensive requiring heavy investments in the production of heavy water and for facilities required for the fuel cycle. It is also to be recognized that India depends on foreign countries, particulary the United States, for enriched uranium 8 tons of which was ordered by President Carter on April 28, 1978. Fortunately, India produces its own nuclear equipment, such as fueling machines, reactor vessels, heat exchangers, etc. Yet despite all its possibilities, nuclear energy remains a far away source for India's development.

The total consumption of electricity in India today is 110 billion Kwh compared to 2,000 bllion Kwh in the United States. By 1990 the installed capacity which is 20 million Kwh will increase to 85 million Kwh.

India is a country of villages and 78% of its people live in rural areas, but hardly 35% of the 6,00,000 villages are electrified. For the people far away from cities the major sources of energy are firewood, animal manure and agricultural waste. Hardly 30% of Indian forests are left. About 150 million tons of agricultural waste are utilized each year.

At the present rate of careless destruction of tree, woods and forests India will have no forests left by the end of the century. If India succeeds in electrifying 80% of its villages by the year 2000 and is able to supply bio-gas or other forms of energy it will be possible to save the forests from insane destruction.

There has been intensive efforts all over India in developing the bio-gas system for the supply of domestic energy and for street lighting. As of now hardly ½% of the villages have been reached in these efforts. It must be recognized that bio-gas energy will not meet the dmands of industrialization in the country.

It is in this respect that non-conventional sources of energy should be explored. Among the various non-conventional sources, the wind, tidal and geothermal sources hold limited prospects. The most promising source of energy is solar power. Recent researches in the development of solar energy hold unlimited possibilities. Solar energy is perennial. After the initial investment, the cost would be marginal. It is free of pollution. Even with terrestial utilization of solar energy with the effective development of solar heaters, solar collers, etc., at least 15% energy can be supplied to Indian villages since India gets on an average 260 clear days in a year.

Unfortunately, the sun, with all its potential to supply energy, has been discovered only recently with the advances in physics, astronomy and the space science. During the last two decades the research and development efforts in solar energy have led to some useful discoveries for low grade heat such as solar water heating, space heating, drying, distillation, space cooling and steam cooking. Even though

much of the solar energy development is at a relatively primitive stage, many fundamental researches point up to the scientific and technological developments, by which terrestrial and space solar energy conversion will become a reality within the next 25 years.

The two important developments in this respect need a special attention. Dr. Peter Glasser of the United States has tested a solar power plant, which can be mounted in satellites in synchronous orbit of the earth. It will convert the sun's energy into electricity and transmit it to the earth. The first industrial application of this technology will occur before 1985. At present, the cost is a major factor, particularly in competition with the conventional energy sources such as oil and coal.

Another significant development in tapping the solar energy as a permanent source is the space colonization. It is based on the concept that man must overcome the planetary "hang-up". It is possible to set up a city about 125,000 miles up in the space. Its purpose will be not only to free man from limitations of the earth but also to provide a perpetual supply of energy by the same process as the conversion of solar energy to electricity and then transmitting it through micro-waves to the earth. The cost estimated for setting up the city of first 10,000 people would be in the order of $10 billion and it could be built by the year 2005. It is generally agreed that the supply of solar energy will reduce the problem of pollution related to the burning of fossil fuel to an insignificant degree.

In the long run, however, heat in the earth's atmosphere will increase because of solar energy conversion. The other major problem we must contend with is to set up solar panels, e.g., we need a panel of 7 ft. by 7 ft. to light a 100 watt bulb. Then again, provision for the collection of solar energy for night and for cloudy days has to be made.

Even the geosynchronous solar-power station 125,000 miles up in the space will have to contend with the micro-

meteorites. It is hoped that many of the present difficulties will be overcome during the next decade.

In India solar energy research projects have been supported by the department of science and technology since 1974. The areas in which significant developments have taken place are as,follows :

1. Solar Pumping.
2. Solar drying. Driers were developed as early as 1966 for the purpose of drying crops and even local laundry. The forest research institute has designed a solar kiln to dry timber.
3. Solar potable water. Solar distillation in the near future will be the best method of supplying clean and potable water in rural areas.
4. Solar slurry in heaters for biogas plants.
5. Mini-power plants—5 Kw to 50 Kw for rural electrification.
6. Solar power heater: such power heaters have been developed in several parts of India.
7. Building heating and cooling—developments in this area have been quite significant.
8. Solar ice-making.
9. Bio-conversion of waste into fuel.

India is a country of the sun, yet it has grossly neglected the use of solar energy for development purposes. Since India is a country of villages, the decentralized energy required can be most easily made available through mini-solar plants. Also requirements of energy in India are much lower than in most of the western countries. Without changing the life-style most of the basic energy needs of people can be met by concentrating on solar energy.

The resources of the earth are limited but more so on the subcontinent of India where in one-third of the land of the United States every seventh person of the earth lives. To

drag the masses out of poverty and wretchedness India will require an industrial base, the control of population, fast agricultural development and a different, more equitable economic order. Whatever its political, economic, and social system, it will require a gigantic amount of energy to garner the fruits of modem age. No other source we know of today offers a reliable, sound and economic source of energy as. the sun.

The limits of the planet cannot be the limits to India's development. Far beyond space on the sun, on the moon, in the astroids, on other planets, in the stars and even in some far away galaxies, wherever man's mind can penetrate, lie the resources which can and will bring the ultimate salvation of man.

SPACE CITY & SOLAR ENERGY

Around the world, thinkers, planners and policy-makers have been engaged in a crucial debate concerning limits to the growth on this finite planet of ours. During the last two million years that man has been on the earth, it has never been in such a state of disanray as it is now, mainly due to the Industrial Revoluion, which started about 350 years ago. Man is an undisputed and a dominant force in determining the destiny of the world.

Some of the critical problems faced by the earth are:

(1) Population explosion

(2) Continuing depletion and even exhaustion of the material resources

(3) Energy crisis

(4) Poverty in the developing countries.

The earth's population which is 4.5 billion at present will reach 6.5 to 7.0 billon by the year 2000 A.D. To meet

the increasing demands of the dangerously growing population many resources of the earth are over-burdened and may even run out sometimes during the next century. Unless man finds newer resources or curtails his demands significantly, there will be massive deprivation, wretchedness and disease.

In this struggle, the Indian situation is particularly critical with the population of 625 million, which will reach 950 million by the end of the century. India faces the crisis of numbers, unparallelled in any major country of the world. Moreover, its limited oil and gas resources will be exhausted by 2010 A.D.

In these circumstances, the project to build a city in space should be considered. This is a major breakthrough which will take humanity from a fiction to newer realities beyond this planet.

For the first time, by applying present technology and the available resources, it is possible to build a city near a point L 16, approximately 125 thousand miles from the earth. The cost of building such a city will be around $10 billion dollars which the U.S. pays for the import of its oil. The material for building the city can be mined from the moon and even asteroids except for those like hydrogen which can be brought from the earth. The population of the first city will be 10,000. Later on, larger cities which can accommodate up to two million people can be built. Once the feasibility studies are completed, the work on building such a city can begin in 1982 and the city should be ready for habitation by 2005 A.D.

The idea of constructing such a city for solution to the problems of the earth was conceived and is now vigorously pursued by Dr. Gerard K. O'Neill of Princeton University. He is the chairman of the council for the space city and solar energy. Still there are many problems to overcome before realising the dream of constructing such a city. But the plan is to build the city with all the amenities

best cities of the world provide such as houses, gardens, medical centres, swimming pools and even farms and factories. The city will provide pleasant and enjoyable environment without the problems of congestion, pollution and many of the diseases.

The main function of the city will be to supply the clean, dependable and cheap energy to the planet. Away from the atmosphere of the earth and its day and night cycles, the space city with its solar satellite power stations will produce electricity which will be sold to the earth at less than 10% of the cost of generating electricity on the planet. Solar energy would be converted to electricity and then it will be transmitted to the earth by micro-waves and received by antennas at the receiving stations in different countries. There it will be converted back into electricity and distributed through the local grids.

As earth's demand for energy is increasing in geometrical progression, with the accelerated depletion of the energy resources, solar energy is the ultimate salvation. The sun will supply the energy for at last 5 billion years more. The need for solar energy is even more stark for the developing countries where industrialisation is a must for eliminating poverty and energy is the main input in the process of industrialisation. At the periphery of the space-city, there will be farms supplying fresh vegetables almost every day. The city will spin at 2 r.p.m. around the axle, thus creating artificial gravity on the inner surface, which will be earth-normal. Each person will have a steady supply of 15,000 gallons of water. Practically all the waste will be recycled. Things which cannot be producd in the city will be imported from the earth. Most of the people will work at the power stations and during their vacations they may visit the earth or other cities when they will be built.

Inside the city the normal life could be designed by earth's standards. The day and night can be artificially created, if so desired. Timings can be adjusted as suitable. The climate would be 70•‹Fall year round. Most of the travelling within the city could be done by walking or on bicycles.

The space-city by no means will be an utopia. It is an exploration of a new frontier for the man's survival and progress. Men may bring their old problems of conflicts, jealousies, competition, etc. or they may design new social systems in which men will overcome the earthly problems and find happiness for all. In the beginning people may find the space city a lonely place, but in the long run they may get used to it.

Building the space-city should not detract planners and engineers from the immediate problems affecting our cities. Problems of most of the cities in the world are grave with pollution, slums, traffic congestion and crime. Our first concern should be to attend to these problems. Building the space city is for the purpose of supplying cheap energy to the earth in order to help solve problems here. Beyond that, man must search for space and resources in this vast universe. Our limited earth cannot confine man forever. Answers to space exploration lie in the minds of man, in tbe discoveries of laws of nature and in application of these laws to master the space. Possibly one day man will be able to put most of the industries in the space-cities in order that he can enjoy the bountries of earth. There is no reason for two-thirds of humanity to suffer poverty and deprivation that they do today while enormous resources lie idle in the millions of asteroids, moon of the outer planets and the outer planets themselves. The universe provides infinity of possibilities for man to search, discover, find, use and enjoy for billions of years to come. The answer is in daring and determined efforts of man to bring benefits of life to everyone.

The famous Russian writer Tsiolkowsky once prophesied "Man will not always stay on earth; the pursuit of light and space will lead him to penetrate the bounds of the atmosphere, timidly at first, but in the end to conquer the whole of solar space."

"People must come to accept private enterprise not as a necessary evil, but as an affirmative good".

—Eugene Black

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The Forum of Free Enterprise is a non-political and non-partisan organisation, started in 1956, to educate public opinion in India on free enterprise and its close relationship with the democratic way of life. The Forum seeks to stimulate public thinking on vital economic problems of the day through booklets and leaflets, meetings, essay competitions, and other means as befit a democratic society.

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