GREEN ENERGY

Prof. Soli J. Arceivala

FORUM
OF FREE ENTERPRISE

"Free Enterprise was born with man and shall survive as long as man survives".

- A. D. **Shroff**
Founder-President
Forum of Free Enterprise

INTRODUCTION

We are, indeed, very fortunate to publish this booklet authored by Prof. Soli J Arceivala, one of the most eminent technocrats and experts on the subject of energy and environment in India. For well over last decade or so, there is a growing awareness in our country about the challenges posed by global warming and climate change. For the emerging economy like India, which is witnessing a significant transformational shift in its developmental process during the post-reforms period, the dimensions of strategic and policy dilemmas are going to be increasingly intense.

Witness, what the author at the very outset states so succinctly in stating the problem: ".... per capita energy availability in the country has to increase 6 times in the coming years to meet the county's needs while the room for increase in carbon emissions is only 3 times the present emission".

Based on this premise, going forward, there is going to be a complete mismatch between our future requirements of energy and its likely impact on India's carbon footprints, especially given the present heavily fossil fuel oriented pattern of our economic development. Thus, our energy consumption will obviously be governed by the imperatives of achieving high real GDP growth (about 9 to 10% per annum) for at least next two or three decades so as to ensure that an average Indian citizen comes to have a decent middle-income international standard of living. By implication, our annual per capita income will by then have to be around US$20,000 to 25,000 as compared to our present modest per capita income of less than US$1500. How to make this developmental aspiration environmentally sustainable?

After stating the crux of the problem, Prof. Arceivala goes to his core theme in this scholarly article by highlighting the importance of alternative sources of energy. But what is most dear to his heart and thought process is the Green Energy. And for him the word GREEN stands for "Growth with Resources, Environment, Enhancement and Nature". The author briefly evaluates the current status of various new and renewable energy sources, but focuses his analysis on three presently most important sources of energy, namely, wind, solar and biomass. At the same time, he also covers some key issues about other alternative sources of energy such as hydro, shale gas, nuclear, geo-thermal, wave energy, etc.

The critics will obviously point out several limitations and constraints in exploiting the full potential of these alternative sources of energy. But Prof. Arceivala, as is to be expected from a person endowed with solid research, courage of conviction and long-standing practical experience, both in India and abroad, offers convincing anticipatory response on issues of economic and technical viability of his proposition for promotion of Green Energy. Also, from the perspective of policy making, there is so much to listen and learn from this booklet.

We, in the FORUM, are especially grateful to Prof. Arceivala for preparing this booklet, based on his very comprehensive and well-written manuscript of the book, for the benefit of not only our members, but also for much wider audience, including students, proponents, practitioners and policy-makers. He has a missionary zeal, and believes in spreading the message of Green Energy far and wide and we wish to make our own modest participative endeavour in this massive task!

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Editor

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Prof. Soli J. Arceivala*

WE HAVE BEEN BUILDING HYDRO AND BIOMASS SYSTEMS. WIND AND SOLAR ARE READY, WAVE ENERGY& OTHERS WILL TAKE A LITTLE LONGER

The Present energy situation

The world has grown accustomed to using old style fossil fuels like coal and oil for generating power although they are getting more and more expensive each day and are found to be increasinglyaffecting global warming and climate change. The low carbon footprint India has at present is because much of rural India is yet un-electrified and unindustrialized. Simply put, the situation in India (as summarized by the Bureau of Energy Efficiency) is that per capita energy availability in the country has to increase 6 times in the coming years to meet the county's needs while the room for increase in carbon

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emissions is only 3 times the present emission. Thus in the future we will have to follow a low-carbon economy if we have to continue to play our role in the world.

Moreover, India has little oil and can ill-afford to continue importing it in the large quantity it is needed to-day, India has large coal deposits but coal is messy to use and polluting. What are then the alternative sources of energy that we can exploit, at reasonable cost, and which are politically secure to use in difficult times?

Important alternative sources of energy

There are several important alternative sources of energy - some renewable, some long lasting, some free from CO_2 production, and some totally unexplored by us at present. These sources are listed below:

Wind
Solar
Hydro-power
Agricultural biomass and Community wastes
Gas from solid wastes (Waste-to-energy plants)
Coal gas, natural gas, LNG, CNG, LPG
Shale gas
Biofuels from oil-bearing plants,
Nuclear energy
Wave energy
Geothermal energy

, This booklet mainlyconcentrates on three presently most important sources of energy – wind, solar and biomass - and what we can do with them at today's prices. Ultimately, price is what determines its usage. The fact that they do not produce any carbon gases like CO_2 or CH_4 is of course an added advantage in these days of global warming and climate

change. But, hard-headed businessmen as we are, we prefer to stick to the price advantage.

These three forms are also referred to as **"Green Energy".**

To many people "green" is a very meaningful acronym standing for "GROWTH with RESOURCES, ENVIRONMENT ENHANCEMENT and NATURE". That is exactly what green stands for. **It allows you to use energy to grow without using up your natural resources or spoiling your environment!** This is what every country wants. The wind, sun and biomass almost come for free in nature. Yet, their conversion into usable energy costs some money and, therefore, we have been slow so far in using it. But, let us read on.

The principal renewable sources of energy available for use in India up to end of March 2010 are according to the Ministry of New and Renewable Energy (MNRE) the following:

Small Hydro Power projects (upto 25 MW)	2,735 MW
Wind Power (India is said to be 4th largest)	11,807 MW
Solar Power	12 MW
Solar PV street lighting systems	88,300 nos
Solar PV pumps	7,300 nos
Biomass Power (non-bagasse, agro residues)	I ,100 MW
Waste-to-energy	110 MW
Solar water heating, collector area	3.53 Mill sq m
Solar lanterns, pieces	8.0 Mill pieces
Family-type Biogas plants	4.2 mill units
Biomass cooking stoves	35.2 mill units

Yet with all these activities, renewables constitute less than 3% of all energy consumed in India at present. Our target is to get to around 20% by 2020. Cost is one reason.

Solar energy for example, costs more at present than energy produced from oil or coal. The whole scale of activity is so small at present that unit costs are high and we also have to depend on some imports. Subsidies have to be given to make things attractive at present.

Let us look at wind and solar energy first, more closely, as renewable sources of energy for domestic and industrial purposes. For general usage, their costs are high at present and some fiscal incentives are needed to make them attractive. However, even now their costs are "affordable" under certain circumstances discussed later. Costs will surely come down in near future.

WIND ENERGY

A wind energy plant on average needs an investment of Rs 5.5 crore per MW, compared to Rs 4 crore for a thermal (oil-based) plant and Rs5 crore for a hydro-power plant, today.

To promote greater use of wind energy in India, many more wind mills, wind-turbines, and wind farms need to be set up to generate electric power where wind is found to be blowing reliably. The key word is "reliable". In India, wind is generally strong during the monsoon months but often very weak thereafter.

Several steps, such as the following, are necessary to take in order to encourage the general public to install and use modern, better quality, low-friction, wind-operated systems:

Firstly, locate geographic areas in India where wind farms can be set up assuredly

People do not know where wind is strong and where it is weak. In certain locations e.g. coastal areas, hilly areas and other specific locations where what is known as "wind-tunneling" effect occurs, all make excellent sites for installing wind turbines.

Everybody knows that wind does not keep blowing all the time. It stops after a while. In most countries, it generates power for only 20 percent of the time, and either needs storage batteries to tide over other times or needs hybrid installations including solar systems along with wind (see later). Currently, ideal average wind speeds are reported to be between 7 and 9 meters per second (15-20 miles per hour) for utility-scale wind turbines suitable for commercial applications.

Power obtainable from wind is a function of the **cube** of the speed. A wind speed increase from 6 m/sec to 7 m/sec would increase the power generated by as much as 50%, no small benefit. India is unfortunately reported to be in a region of low wind speeds barring the monsoon months. Strong winds blow during the monsoon season only. (The Ministry has estimated a total potential of 45,000 MW only from wind though new research would tend towards more optimistic predictions).

This kind of wind speed is best achieved by going above trees and buildings, preferably on building terraces. One advantage of locating on terraces is additional land is not needed. However, structural stability has to be assured in each case and this is best done early on at the building design stage rather than afterwards.

Secondly, give fiscal incentives to promote more installations.

Already, wind power acquisitions are seen as a tax-saving device since accelerated depreciation at 80% is allowed in the first year itself. Another incentive can be offered in form of enabling reverse selling of surplus electric power to national power grids so that those who generate power can also earn some money from it. Reverse selling is in a way encouraging public-private-partnerships to increase installations.

Thirdly, where land is a problem, consider sea-based installations.

The Norwegian energy giant "StatoilHydro" has successfully built the world's first full-scale floating wind farm on the open sea as an experiment to harvest electricity in an environment of strong, low-level winds and fewer space restrictions than are found on land. US and Germany have also approved construction of the first offshore wind farms in Massachusetts and in the North Sea, respectively, This seems to obviate the necessity of large-scale land acquisition which is today becoming a severe problem in India.

Incidentally, the following requirements for wind systems may sound discouraging but are not so in most cases:

Before wind turbines or wind farms can be installed in certain places, one may need permits from appropriate authorities involving submission of (i) a noise study (ii) an avian study to determine potential impacts on birds and bats, and (iii) an aviation administration study to determine if the wind turbine might interfere with aviation radar. Their clearances must first be obtained.

India's efforts

A newly formed company called Green Infra Ltd (GIL) sponsored by IDFC Private Equity, has bought up a 60 MW wind farm in Karnataka and another 40 MW installation in Maharashtra from British Petroleum's BP Energy. GIL is also looking to buy 250 MW wind energy capacity from DLF and eventually reach a total of 500 MW capacity in 3 years. ONGC has set up a 50 MW wind farm project in Kutch District at Bhuj, Gujarat, using 1.5 MW machines installed on 78 m high towers. The technology used is said to be nearly maintenance-free and saves the Organization nearly Rs 30 crores per year in electricity charges.

India is reported to be ranking fifth in total installed capacity with 9,645 MW of wind power installed by the end of 2008. A few foreign-based companies are setting up shops in India to benefit from lower costs and lack of conventional electric grids in small and medium-sized cities. In Europe, installation costs are said to be around $ 2.20 for every megawatt of off-shore wind built. In India, similar installations are expected to cost 30-40% less. Where much power is needed (e g, for an industry or a small township) a single wind turbine may not suffice and a wind farm may have to be set up. In such cases, enough land may need to be acquired for the purpose. Land acquisition may pose a severe problem as explained later.

Wind energy systems have been provided in India by Indian as well as foreign companies. Some Indian companies have also provided wind energy systems in other countries. An Indian firm called "Suzlon" is today a world giant in providing large-sized wind energy systems both in India and overseas to which it exports.

Solar energy systems

As a tropical country which receives much sunlight, India tops the world (along with California and Hawaii in the US) in its potential for developing solar energy systems. Spain, Italy, Australia, and China come next on the list. However, in actual implementation Germany and Spain top the list at present.

Solar energy systems consist of the following:

- Solar thermal (solar cookers, solar water heaters)
- Solar photovoltaic (stand-alone or grid systems for producing electricity)
- Solar concentrators (for larger installations producing electricity)

Indian manufacturers are presently offering only (1) small solar items such as solar activated lanterns and cookers, (2) solar water heaters for bathrooms, and (3) photovoltaic panels manufactured in India. Concentrated solar power systems for larger habitations exist in Spain and USA, but have not yet been installed in India. Many Indian companies ranging from Tatas, Birlas, Jindals and many more are now jumping on the solar band wagon! JSW Green Energy an Indian Company belonging to the JSW group is planning to use in India a unique lightweight and flexible photovoltaic device developed by an American group.

Solar cookers have been in use since a long time. They have very useful application in case of schools, hostels, etc, where meals have to be prepared usually in large numbers. They are also useful for religious centres where large crowds visit on certain days and meals have to be prepared for them. Their use makes cooking cheaper and more hygienic and also saves production of CO_2 which would be emitted from use of other cooking media like LPG, wood, charcoal, etc. There are cases where such organizations have benefited from Certified Emission Reductions (CERs) and Carbon Credits have been profittably sold on the world market.

Solar water heaters are equally popular for bathrooms and kitchens where hot water is required in relatively large volumes for hostels, hotels, hospitals, guest houses, industry canteens and such purposes. Such systems have proved popular with large-scale users for whom payback periods as short as 2 years, have been noted. Several installations of this type have sprung up in different parts of the world. Their use is particularly economic where large volumes of hot water are continuously needed each day, such as in hotels, hostels, hospitals, commercial kitchens, etc. Separate plumbing systems may be needed from the roof to the bathrooms to

benefit from solar hot water systems. For smaller systems for individual families, the payback periods are much longer and governmental subsidies may be needed to make them more attractive. Their use could, and should be made mandatory in case of larger installations. A hot water system that gives 125 liters per day comes for about Rs 20,0001- only, and saves a lot of fossil fuel.

Solar (PV)Lanterns

Solar activated lanterns, (TERI-type) are the simplest and smallest type of devices which use solar energy. They require the use of small handy photo-voltaic panels and have relatively short payback periods. They constitute an excellent answer to the absence of conventional electrical power for lights in rural and semi-rural areas of India. Only an initial investment in the unit has to be made. Thereafter, solar radiation generates the electric power for free. But the power needs to be stored in a battery. The running cost consists of replacement of the battery every 2 to 3 years. By the year 2022, India expects to install 20 million solar lights which would result in a saving of about 1 billion litres of kerosene every year.

Acompany based in Delhi has developed a solar powered unit using an LED-based lamp that is waterproof, portable and runs for 12 hours on the stored power. It is likely to be an attractive replacement for the conventional kerosene lamp.

Solar (PV) panel, Stand-alone systems

Two types of PV installations with panels are normally made: stand-alone systems and grid connected systems.

Stand-alone sources of renewable energy find favour in rural and urban areas of India for generating electricity at the spot where it is required to operate one of the following:

- a tube-well pump, or
- an intermediate station for mobile phones, or
- small water treatment units to remove hardness, arsenic or fluorides and such other impurity from locally available drinking water.
- as a standby source of electric power instead of a diesel generating set for operating a machine or process in an industry. (The real cost of generation of diesel power is reported to come to around Rs 17 per kWh if we add the subsidy component. This cost is more or less the same for solar PV power).

A good example of stand-alone systems are the telephone poles provided along the Mumbai-Pune expressway, each carrying its own PV panel on top to generate electricity to run the telephone lines.

According to Prof Bannerjee, Head of Energy Systems Engineering, IIT, Bombay, the capacity of solar panels varies widely starting from 2 KW to about 200 to 250 KW. Prof Bannerjee, refers to them as modular units, much like lego sets which can be readily put together. If you intend to set up a 1 kW installation, you would need the panels with their mounting structure, a battery to store the power, an inverter unit to convert from DC to AC, wires, cables, etc, which along with labour would cost about Rs 3 lakhs upfront. The batteries, costing about Rs 15,000, would need to be replaced every 3 – 5 years and one would end up spending Rs 12 – 15 per kWh. The PV panels often carry a 25-year guarantee but are likely to last even longer.

A company has also stepped in to meet the growing shortage of drinking water by designing a solar system to operate a water generator that converts water from the

atmosphere (humidity) into 500 -1000 L of fresh and clean drinking water. They have also designed a module with a solar panel suitable for mobile towers. These units replace the diesel generator sets which currently serve as back-up for the towers.

Solar (PV), Grid-connected systems

Grid connected systems with solar panels are generally fitted on roofs in urban areas. Thus, no additional land is required as roofs are used. This can be a great advantage in crowded urban areas.

Ideally, all such systems should be in full sun from 9AM to 3PM in mid-winter.

Installing PV systems is reported to be expensive at present. Costs will hopefully come down from Rs 15-16 per unit without subsidy (Rs 9.01 unit reported presently with subsidy). It is interesting to note what an eminent industrialist states that companies presently spend as much as Rs 30/- per unit with a "genset". They could as well save some money by switching over to solar PV panels (without any subsidy) and what is more solar energy would be entirely sustainable and would cut down on cost of transporting fossil fuels.

Some of the installations that have come up presently in India in spite of high costs are because of the desire to break free from long hours of load-shedding which would otherwise have to be faced by the industries, especially in smaller Indian towns.

A conventional-type system capable of giving about 1 KW of energy would need a capital investment of about Rs. 3 lakhs upfront. Sometimes, the installation costs may increase by another Rs 1 lakh if difficult conditions are encountered at site. As more installations come up in India, costs would come down and pay-back periods get reduced. Tax incentives and subsidies would also help.

An advantage of PV systems, however, is that long transmission lines are not necessary, nor is much land required to install them. They are generally fitted on to the building roofs. More and more solar modules are now being fabricated as building materials so that they can be integrated into the building's fabric by architects. They include solar roof tiles, wall materials and semi-transparent roof material for atriums and skylights. These are destined to increase usage in the near future.

An attractive inducement for solar installations is payment for "feedback" of electricity from private individuals into the public grid. It would encourage private capital to come in if payment is made at a rate that would make such feedback profitable. A recent governmental ruling in India requires all electric supply companies and electric boards to have at least 5 - 7% of their energy supplied from renewable sources, and pay Rs 18.501- per KWh for captive feed-in systems. This makes feed-in an attractive proposition. (In Germany the stipulation is 15% of energy must be from renewable sources). This should give a new push to installation of renewable energy systems for feed-in into the existing grids on private initiative in urban areas of power short cities.

The Indian Oil Company (IOC) is reported to be considering setting up in association with Bharat Heavy Ltd. (BHEL) a solar power plant worth about Rs100 crore in Barmer, Rajasthan, based on the PV panel technology. The Government hopes that by 2022, solar power installation in India will reach 20,000 MW. It also hopes that 9,000 villages will benefit from soft loan schemes which will be refinanced by the Indian Renewable Development Agency Limited. Rooftop solar power will be promoted by providing incentives for self-

use. To enhance human resources, the technology institutes are being asked to develop suitable training courses.

National Targets

The Jawaharlal Nehru National Solar Mission targets 1100 MW grid solar power, 7 million sq meters solar collectors and 200 MW off-grid solar applications in the first phase by 2013, and 20,000 MW of grid solar power, 20 million sq meters solar collectors and 2000 MW off-grid solar applications by the year 2022. There are several off-grid applications which are already commercially viable or near viable where rapid scale-up is possible, with resulting reduction in imports of fossil fuels. The Indian authorities are hopeful that the target of 20,000 MW of solar generating capacity by the year 2022 will be met even earlier than that year and India will become a global exporter of solar power systems

Under the National Solar Mission, three major initiatives are proposed to be undertaken:(1) Create volumes to encourage large-scale manufacture, (2) announce a long-term policy to purchase power from renewable sources, and (3) support R & D.

A Solar Energy Society of India (SESI) has been formed to promote dissemination of information, co-operate with other research bodies, NGOs, etc, and generally to promote R & D in the subject, and further its applications. According to SESI, most parts of India receive solar energy of 4-7 kWh per sq meter per day which signifies about 5,000 trillion kWh per year of energy over the whole of India

According to guidelines issued by the Central Electricity Regulatory Commission (CERC), India, investments in renewable energy plants such as solar, wind and biomass, will get a pre-tax return of 19% per year for the first 10 years and 24% per year from 11th year onwards.

Concentrated Solar Power Systems:

While efficiency of PV panels is only 10-15%, it is relatively higher at 24% for Concentrated Solar systems using parabolic mirrors.

Large-sized plants for supplying electricity to urban areas and large industries are presently coming up in a few parts of the world to demonstrate various new technologies. Experience has shown through the development of special large-sized units called "solar concentrators" for power generation in Spain, US and elsewhere that it is possible to generate power from solar energy on a large scale but there are still a few problems yet involved in development of solar power for cities and large consumers.

Remember solar energy is plentiful in nature but available on the earth in "dilute" form. Hence more land is needed (about 10,000 acres for 1,000 MW plant, the land alone costing around Rs 100 – 200 crores!). Cheaper land would be available in an area like the Rajasthan desert. Also, from the experience of Spanish installations, large parabolic mirrors shaped as ultra-long troughs are needed to concentrate sunlight on to a long tube of molten salts that store heat. The heat energy is stored in molten salt (actually a mixture of two fertilizers, sodium nitrate and potassium nitrate), This heat is then used in a conventional thermal power plant to give electricity at about Rs 4/- per unit. It is hoped that with further research and improvements in future the Concentrated Solar Power (CSP) system costs may become competitive with conventional power and larger-sized units could be developed. There are already signs that costs are sure to come down for both CSP and photovoltaic panels

Land availability may, however, become a problem in India as experience in Singur and Nandigram, West Bengal,

has shown. Even though desert lands can be brought into use without affecting agriculture, often, even what is classified as wasteland by Government, is considered valuable by villagers who use the land for grazing, collecting minor timber, and as transport corridors. Villagers have also spurned joint ventures with corporate bodies out of mistrust. Hence, land can become a serious problem in India.

Moreover, water is also needed to wash off dust from the solar mirrors. This water may be scarce in wasteland areas and need expensive reuse techniques to make it possible. Use of solar energy is thus not so simple a problem as it may seem. Another problem is how to store heat produced during the day for later use. First commercial solar plant with heat storage opened in 2008 in Guadix, Spain, East of Granada. During the day the molten salts are heated, while in the evening it gives back heat to make more steam. A Spanish company is now building a plant in Arizona, USA, for Phoenix and Tucson which will generate 280 MW in 2012.

Germany and Spain have invested heavily in solar power. Germany has greater than 5 Gigawatts capacity and is the largest producer of photovoltaic power. Electricity generated from solar energy (in 2006) in gigawatt-hours is reported to be: Germany 2220, US 565, S. Africa 532, Spain 125, China 105, Australia 31, S Korea 31, Italy, Netherlands, Switzerland, 20-30 each, Canada 21, India 19, Mexico 10.

In May 2011 a news item states that the Maharashtra State Cabinet approved the setting up of a 150 MW solar power project (touted as the largest in the world) at Shivaji Nagar in Dhule District. It is expected to be commissioned by March 2012. The Maharashtra State Power Generation Company (Mahagenco) has already commissioned two other solar energy projects in Chandrapur. The cost of this project is expected to be about Rupees 2,000 crores of which 20% will be borne by the State and 80% will be loaned by KFW, a German financial institution. Electricity from the new plant will be sold at Rs 17.90 per unit against its expected generation cost of Rs 12 per unit.

A fantastic project is hopefully being conceived using the large and barren Sahara Desert area in the north of Africa to develop a Concentrated Solar Power device to generate enough electric power to meet the entire energy needs of Europe! The energy generated would also enable desalination of sea water needed for humidification to grow crops in greenhouses located in the Sahara Desert. It is an excellent example of synergy between CSP, seawater and greenhouses. Land is available, solar energy is available, generation of power is possible, but the conveyance and distribution of power from the desert to various European countries would pose enormous problems and involve large costs. Of course, no greenhouse gases would be produced. In India, the deserts of Rajasthan and Thar might hopefully be developed one day on similar lines as the Sahara though several other areas are also likely to be considered.

Satellite-based CSP systems

The land problem is the most serious problem in India both for solar power and nuclear power development. In the case of solar power, the problem could perhaps be avoided to some extent by the recently planned development of **"Satellite-based Solar Power Systems"** under which solar collector panels would be placed in a geo-synchronous orbit in space (to benefit from 24-hour sunlight) and solar power beamed to earth in laser or other form for subsequent conversion to useful electricity. These technologies are not yet fully ready for commercial exploitation but are mentioned to show the lines on which thinking is going on. This is where the future of

solar power lies. A 24-hour supply and no land problem! Let us hope ISRO will take up the challenge someday soon.

Wind-Solar Integrated (Hybrid Systems) for "Green Buildings & Industries"

Hybrid systems are installed where solar and wind-operated systems are both used to complement one another. Solar systems would not be available at night or in cloudy weather, while wind-driven systems would not work at no-wind times. Thus, the two could be made to complement one another to keep power supply available for longer time of day and night.

First generation "green" buildings provided for better planning and design of the structure architecturally and engineering-wise, so as to reduce the building's carbon footprint. Second generation "green" buildings would in addition to better engineering and architecture, also generate some electric power without adding to its carbon footprint.

Mention must be made of a building in north Pune ("Orange County") which I call "second generation" green building, where wind-mills and solar PV panels have been installed to generate enough electricity to operate the building's lifts and some common services besides giving free "green" energy to all its 36 flat owners. As said earlier, this becomes a case of Public-Private-Partnership which is welcome because Government is perennially short of funds and welcomes the input of electricity. The builder benefits from a valuable selling point to attract flat buyers who would prefer free electricity rather than a gymnasium or some other attraction thrown in by the builder when selling the flat.

Hydropower Projects

In a monsoon country like India, large hydro-power projects have been built since ages and are considered so important that a separate ministry is devoted to handle the subject. Bhutan also has several hydropower projects because of its mountainous terrain, but the electricity so produced is solely for the benefit of its neighbor, India. US, Germany, China and India rank high in the world.

In fact, hydro-power projects are preferred in modern times, wherever possible, because no CO_2 is released in generating electricity therefrom.

In hydropower projects rainwater is harvested in a natural or man-made reservoir located on a high terrain and released as desired to drive turbines located in a valley below to generate electricity, thus converting the potential energy of stored water into electrical energy. After use the water is released to a river downstream where the flowing water can further provide energy, if desired, to operate a wheel or hydraulic ram to pump up some small quantity of water. Mumbai has been served for many years since early 1900's by a large and dependable hydro-electric scheme (Tata Hydro at Bhivpuri near Mumbai) with the monsoon filling up its reservoir and renewing its life each year on time. There are several other examples of commendable hydro-electric and irrigation projects in India.

Energy of flowing water

The energy of flowing water in any stream or river into which the water from the turbines is released downstream, can be harnessed to (1) rotate a wheel or (2) operate a hydraulic ram, if desired. Such devices have been used since time ,immemorial, though many are not to be seen nowadays.

Small hydro-power projects upto 25 MW capacity are reported to remain a problem because most of the streams and rivulets in India are not perennial. Any attempt at creating small dams on such streams causes objections from the

downstream farmers and also often leads to deforestation. Nonetheless, about 2,700 MW of electricity is produced in this manner at present.

Agricultural Biomass and Community Wastes

Agricultural biomass (crop residues, sugarcane bagasse, leaves, twigs, grass, etc) and community wastes (sewage, industrial wastewaters, etc) can all be a good source of biogas. Agricultural biomass is often treated more like community solid wastes and deposited in landfill sites. Other wastes like sewage and industrial wastewaters rich in organics are treated like liquid wastes and sent to municipal waste treatment plants or Upflow Anaerobic Sludge Blanket (UASB) plants or specific waste-to-energy plants for anaerobic decomposition. Municipal solid wastes are sent to landfill disposal sites and give off biogas which can be harnessed, if desired, before it is given off to the atmosphere.

Bio-gas production through anaerobic decomposition of organic matter mainly involves production of methane (CHI) and carbon dioxide(CO_2). Three kinds of treatment plants are involved:

- Gobar gas plants in rural areas
- UASB-type plants in urban and industrial areas
- Waste-to-energy plants in specific locations

Gobar gas plants

They are the simplest in this category and are generally small in size, suitable for individual families in rural areas using human excreta and/or manure from a few cows or buffaloes. For agriculture and milking purposes, rural families tend to maintain a small number of say 3 or 4 cows or buffaloes each. Their dung helps run a bio-gas plant and produce bio-gas which helps the family to cook and heat as required without depending on their womenfolk to go in the adjoining fields and forests to collect wood / twigs to light fires at home for cooking or heating. This, incidentally, reduces deforestation and saves the womenfolk their time. Gobar-gas plants also prevent indoor air pollution, encourage better sanitation in rural areas by ensuring that toilets are constructed and feces is drained to the bio-gas plants rather than left in the open. All such activities when carried out on a large enough scale can change the face of rural India, putting more money and more time in the hands of rural families.

A CII-Godrej publication indicates that a 4.5 MW biomass based power plant installed in Karnataka consumes about 150 tons of biomass per day to generate about 1 lakh units of electric power. The same problem of fuel availability afflicts power generation from animal wastes. About 100 tonnes/day of cattle dung is required to generate 300kw of power. Such large amounts of dung would be only available from large-scale cattle sheds. Thus, the full potential for power generation from agro-wastes and such other sources yet remains relatively unexplored in India.

UASB plants:

Sewage and industrial wastes larger in volume and high in organic content can be treated in UASB (Upflow Anaerobic Sludge Blanket type) plants without use of external power to undergo anaerobic stabilizationand produce biogas containing CO_2 and methane (CH_4). Because concurrent production of carbon dioxide (CO_2) and methane (CH_4) occurs the modern-day challenge for engineers lies in the ability to separate (relatively easily) CO_2 from CH_4 before emission to the open environment. The methane is usable as renewable type fuel while CO_2 must be prevented from entering the atmosphere. A simple method of removing the CO_2 is by bubbling it through

an algal pond. If the biogas is available in large enough quantities, it can be fed to a dual-fuel engine and electricity produced.

If this can be done easily, anaerobic digesters, UASBs, waste-to-energy plants will all be more in demand than ever before.

Waste-to-Energy plants

Several activities produce organic wastes in reasonably large quantities at their sites such as at market places, industrial canteens, hotels, etc. One could locate suitable sites, on case by case basis, for installing individual "waste-to-energy" plants for which technology is available. For example, at market places where much solid and liquid wastes high in organic content are collected, waste-to-energy plants can come up to advantage. One could also get Indian or foreign-made plants on B.O.T. basis so that least capital investment is needed from the local body. The local body will only have to give land on lease basis and ensure maintenance will be adequate. Thermax, Pune, is reported to be tying up with Lambion to provide energy generation plants from wastes in India

Mention must be made of the Bio-methanation plants (Nisargruna) developed by the Bhabha Atomic Research Centre **(BARC)** which are being successfully run in India for treating food and kitchen wastes from large canteens of industries and offices, camps and religious fairs, food processing establishments, market places, etc.Wastes that cannot be treated by bio-methanation are coconut shells, egg shells, big bones, plastic/polythene, glass, metal, sand, slit, debris and building materials, wood, cloth/clothes, ropes, nylon threads, batteries, tyres/rubber, hazardous and chemical industries waste, etc, and are excluded.

Municipal solid wastes disposal

In India, the conventional system of handling solid wastes has been to use petrol or diesel driven vehicles for collection of the waste from roadside bins or from houses, followed by transport to a low-lying dump-site for disposal by dumping. The waste is left there to undergo self-stabilization and the gases produced are allowed to escape to the open atmosphere. In some of the larger cities, the people may be encouraged to segregate the waste so that salvageable material is picked up separately by rag pickers and recycled into the market. The collection system may also benefit from use of waste compression trucks and transfer stations. Ultimately, all solid waste of the city goes to the dump or landfill site for final disposal.

The collection vehicles use diesel oil quite extravagantly. For India it is an imported item. These vehicles should either run on biogas or CNG or be converted to EV (with electricity generated by solar panels).

Solid wastes disposal: Modern trend in case of larger cities is to go for sanitary landfill instead of plain dumping although the former is relatively more expensive than dumping. Hence, to help meet costs, bio-gas is collected from the disposal site and sold for its fuel value. Gas collection and utilization is also favoured these days because of global warming considerations and the income it generates for the local body.

Incineration of the solid waste instead of dumping or landfill is done mostly in Western countries, not yet in India. Across Europe there are over 400 plants of the "waste-to-heat" type. Such plants use the city's solid wastes as fuel instead of oil or other fossil fuels and have efficient waste gas cleaning devices incorporated in them so as to remove

mercury, dioxine, CO_2, etc, besides smoke, soot and dust. Their excess heat is piped for use in adjoining homes or for producing electricity. Denmark, Germany and Netherlands seem to benefit most from such plants. They save land too.

Delhi is reported to be getting its first waste-to-energy plant based on 2,000 tonnes of the city's solid waste and capable of producing 16 MW of electric power in the first phase. Even then, the plant to be established by Jindal Ecopolis at a cost of Rs 200 crores, will consume only 1/3rd of the city's solid waste.

Coal Gas

Coal deposits are substantial in India and coal gas was once produced in large quantity. Coal gas is also referred to as town gas and in the past was the principal fuel for domestic heating and cooking. It has now tended to be replaced by natural gas. Coal was also used in the past to generate "Producer Gas" to drive vehicles (especially in the War time when imported petrol was scarce but coal was locally available). However, it has tended to lose favour as it is based on a polluting, fossil fuel like coal.

Natural Gas Deposits

Natural gas deposits have been found in abundance in the Qatar region of the Middle East, as well as in Russia and in the North Sea above Britain. The gas is composed mainly (>90%) of methane. It is odourless, non-toxic and non-corrosive. It liquefies at atmospheric pressure when cooled to -1600 C. Qatar has invested heavily in refrigerated ships to transport Liquid Natural Gas (LNG) to other countries, whereas Europe receives its supplies through pipes laid from Russia. Natural gas has been extensively used in some cities of India owing to its relatively non-polluting nature and ease of distribution.

India has also been fortunate to recently find enormous gas resources which will no doubt be used extensively in the years to come. The gas deposits found in the Krishna-Godavari basin will last for many years to come. They will, in fact, slow down to some extent the development of other renewable forms of energy unless the latter are made mandatory or some tax benefits are given. Moreover, gas turbines are reported to have a 60% efficiency of conversion to power, which is only next to nuclear power. Gas resources seem to have an excellent future in India.

Compressed Natural Gas (CNG) is generally supplied at high pressure in small cylinders and is used both in households as well as transport. Mumbai's 55,000 taxis have switched over from diesel to CNG as a means of controlling pollution from their tail-pipes. Its pricing has also been favourable for the switch over. .The use of CNG is also likely to increase in the future as population increases and as the people use it increasingly for transport purposes.

Liquid Petroleum Gas (LPG) is different from LNG. LPG is almost all (95%) Propane, and some butane. No cooling is needed but under heavy pressure it liquefies. It is also sometimes used in transport.

Gas from shale

Shale gas is a type of natural gas found in rock formations and requires specialized production techniques. The USA first produced shale gas in 1989 and is reported to have later developed a new and easier method of extracting gas from shale, a common sedimentary rock found across the world. Shale gas exploration entails vertical drilling followed by horizontal drilling. Shale gas is found in tight reservoirs that have poor permeability. Shale gas requires large number of wells as the volume per well is small. In 2009, shale gas

accounted for as much as 13% of total energy consumption of US. Almost all states in US have reserves of shale. Europe and China are getting into the act now. Reserves have been found in Poland and Australia. Potentially, every rock formation can have shale gas.

India also has massive shale deposits and thus there is good scope for gas being released from there for use. Reliance India is reported to be tying up with US companies in order to learn their techniques. Besides large quantities of gas already available in India from the Krishna-Godavari offshore basin, gas from shale deposits seem to be available all over the Gangetic plain, Gujarat, Rajasthan, NE Assam, and some coastal regions. New gas deposits are being constantly found offshore.

Gas extracted from shale deposits is definitely likely to benefit India. India has a strange restriction at present against harnessing non-conventional sources. Firms are allowed to produce conventional oil and gas, but they have to keep their hands off coal gas, methane and shale gas even if they discover them in their exploration blocks. Since gas can be a cheaper and cleaner alternative to oil, a policy change is urgently required to allow exploitation of shale gas and methane without delay.

Bio-fuels

There are two prominent types of bio-fuels in the development stage, both obtained from agricultural sources:

1. Cultivation of "Jetropha" plant (an oil-bearing plant) whose oil can be used as an additive with petrol or diesel.
2. Another bio-fuel is 'Ethanol' which can be used as an additive or as an alternate fuel, obtained through chemical

conversion of agricultural products such as corn or sugarcane

Brazil has shown us that a mix of 5 – 10% bio-fuel along with regular petrol can be used for cars without any changes to their mechanism. At 5% blending, a country like India is estimated to need about 600 million litres per year and at 10% blending it would need double this quantity.

However, use of bio-fuels has been somewhat controversial. Their use appears desirable where **sugarcane** is the source and the country is tropical like Brazil and India as the energy balance is of the order of 8:1 there. In colder countries where the biofuel is made from corn, the energy balance is considered to be so unfavourable that when one considers all inputs like water, fertilizers, gasoline and transport for cultivating corn, it is not worthwhile to do so. India fortunately grows sugarcane.

The problem in a populous country like India is that area available for food cultivation and water cannot be diverted to make way for bio-fuels instead of food. Here, the Jatropha plant comes to our rescue. Jatropha is regarded as a better alternative to sugarcane as it needs much less water (even wastewater will do) and can be grown on land considered 'wasteland' for other purposes. With diesel engines, Jatropha can be used unblended on 100% basis also. Jetropha has performed well even on high mountain and sub-zero temperatures.

India needs a large-scale effort to grow and market suitable bio-fuels like Jetropha to make them easily available at every petrol station in the country so that their use is promoted. This involves a very large-scale, countrywide effort at cultivation, storage, distribution, pricing, etc, for the bio-fuel on the same

lines as is being done by government agencies for marketing petrol and diesel.

The Indian Oil Corporation (IOC) is reputed to have made a welcome beginning along with the Chhattisgarh Renewable Energy Development Agency in cultivating Jatropha on 600 hectare waste land in Madhya Pradesh. It is hoped Government will continue to show consistency in its policies for promoting use of bio-additives irrespective of the world price of oil. The use of Jatropha oil for fuelling aircraft also has tempting possibilities but needs to be further proved through trials which are on.

It is necessary to clarify that both fossil fuels and bio-fuels produce CO_2 when burnt. In the case of fossil fuels like coal or oil, the carbon sequestered in it for millions of years is released when burnt. This gives an additional load of carbon on the environment and can lead to global warming. In case of bio-fuels, CO_2 is also released from the carbon contained in the oil, but it was extracted earlier from the atmosphere in recent photosynthesis which generated the plant in the first place. Bio-fuels are therefore considered as "carbon-neutral".

Nuclear energy

In India, at the present time, development of nuclear energy (though not strictly renewable) is being considered although the Chernobyl and Japan disasters are much feared. Its efficiency of conversion to power is high, upwards of 70%, and it can reduce India's power shortage without producing any CO_2.

The availability of large deposits of Thorium in India is encouraging provided its use can be safely engineered in preference to Uranium which is presently favoured but reported to be in short supply in India and needing import.

One of the severe problems in developing nuclear energy is its enormous land requirement. A large chunk of land has to be left surrounding a nuclear plant from safety considerations. An additional chunk of land around this area has to be left for controlled activities and habitation. And yet another chunk of land has to be provided nearby for holding the nuclear waste for long periods. Its land requirement seems to be even more than that for solar concentrators. Where is so much land to come from? Land availability becomes the most severe problem in undertaking a nuclear project. The recent Jaitapur Nuclear project has high-lighted these difficulties and showed that land acquisition policy of government has to be reviewed and made more people-friendly, if it has to succeed.

Another problem is the long time period required for getting international permits for nuclear plants (about 10 years) and their construction (about ***5*** years). Thus, investments have very long pay-back periods.

Wave energy

Other important forms of renewable energy are wave energy, and geo-thermal energy. Scope exists for their usage wherever available and possible to use. Not much research work appears to have been done as yet in India with these systems.

The wave potential is said to be around 1,000 times more than the wind potential. Waves are a stable and predictable source of power, taking into consideration diurnal and seasonal variations. Wave energy results in a substantial quantum of 'power generation since the energy generated varies according to the square of wave height (as compared to wind power which varies according to cube of air speed. In addition, water is some 850 times denser than air. Moreover, infrastructure requirements are said to be much less, since wave energy

needs only 11200 of the land area of wind energy. Further, generating wave energy entails lower infrastructure costs.

According to an UNFCCC update (EB 51) four different technologies are under development in USA and elsewhere. Among the mature ones, is the "Terminator" installed near shore in California and shown to be able to produce electricity at about 10 cents/KWh.

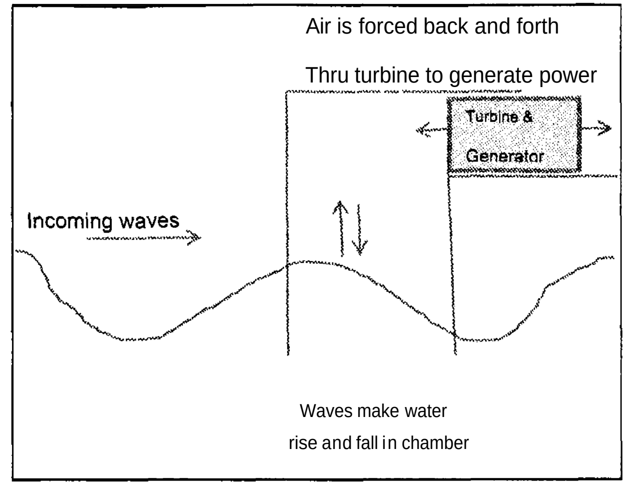

Fig # shows a turbine device to generate electric power from wave energy.

No project on wave energy harnessing has yet been set up in India in spite of its long coastline and the presence of important ports and cities on the coasts.

Geo-Thermal energy

Geo-thermal energy is available in certain parts of the world e.g., Iceland and around southern Russia and can be used in the form of hot or lukewarm water in homes or public baths, welcome in a cold country. It is reported that 25% of Hawaiian electricity is geo-thermal. In Iceland, nearly 80% of all homes are heated by geothermal energy.

Naturally available hot water from a groundwater source can be, for example, piped and supplied city-wide through a network of tunnels built to facilitate their maintenance. The Chinese city of ***5*** million people, Xiang Yang, is hoping to set up one of the world's largest urban geothermal heating systems.

India is supposed to have a large scope for setting up geothermal energy projects, but no progress has yet taken place in this direction to find out if any scope really exists.

Peoples preferences

Aquestion that one may ask at this stage is: which system of all those described above might catch the fancy of the Indian public? The answer would perhaps be one that meets the following commonsense criteria at all times would likely to be the most favoured and become the most sustainable:

- It has to be reliable (political security is important)
- It should be easy to install, safe to use and sustainable
- It should give the best financially attractive solution to the energy problem.

It is clear that wind, solar, hydro and wave energy would win hands down, any day. These should be the alternative sources of energy to concentrate on.

In un-electrified rural areas:

TERI-type solar lanterns and similar devices for lighting would have a good chance of success along with gobar gas plants based on cow-dung for generating biogas for cooking. Another source of renewable energy likely to find favour

in Indian rural areas is the stand-alone solar PV panel for generating electricity at a spot to operate a tube-well pump or a telephone or an intermediate station for mobile phones, or small water treatment units to remove arsenic or fluoride or such other impurity from drinking water. Furthermore, any system which can be integrated with the village economy would have a greater chance of success.

In urban and industrial areas:

Any renewable energy system based on wind, solar, hybrid and bio-mass technology to generate electricity is likely to find favour especially for:

- Developing the use of biofuels like Jetropha as additives to reduce the use of fossil fuels which need to be imported.
- Replacing diesel-operated motors for elevators (lifts) and pumps for common services in co-operative housing societies.
- Large-scale use of such devices is waiting to make a beginning in second generation Green buildings in urban areas of India for "feed-in" into city's grids which are invariably in need of electricity supplements to meet shortages. It also becomes a kind of welcome public-private participation provided investments are guaranteed at favourable returns.
- Transport seems to be going in favour of electric vehicles (EVs) provided the vehicles can be re-charged at night using solar energy from Green buildings to produce electrical energy at reasonable cost.
- Reducing/replacing use of fossil fuels for operating infrastructural items for water supply, wastewater disposal and solid wastes disposal.

Policy issues

Finally, at least three important policy issues become urgent for Government to look at so as to facilitate implementation of above type projects and programmes:

- Land acquisition policy (how to make land acquisition more people-friendly, etc)
- Research policy (to direct our research strength on selected topics such as harnessing "Wave Energy" which seems worthwhile to pursue)
- Fiscal policy (to encourage investment and Public-Private-Participation in energy-related items)

Both geographically and economically India is very well placed with its climate to develop various renewable sources of energy for which abundant potential exists. Moreover, their development, as demonstrated by Germany, does not necessarily diminish the GDP growth rate of a country.

SHAILESH KAPADIA

(24-12-1949 – 19-10-1988)

Late Mr. Shailesh Kapadia, FCA, was a Chartered Accountant by profession and was a partner of M/s G.M. Kapadia & Co. and M/s Kapadia Associates, Chartered Accountants, Mumbai.

Shailesh qualified as a Chartered Accountant in 1974 after completing his Articles with M/s Dalal & Shah and M/s G.M. Kapadia & Co., Chartered Accountants, Mumbai. Shailesh had done his schooling at Scindia School, Gwalior and he graduated in Commerce from the Sydenham College of Commerce & Economics, Mumbai in 1970.

Shailesh enjoyed the confidence of clients, colleagues and friends. He had a charming personality and was able to achieve almost every task allotted to him. In his short but dynamic professional career, spanning over fourteen years, Shailesh held important positions in various professional and public institutions. His leadership qualities came to the fore when he was the President of the Bombay Chartered Accountants' Society in the year 1982-83. During his tenure he successfully organized the Third Regional Conference at Mumbai. He was member, Institute of Fiscal Studies, U.K.; member of the Law Committee and Vice-chairman of the Direct Taxation Committee, Indian Merchants' Chamber. He was also a Director of several public companies in India and Trustee of various Public Charitable Trusts.

He regularly contributed papers on diverse subjects of professional interest at refresher courses, seminars and conferences organised by professional bodies.

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

- Eugene Black
Former President,
World Bank

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