

SOLAR ENERGY AND IRAN'S ENERGY NEEDS

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The realisation that traditional fuel sources are in ever shortening supply, and the growth of energy power politics have caused nations in all stages of development to reassess their energy programs. Having the technology and capital to do so, it has primarily been the highly developed industrial nations who have explored avenues leading to greater freedom from fossil fuel sources.

In their eagerness to join the advanced industrial group many developing nations adopt a "quick fix" - blindly borrowing fossil fuel based technologies. In doing so, they follow entire patterns of development set by those advanced nations; setting up capital-intensive, highly energy consuming and labour saving industries. This creates dependencies on their technological predecessors for the skills of implementation, the materials - in short, the technology "package". To sustain such a growth pattern would demand massive efforts at raising energy production and energy consumption. Can developing nations really afford to do so? Doesn't realistic appraisal deem decentralized, low energy consuming technologies as more suitable for the developing countries?

The majority of Iran's people live in rural areas. Due to the nature of their life support systems we may consider the nation as having an essentially rural character. Low technologies are particularly suited to the needs of the rural profile. Further, the ever increasing drain of workers to the promise of the cities might be stemmed by the employment opportunities created by the adaptation of low technologies to local needs.

The daily average consumption of a village of 500, for example, has been estimated at 200-300 kw (kilowatt hours); 100 kwh for cooking, 100 kwh for irrigation, 50 kwh for entertainment. How might this energy be supplied? Most of the smaller villages are in areas of low accessibility. It is uneconomical to incorporate them into the existing power distribution system. Even moderate sized towns, because of low power demand potential (due to the lack of village industries and production) do not fit easily into the present system.

Yet there exists no adequate substitute for electricity. Fossil fuels

are in decreasing supply and their transportation is difficult. In the villages animal dung and firewood provide a large portion of the cooking fuel. But the increased use of firewood will lead to the depletion of already low supplies, with consequent effect on the ecosystems dependent upon the woodland covers. The animal wastes could be used much more effectively to ease the fertiliser shortage and through bio-gas plants for village use in a variety of ways.

In the long run, an attractive alternative could be solar energy. Even the present state of the art indicates that this freely available clean source of energy could satisfy the needs of small localities. Does enough sun shine on Iran to make it possible? Primarily, solar energy is available to countries located in the "sun belt" - 40° north and south of the equator, with peak intensities within 24° north and south. This encompasses almost all the developing countries of the world. Solar energy available to Iran is a little more than 200 BTU per square foot of area every day. As solar equipment improves a larger and larger portion of that energy becomes available. In fact, it is becoming increasingly evident that solar energy could offer the only long-term energy supply to small villages. For larger villages and towns mini-solar plants are being developed to assist, if not substitute for, other sources.

Technologically advanced nations are pursuing a number of schemes for large-scale conversion of solar energy into electricity.

Some of these are:

Solar farms- as the name implies, solar energy would be culled and harvested for distribution. These are collective community generative systems. Some proposals for covering vast expanses of desert with huge collectors are being explored in the United States.

Rooftop Array- as opposed to communal collection, this system utilizes individual dwelling structures to position enough solar electric (photo-voltaic) cells to provide for the family within. The system, which is fairly well developed, can serve as a back-up to an existing supply or as a complete, independent source.

Satellite system- An American consulting firm, Arthur D. Little, of

Boston, has proposed the orbiting of a giant satellite, to be in fixed position relative to the sun. The collector, 91 square km., would gather energy 24 hours a day, transform it into microwaves, and beam it back to an earth-based receiver, 3 km. in diameter, collecting 10 megawatts of electrical power. This project would cost an estimated 20 billion dollars.

Such proposals need not concern us immediately. For Iran, we must concentrate primarily on the rural and agricultural sectors, and the technologies considered should be "soft" and not chained by the investment of high capital sums.

As we now turn to the specific applications of solar energy we may feel that the initial exploration and extension costs are rather high. Yet it must be kept in mind that such is the nature of departures with existing systems, and that long-run costs - both social and economic - should be considered instead.

In order to understand the operating principles underlying the utilization of solar energy we must first examine the processes by which the solar product is transformed into energy:

Heliochemical - This is the basic process by which plants utilize natural elements for growth. We usually refer to this as Photosynthesis. As important as it is to the chain of life on this planet (including the formation of fossil fuels upon which we so heavily depend) man has yet to synthetically duplicate the functioning of a simple (!) blade of grass.

Helioelectrical - Quite contrary to the above wonder of nature, the helioelectrical system is made by man. The process referred to is the conversion of solar radiation into electrical current through playing with the atomic structures of certain elements under magnified solarly. With the exception of one satellite, all space vehicles have been powered by solar cells. This process will be discussed in greater detail later.

Heliothermal - Everyone has felt the heat of a metal object which has been lying in the sun for a few hours. This is heliothermal action. Experimenters have found that blackened metal surfaces absorb enough

radiation in the form of heat to make this the basis for the many devices utilizing thermal principles. Temperatures exceeding 300°F. (150°C.) have been attained using this basic process. When tubing is run across the face of the plate the heat is transferred to the liquid inside. This is a flat plate collector used in heating water and other liquids. Other devices, to be discussed shortly, have accomplished temperatures ranging from below freezing to almost 6000°F. (over 3300°C).

As stated, the small power requirements of the rural, agricultural, and domestic sectors must figure predominantly in any consideration of solar energy in this country. The further development of hydrocarbon fuels, the construction of large central power plants and their operation, and the distribution of energy require tremendous capital expenditure. These methods strain the economies of even the western world. More serious, immediately, is the worsening deficiency of vital inputs required for agricultural development (irrigation supplies, farm implements, and quality fertilizer). How can solar energy assist here? In the agricultural sector the need is for solar engines and pumps for motive power and irrigation, and solar drying devices for drying cash crops and seeds. Indirectly, solar heated water could be used to heat biogas plants for year-round operation, thus making large amounts of its nitrogen-rich slurry by-product available for fertilizer at local levels.

Solar pumps and engines - Several countries have already developed experimental models. A flat plate collector feeding a low-temperature engine system with an output of 75°C. and a condenser temperature of 30°C. has been developed for use at a field site in Senegal. The unit operates as follows: A collector area of 72 sq. meters offers 10 cm³/hour of water for 6 hours daily from a well depth of 20 meters. The solar heated water circulates by thermosyphoning (heated water will rise, and in a closed system will force circulation), operating a closed cycle using butane as the working fluid; the condenser being provided by the pumped water. The engine cycle is a reverse refrigeration cycle in the sense that the evaporated butane activates a piston and thus delivers energy. Low pressure butane vapour is condensed in the condenser and injected into the hot side exchanger via a reinjection pump. A hydraulic pump coupled to the engine lifts the water from the well.

As is the case with most experimental models, the efficiency of this unit is rather low. Yet the principle is proven and several research organizations are now in the process of refining the operation. The idea seems based on solar power generators to be discussed later.

Solar driers - As with many solar devices, this one had its origin centuries ago when people would dry cereal grain in the open or collect salt from dehydrate basins. Associated with this drying process, however, are three major sources of contamination. These are wind-blown debris (dust, organic matter), animal and human interference at the drying beds, and of course pest and insect invasion, not to mention the threat of rain. If a little technology is employed the natural process of solar drying can be made much more efficient, with much improved quality and little waste and contamination. The cost of the drying unit is more than compensated for through increased profits from cash crops, export items, seeds and commercial products like fish, dehydrated fruit, timber, vegetables, etc.

The drier itself is an enclosed drying area covered by transparent material (polythene is good but glass has a better life). The area may be made of wood, though larger, permanent models can be constructed of concrete, stone, or other local materials. Air circulates through the box via several ventilation holes. The material is heated and dehydrated by the concentration of the sun's rays. The moisture exits through the ventilation holes.

Another model uses a separate solar heater and then circulates the air (by natural convection in some models) into storage bins. These bins are for larger quantities and continuous feeding methods.

The rural and domestic sectors could use a variety of devices to supplement, if not replace, traditional sources of energy.

Solar distillation - The process here is simple evaporation. Brackish or salt water, or even sewage sludge, is run into a closed, shallow trough or pan which has been painted black. The pan absorbs the solar radiation coming through the sloping glass covering. The liquid evaporates after suitable temperatures have been attained, condensing on the inside of the glass. Gravity forces the condensate to trickle

down into collector pans. The first recorded still of any size was constructed in the Andes mountains in 1872. Designed to supply fresh drinking water to the men and animals of a mining operation, the still was almost one acre in size, delivering 6000 gallons (26000 liters) daily from a very brackish source. The need for purification and filtration systems in towns and villages is rather obvious, considering the number of parasites and other contaminants in local waters. Further, distilled water is needed in gas stations, school and scientific research centers, health centers and many industries.

Solar water heaters → Almost 25% of all private homes in Japan and a considerable percentage in other countries are equipped with solar water heating devices. Though there are a variety of models and styles, the basic operating principle is shared by all. The water is heated in a flat plate collector and transferred to insulated storage tanks by process of thermosyphoning. In larger units solar or electric pumps may be used. In areas where below freezing temperatures are recorded for prolonged periods of time an anti-freeze is often added to the water. This requires a closed circulation system and heat exchanger into a fresh water supply, since anti-freeze must not be imbibed. Even in January, if the sky is clear, morning temperatures of 50°C. and above are obtainable. In northern Great Britain a rooftop collector measuring 60 square meters delivers winter flows of 10 liters/min. at 45°C. Domestic needs call for washing temperatures of 40°C. while about 80°C. is required for sterilization of dishes and equipment. These temperatures are within the range of well-designed solar water heaters. If much higher temperatures are desired, the solar unit may be used to pre-heat the water, thereby saving substantial amounts of fuel.

This basic design has been used for solar air heaters as well. Instead of tubing, an "air space" is allowed between the glass and blackened sheet (or finned for greater absorptive area). Cool air travels through the inlet at the bottom, is heated, and passes out the exit vent at the top, utilizing the "chimney effect" of forced air convection.

Solar refridgerators - In villages and towns cold storage facilities are needed to combat spoilage of foods and medicines. Without such facilities the spoiled products are often still used, creating serious

health and sanitation problems. Kerosene refrigerators, using the absorption principle, have recently been adapted to work with the lower temperatures of solar collectors. The process is basic to the refrigeration industry. Solar heat is used to evaporate a refrigerant vapor (in most cases ammonia) from a mixture of ammonia and water in a generator. The vapor is condensed in an absorbing liquid (water) and released into the evaporator through a nozzle. During evaporation the ammonia takes heat from the surrounding space, cooling it down. This is the "refrigeration effect". The spent vapor then returns to the absorber, thus completing the cycle. The Coefficient of Performance (ratio of the cooling effect to the amount of heat needed to produce it) is at present lower than market refrigerators which use electricity. Yet the purpose of attaining freezing temperatures can be achieved, and improvements are on the way.

A variation on this system uses a fan to remove the cooled air into the room, thus achieving "air conditioning". However, this system is not presently suitable for mass consumption.

Solar power generators - Though this field has long been researched little has been accomplished until recently. A 10 kw power pack, designed by Dr. Harry Tabor, an Israeli scientist, is now near production. The system combines flat plate collectors boosted by reflective mirrors to produce steam at 150°C. (and utilizes gases of the Freon family instead of ammonia). The steam drives the power delivery arrangement of a Rankine turbine (invented a century ago) and is regenerated through heat exchangers into the collectors. The cycle turbine, equipped with field and armature, produces electricity.

Though the principle has been pioneered it will be several years before the system is economically competitive with present generators. Similarly, photovoltaic devices, which turn the sun's rays directly into electric current, are well developed but still beyond the reach of the average consumer (in any country).

Solar production of electricity is achieved by combining the incomplete electron shell of a piece of silicon semi-conductor doped with phosphorus and a similar piece of silicon doped with boron. Under the

influence of a photon of light energy the ensuing sharing of electrons fields produces an open electrical circuit. Experiments with cadmium sulphide and even organic materials may prove more efficient, however, the cost of photovoltage is still \$20-100/watt (down from \$1,000/watt a few years ago).

Solar cookers - Pioneered in India over a century ago, popular models began appearing during the 1940's designed by M.K. Ghosh in Calcutta. There is currently a variety of stoves and ovens on the market, yet their potential has not been realized. Basic ovens are insulated boxes with a double glass face and reflectors. Simple models generate 120°C., while an improved design by Dr. Marie Telkes can generate 200°C. on a bright day.

The value of solar cookers may lie in the great saving of costly fuels. Under a bright sun a reflective parabola design (focusing the rays on a pot or pan for immediate heat) generates a heat comparable to a 400 watt electric hotplate, a standard device in Japan. If the fuel replaced is dung, there are also benefits to agriculture (releasing fertilizer material) and public health. Even if used for only two meals per day there are benefits accrued.

This article has tried to introduce the basic principles underlying the utilization of solar energy, and examine some of its specific applications. It is by no means complete; substantively or technically, yet it is hoped that this brief presentation has been sufficient to illustrate that solar energy is no longer the child of science-fiction writers and retired engineers. The fact of its development has profound implication for independent and localized growth, free from the restrictions and unforeseen consequences of imported "technology packages". This may be a major component of the national and regional advancement that we all hope for. It is real, and tangible as sunburn.